FARM MACHINERY FOR UPLAND RICE

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Introduction

There is an urgent need for increasing crop production to meet the demand for larger quantities of food, which is required by the expanding population in Thailand. Agricultural production in developed countries increased by 50% from 1957 to 1975. A higher increase of 60% was obtained by developing countries. However, because of a higher birth rate in the latter category the agricultural production per capita was virtually constant. Thailand exports large quantities of rice but some of the Southeast Asian countries are less fortunate, they fall far short of meeting the food needs of their people.

Increasing food production will further expand food exports which are important to balance payments in international trade and help pay for the increasing cost of energy until alternatives come on stream. The balance of payments problem faces my country as well as yours. The energy shortage may adversely affect growth in mechanization to some extent in the short term. However, it appears that fuel should be available for farm equipment. Only 2% of the petroleum fuel consumed in Thailand is used on farms and food production would drop to unacceptable levels if fuel for farming was significantly reduced.

Crop production can be increased by adopting new developments such as high yielding varieties with disease and insect resistance, irrigation and water management, pesticides, good soil and crop management, fertilization, cropping systems, and mechanization. In other words, mechanization is only one of several means available for increasing production. However, it can contribute substantially to this end. But more

importantly, it behooves us to work toward the integration of research and development from all disciplines, to maximize the benefits to the farmer.

The objective of farm mechanization is to relieve labor shortages during tillage, transplanting, harvesting and threshing. Industry is continually expanding and small farm machines are necessary to replace the people who are leaving the rural areas for jobs in offices and factories. We sometimes hear of concern that farm mechanization will increase unemployment. This same view was expressed in the U.S. 50 years ago. In retrospect U.S. farm mechanization was required to replace people who were migrating off the farms. Developments here may be similar.

Benefits from Farm Mechanization

1. Increased crop production

   a. Timeliness. The fact that crop production increases when farm operations are achieved on time is well documented. The traditional practice in the northeast is to wait for rain before starting to plow because the buffalo cannot pull the plow for long when the soil is dry. But, in a year when the rains start late some farmers cannot get all of their fields in production which reduces the harvest. Those faced with a labor shortage during the harvest season experience increased field losses when a paddy is harvested and threshed late.

However, increased production in a single cropping system will not justify mechanization if the labor supply is ample.

b. Facilitate multi-cropping. Specialists in cropping systems have developed program for two and even three crops per year. This is feasable without major irrigation facilities if some supplemental water is available, such as shallow wells for the first and third crops. But the system requires mechanization. Without equipment, the time required to get one crop harvested and the next one started is too long to realize maximum harvested yields.

2. Increased time available for other activities

a. Further increase production through a fertilization program, weed control, maintenance and weeding of bunds.

b. Increase in income from off-farm work.

c. Leisure time. Although this will not improve the farmer's economic position, it may be a factor in deciding to purchase machines in some cases.

3. Reduction of drudgery and hard work required to produce food.

Potential for Increasing Rice Production

The average rice yield in Thailand was 1.86 T/ha in the 1978-79 crop year, with considerable variance between regions.

Region	Tons/ha
North	2.70
Central	2.11
South	1.88
Northeast	1.35
Country Average	1.86

With a potential yield of 6-8 T/ha the total production can be increased considerably, and should be able to keep ahead of the demand. An annual average yield increase of 2% will double production in 35 years, without increasing the area in rice production.

Development of Farm Machinery in Thailand

Considerable activity is directed to the development of appropriate technology farm machinery for the Thai rice farmer, including equipment for use with improved cultural practices for upland rice. These machines may also have application to other rice producing countries. Similar activities are being pursued in many of them.

The Agricultural Engineering Division of the Ministry of Agriculture and Cooperatives has been active in developing and promoting better farm equipment since 1957. The International Rice Reserch Institute (IRRI)

small farm machinery program was introduced to Thailand in 1971 with the Agricultural Engineering Division in the role of a cooperator. Since 1974 the two organizations have actively pursued a joint activity, the Thai-IRRI cooperative project in machinery for the small rice farmer. This program is pursuing the test and development of manual, animal and engine powered machines. Approximately half of the effort over the past 2 1/2 years has been directed to manual and animal powered implements. Most of the machine designs are received from IRRI headquarters in Los Banos, Republic of the Philippines. USAID provides the financial support for the IRRI input to the cooperative project. Other groups involved with the Agricultural Engineering Division in machinery development are the ESCAP Regional Network for Agricultural Machinery and the UNDP/FAO machinery project.

Farm mechanization is expanding in Thailand. It is more predominant in the central region than in other areas primarily because of differences in economic ability to purchase machinery. The northern region is also purchasing mor emachines than formerly.

Estimated Production and Population in Thailand, 1980

	Production	Country Population
Power Tillers	50,000	250,000
Tractor (under 20 Hp)	9,000	31,000
Tractors (20 Hp and up)	4,000	33,000
Threshers	4,000	12,000
Irrigation Pumps	-	474,000

Several of the farm machines being developed by the Thai-IRRI cooperative project are applicable to upland rice. It is anticipated that they will be adopted more rapidly in the future. Factors that will promote the mechanization of upland rice production are:

1. Job opportunities off the farm. New factories and offices are being built in the urban centers. This results in a long run trend to decrease the rural population.
2. Improvement in economic position of rice producers. Ministry and aid programs are directed to increasing the net income of farmers which will improve their purchasing power. Seed for a high yielding variety is a small incremental cost compared to a native variety. This may be the best way for a poor farmer to increase his production and provide the means for purchasing other inputs to further improve his position.

Machines for Upland Rice

1. Improved Buffalo Plow. The buffalo plow is used primarily in bunded paddy, but it is also used to some extent in upland conditions. Much of the upland rice in the North is on steep slopes which are tilled by hand. However, some of it is grown on comparative level fields. In the Northeast, the fields are more level and are adaptable to tractor tillage. A lower draft buffalo plow offers an alternative to hand tillage in the North. Soil erosion can be reduced by plowing on the contour of the hillsides. A project with the objective of reducing the draft of this implement was begun over two years ago. Two hypotheses were

investigated for reducing the draft.

a. A moldboard with a larger radius of curvature.

b. Rotation of the plow assembly clockwise about a horizontal axis, as viewed from the rear, to provide a more gradual approach to the soil.

A buffalo plow manufactured in Khon Kaen was selected as a basis for comparision. Three moldboards with differing radii of curvature were fabricated. They were mountable on the plow frame, both at the manufacturer's normal attitude (0°), and rotated 20° clockwise. The plow was fitted with gage wheels for controlling the depth at 127 mm (5") for the first test in upland soil conditions in June, 1979. Mechanical power was used rather than buffalo, since this should produce more uniform velocity to facilitate measurement of the draft force. The lowest specific draft (kg/sq.cm. of projected area of furrow slice) was with the largest radius of curvature moldboard at either plow attitude. The 20° attitude significantly reduced the draft compared with the 0° attitude. Subsequently a third improvement was incorporated, reducing the point suction angle of 22° used by the Khon Kaen manufacturer, to 18° on the experimental plows.

A test plow frame with provision for indexing the attitude of the plow in 5° increments from 0° to 30° was constructed, to facilitate the determination of the optimum attitude angle. The draft reduction obtained was encouraging enough to suitably mount a larger power tiller moldboard on the test plow frame. It had 84% more projected area than the manu-

facturer's plow and required slightly less total draft in an upland test. In a paddy test this moldboard required more draft than the manufacturer's plow but the specific draft was reduced by 29%. The average specific draft reduction in upland tests at three locations, Phraputtabaht, Kamphaengsaen, and AIT, was 38%. The average reduction was 30.4% in four paddy tests, with the depth controlled by replacing the wheels with skids. The results generated two recommendations:

a. A new wider plow point and moldboard with 50% more projected area and top width than the control plow at 127 mm plowing depth. The radius of curvature is 46 cm, attitude angle is 20° and the suction angle is 18°. This requires approximately the same total draft as the control plow in limited testing but it will reduce the plowing time by about one third, producing a timeliness benefit in paddy conditions. It is not recommended for upland soils.

b. A plow similar in shape to (a), above, but with a projected area and top width at 127 mm plowing depth comparable to the manufacturer's plow. This unit will reduce the total draft requirement to two-thirds of the requirement for the manufacturer's plow. It may be used with small animals, for deeper plowing, or specifically for upland conditions. Significant yield increases have been obtained by deeper plowing for some upland crops. (IRRI, 1978).

The Department of Extension at Pitsanuloke became interested in this development. A production plow frame with the two interchangeable recommended plow bottoms, was provided for use in comparative paddy tests with a local plow. A vertical hitch adjustment was provided so they could control the depth comparable to that of their local plow, since they did not have depth gaging means. On three successive days they ran one of the plows for five hours, using the same buffalo. The plow depth was 120-130 mm in each test. The area plowed was maasured each day, as follows:

	m^2	% Increase
Local plow	1,980	
Recommended narrow	2,480	25
Recommended wide	3,290	66

The Pitsanuloke tests indicate an increase in productivity in paddy for the recommended narrow plow over the comparable width local plow. The lower draft requirement apparently resulted in a higher buffalo ground speed; the recommended narrow plow also had a timeliness advantage under paddy conditions. There is a similarity between the area plowed for each moldboard in the Pitsanuloke tests and the specific draft data obtained in our tests.

Is the improved narrow moldboard feasable for use in upland soils? The force required to pull a plow varies with soil type and moisture content. If the field is too wet or too dry, the force required is higher than for optimum moisture content. The average draft for the

Khon Kaen manufacturer's plow in four paddy tests was 123 kg. It is assumed that a buffalo can pull a 125 kg load in upland plowing, with greater ease than in paddy because the buffalo is on firm soil and does not have to exert as much energy to move himself.

DRAFT REQUIRED BY MANUFACTURER'S PLOW

Location	Total Draft (Kg)	
	Actual	2/3
Upland		
Phraputtabaht	143	95
Kamphaengsaen	181	121
A.I.T.	368	245
Paddy		
Bang Khen	113	
Lardyao	141	
Bang Khen	129	
Khon Kaen	111	
Paddy Average	123	

The average draft of the manufacturer's plow in upland tests at Phraputtabaht and Kamphaengsaen was respectively 143 and 181 kg at 127 mm depth. The recommended narrow moldboard would therefore be assumed to require 1/3 less force or 95 and 121 kg respectively. If a somewhat tougher plowing condition is encountered, a reduction in depth from 127 cm to 102 cm would reduce the projected area of the recommended narrow plow. An upland soil requiring 250 kg of draft at a depth of 127 mm with

the manufacturer's plow, which is double the draft in a paddy, would require 128 kg of pull with the recommended narrow moldboard at a plowing depth of 102 mm. Therefore, upland conditions do exist where the recommended narrow plow can be utilized. The recommended narrow moldboard would very likely be too great a load for a buffalo in heavy clay upland soils, unless the moisture content was optimum and the depth of plowing was shallow.

2. Plow Sole Fertilizer Applicator. IRRI has designed a granular fertilizer applicator for attachment to either a buffalo plow or a power tiller plow. The fertilizer is metered by cells in a roller that is located in the hopper bottom. The fertilizer is discharged in the furrow and covered by the next furrow slice. The plow capacity is decreased by about 10% by stops to fill the hopper, which has a capacity of 9 kg.

Very little fertilizer is used with upland rice in Thailand. The recently cleared forest areas are relatively rich in plant nutrients. However, many upland areas in the Northeast are deficient and should be fertilized. IRRI test results, using four methods of fertilizer application in paddy, show that the plow-down deep fertilizer application of 28 and 56 kg N/ha produced more efficient use of the chemical than other methods tested. The trials were on IR36 and IR40 varieties. This method will need to be evaluated in upland rice. With anticipation of increased use of fertilizer in the future, the plow sole fertilizer attachment may have a place in improving the yield of upland rice.

3. Upland Seeder. There is a need for a mechanical seeder for establishing upland rice, to replace the traditional method of making holes with a stick, dropping the seed and covering by foot. This type of planting

is practiced on nearly half of the upland rice grown in Thailand. A mechanical seeder will provide more uniform depth and emergence. The higher capacity should assure a timeliness advantage in getting the crop established.

An IRRI design upland seeder has been under test in Thailand for over three years. Blueprints are available to interested manufacturers. The machine weighs 105 kg. Five-20 cm row, three-40 cm row, or two-80 to 90 cm row spacing are obtainable. The seed drop is readily adjustable from 20, 25, 33 and 50 cm spacing in the row. A split hopper permits an application of fertilizer at planting time. A horizontal seed plate for each row oscillates in the hopper bottom and alternately drops seed and fertilizer. Interchangeable seed plates are available for rice, wheat, corn, sorghum, soybeans, mungbeans, and peanuts. Calibrations can be made for any upland crop. The seed depth is adjustable from 2-6 cm. The field capacity is 1.2 ha/day. It can be pulled by a power tiller or a buffalo. A three row seeder was built specifically for use with a buffalo and to provide a lower cost seeder for the Northeastern region. It has been tested for the past two seasons.

When the seeder is used with rice on 20 cm row spacing and shallow planting depth of about 2 1/2 cm, there is a problem with the quality of seedbeds of the type found in the Ayudhaya area. The localized surface undulations result in non-uniform seed depth and some seeds may not be properly covered. This resulted in the design of a 2 m wide leveler with a weight box. One pass with the leveler produces a smooth surface for the upland seeder. Leveling is not essential in similar seedbeds for 40 cm or wider row spacings for field crops planted more than 4 cm deep.

A secondary problem of plugging the openers exists when excessive grass or weeds are in the seedbed, as may be encountered near a bund. With a 20 cm row spacing the openers act as a rake. The wider row spacings accommodate the trash much better.

4. Manual Cyclone Seeder. The Ministry is promoting hand broadcasting of rice as a low cost method of establishing a crop. This principle is applicable to the deep-water rice area with dry seed broadcast prior to submersion of the soil, and in areas where pregerminated seed is applied to flooded paddy. Over half of the upland rice in Thailand is established by hand broadcasting. After the seed is applied, a light peg or tine harrowing is recommended for more effective seed covering, to improve germination and reduce the loss from birds and rodents.

A manually operated seeder was popular for applying grass or legume seed 50 years ago in the U.S. The units are still being used and manufactured. One seeder was brought to Thailand in 1981 and given limited testing with both dry and pregerminated rice seed. The seed flows by gravity through an adjustable opening to a disk with slingers that is rotated by a hand crank. Performance is dependent on walking straight at a uniform rate, properly spacing the passes, and on a uniform cranking speed. Seed distribution is more uniform than by hand broadcasting. The swath width of approximately 5 meters applies seed faster than by hand. Favorable comments on this seeder have been received. Application rates to over 100 kg/ha of dry seed can be dispensed. The canvas hopper capacity is 8 kg of dry rice. Five additional units have

been built to expand the testing program in the coming season. If this seeder is produced in Thailand, the estimated price to the farmer should be approximately US$13 (฿300). This may well become a popular tool for replacing hand broadcasting for establishing upland rice.

5. Upland Hand Weeder. A blade type hand weeder for use in mechanically seeded upland rice and other crops has been designed and built. A gage wheel controls the horizontal blade depth which cuts grass and weeds just below the soil surface. One pass on either side of each row should suffice. Long strokes are obtainable which is much more productive than hoeing or hand weeding. It shows promise for reducing the time and labor required for weeding upland rice and other crops. Nine weeders have been built for test programs.

6. Reaper. Manual rice harvesting requires a large amount of labor which results in a short supply. Wages higher than the minimum wage by 50% or more are paid in many areas. This has developed an unusual amount of interest in mechanical harvesters or reapers, particularly a cutter bar type that has been developed in the People's Republic of China.

A Thai importer advises that in 1980 he has brought in 2,000 machines from China to 1, September, and by the end of the year he estimates a total of 5,000 machines. Another firm has had over 400 of the reapers produced in Thailand. This indicates the rice producers are accepting the mechanical reaper because of the high cost of harvest labor. The reaper only would sell for $500 but all sales to date are in combination with a power tiller for a price of $2,100.

One machine with a cutting width of 1.6 m has a capacity to .5 ha/hr or 4 ha/day. Since one person can hand harvest 1/8 ha/day, one machine would do the work of 32 people. However, since the windrow requires manual bundling and tying, it is estimated that one machine will perhaps replace 24 people. One individual has expressed grave concern over the effect of this machine on unemployment of landless laborers during the harvest season. However, it will take several years before the majority of the crop is mechanically harvested. The best alternative for Thailand and other countries is to produce the machines locally, to provide jobs and to improve the balance of payments. Farm mechanization must be reasonably compatable with industrialization and the creation of new jobs in urban areas. Thailand's industrial capability is continually expanding. It is believed that the introduction and acceptance of the reaper will be beneficial to the rice farmers and to the Kingdom.

IRRI adopted the Chinese cutterbar reaper design 1 1/2 years ago and undertook an improvement program. A prototype was received in Bangkok from Los Banos in late June. It has been mounted on a power tiller with steering clutches and is being tested. The cutterbar height is adjustable from 14 to 60 cm. Taller crops should be cut with a longer stubble so as not to increase the straw-grain ratio and reduce the capacity of the threshing operation, if by machine or by animal or tractor treading. The cut paddy is transferred to the side of the machine and deposited in a loose windrow.

The 1.6 m machine weighs 85 kg. A smaller reaper 1.0 m wide will also be available. It is anticipated that most of these machines will be purchased by custom or hire operators who will prefer the larger size.

The reaper is adaptable for use in upland or paddy fields in standing or lodged crops. Shatter losses with the machine are less than 1%, which is lower than for manual harvesting.

7. Rice Thresher. The IRRI design axial flow thresher is used extensively in many areas of the Central region. However, traditional methods are employed in Thailand much more than mechanical threshers. Therefore increased production of axial flow thresher is expected to continue.

Percent of Rice Crop Threshed by :

Manual beating	63
Mechanical threshing	22
Tractor treading	7
Foot treading	5
Animal treading	3

A low cost portable thresher with 1/2 ton/hr capacity is available. It has not been well accepted to date in Thailand because most of the threshers are custom operated and higher capacities are preferred. However, some manufacturers are predicting a future trend to smaller machines as custom hiring declines in favor of individual farmer owners. An IRRI design axial flow thresher with a cylinder length of 4 ft and 2 tons/hr capacity is the most popular size. Some machines with three and four tons/hr capacity are being produced.

A new model TH-8 with four foot cylinder has advanced features. Fins on the peg-tooth cylinder pull air in at the feed opening, to provide a cleaner place of work for the operator. The concave rods can be replaced after excessive wear occurs. Improved cleaning of the paddy is incorporated. Production of this model by two manufacturers has begun. With modification, it has performed successfully in sorghum and trials are under way with soybeans. The machine is also adaptable to wheat. A program to raise rainfed wheat after the upland rice harvest has been started by International Maize and Wheat Improvement Center (CIMMYT). The multi-purpose machine should be popular in upland areas where rice and other crops are grown.

Future Role of Farm Machinery for Upland Rice

Mechanization is expected to be utilized more and more in the production of approximately 400,000 ha of upland rice in Thailand. Harvested yield increases can be obtained by a timeliness advantage, better tillage and planting equipment, utilization of improved cultural practices, and reduction of field losses with machinery as compared to traditional methods. Total production can also be increased by mechanized double cropping. Very likely many of the machines that have been discussed will be adopted in the production of upland rice. Further improvements in equipment concepts will evolve because farm mechanization is a never ending evolutionary process.

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