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AGRICULTURAL MACHINERY RESEARCH AND DEVELOPMENT PROGRAM AT THE INTERNATIONAL RICE RESEARCH INSTITUTE

BY

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The International Rice Research Institute was jointly established by The Rockefeller Foundation and The Ford Foundation in cooperation with the Government of the Philippines as a world center for the study and improvement of rice. The Institute is located adjacent to the College of Agriculture, University of the Philippines at Los Baños, Laguna, 40 miles southeast of Manila. The Agricultural Engineering Department at the Institute has been engaged in rice mechanization research for a number of years. The research results are regularly published in the IRRI Annual Report.

The importance of mechanizing the cultivation of paddy and other related crops in the developing countries prompted the U. S. Agency for International Development to support a research contract at IRRI. The activities under this contract are divided into two major groups:

1) Agricultural Machinery Research

2) Economics of Mechanization.

This paper will concern only with the Agricultural Machinery Research activities under the contract.

The services of the Agricultural Engineer (Design) under the IRRI-AID contract were acquired in August, 1967. A brief review of past machinery research activities indicated that to have any significant impact on mechanization, the incorporation of research results in commercially produced machines is imperative. To achieve such a goal, it was necessary to orient the research activities towards the manufacturers of agricultural machinery located within as well as outside the tropical rice producing countries.

The research objectives for the manufacturers located in the

located within the tropical rice producing countries. The design and development of agricultural machinery in the advanced countries is primarily an industry function. General mechanization research is conducted at the public institutions of agricultural engineering research. The manufacturers in the industrialized countries are engaged in their own program of machinery design and development. The contract activities should endeavor to enhance their interest in the problems of rice mechanization and should try to assist their programs on the design and development of special rice machines. Research on specific mechanization problems faced by these manufacturers could best perform this function.

On the other hand the manufacturers of agricultural machinery in the tropical rice producing countries do not have the resources to design and develop suitable machines for local manufacture. A complete machinery design and development service, patterned somewhat along the product development activities in the advanced countries, could provide suitable designs for local manufacture. This will not only provide a much needed service but may help to generate new local industries.

It was subsequently decided to concentrate the contract research activities along the following lines:

(a) Conduct machinery research to assist the design and development of sophisticated rice machinery in the industrially advanced countries. The emphasis to be placed on specific problems of rice mechanization and not the design and development of new machines for commercial production.

(b) Design, test and develop special machines for manufacture

within the tropical rice producing countries. Such activities should envisage the complete development of a machine from the basic concept to the final design for manufacture. It may include the test and evaluation of the initial trial production machines prior to regular production. The commercial introduction of an agricultural machine is an essential link in the mechanization process and needs appropriate emphasis in this part of the program. Technical assistance to local manufacturers in initiating the manufacturing plans could be considered as part of the contract function to ensure proper market introduction.

Along these broad guidelines three research and two design projects were initiated in September, 1967. Experimental and prototype machines for these projects have been built and are under test and further development. The five projects are as follows:

PROJECT NO. 1. Drum Type Power Thresher Design.

The design and development of a low cost power operated paddy thresher was undertaken to meet the requirements of the small farmer and the custom operator in the tropical countries. The large McCormick type conventional threshers are too expensive and are no longer in production. The Japanese type threshers have not been well accepted in the tropical countries due to poor performance with wet crops, relatively complicated mechanisms, and poor service facilities. Consequently, in areas of high humidity, threshing of paddy is done immediately after harvest by manual or animal threshing methods. Custom threshing by power equipment is not practiced for small farmers because of lack of suitable equipment.

The use of Japanese style walking tractors has become increasingly popular for custom tillage in recent years. The custom operators can only make an effective use of their tractors for a relatively short period. A suitable low cost thresher, which could be towed and powered by a small tractor, would enable the custom operators to make an effective use of their equipment over a longer period. The machine needs to be designed for minimum set-up time since custom work may involve threshing at many different locations within a single day.

With the above objectives, the development of a drum type trailer-mounted paddy thresher was undertaken. Figure 1 shows the schematic drawing of the thresher which is under further development in the Department. The first prototype (Figure 2) was successfully tested during the later part of the year. A second prototype utilizing the same basic concept but incorporating many functional and manufacturing refinements has been built and is under further development. The design incorporates a maximum use of locally available components and has been kept as simple as possible for ease of manufacture, operation and service. Extensive field trials of the second prototype are planned for the next harvest season. Development work will be continued until the design is ready for release to local manufacturers.

This thresher utilizes a Japanese style wire loop type threshing drum. This type of drum has been widely used and has proved itself as an effective threshing device with low power requirements. The design departs considerably from existing practices for conveying, separating, and cleaning of the threshed materials.

The 6-foot long hollow threshing drum is mounted within a sheet metal trough. Rubber flaps mounted spirally on the drum sweep the trough

bottom to deliver the threshed materials to the rear end mounted rotary screen separator. An axially mounted fan blows an air stream through the hollow threshing drum and the rotary screen separator. The air blows the light straw leaves and chaff to the rear of the machine and the grains fall through the rotating screen. The tumbling action results in a more aggressive sieve separation under wet crop conditions. Four men can simultaneously feed bundles of paddy for non-stop threshing. The machine can be powered by either an independent 4-HP aircooled engine or the small tractor engines used for towing the thresher.

PROJECT NO. 2. Table Type Power Thresher, Design.

There is a need for simple portable power operated paddy thresher which could be manually carried into the fields. In many countries, paddy fields have no access roads and a trailer type thresher cannot be taken into the field for threshing. Moving of paddy to another location for threshing requires considerable manual labor. With these requirements in mind, a design project was initiated to develop a light thresher capable of being carried by four persons.

The wire loop method of threshing provides excellent threshing under wet crop condition. The arrangement of loops around the periphery of a conventional drum, however, restricts the effective threshing area to approximately a quarter of the total drum surface. To provide a maximum threshing area with minimum weight, a flat circular rotating table type surface with wire loops can be more effective. Such a thresher will also permit a compact, multiple operator feeding arrangement around the periphery of the circular threshing surface. Figure 3 shows a schematic drawing of this type of thresher which is currently under development.

and tested. The machine uses a 4-foot diameter threshing surface with a wire loop mounted at 45° angle from vertical in a self-cleaning spiral arrangement. A wire fence around the periphery of the threshing table provides the initial mechanical separation of the straw and the grain. The underside of the threshing table has a large radial fan and air deflector to help blow the chaff from the grain. The grain collects at the bottom where it is swept and delivered at one end by rubber flaps. The chaff and straw are carried by the air to the top and delivered at one side of the machine. The machine utilizes partly mechanical and partly pneumatic means for straw-grain separation. The machine weighs 160 kg complete with a 4-HP aircooled engine and can be conveniently carried in the field by four persons. No major problem has been encountered with the threshing operation, however, more work is needed on the separating mechanism. Further development is in progress.

PROJECT NO. 3. Tractor Tillage and Mobility Under Soft Wetland Conditions.

Development of adequate traction, as achieved on dry land, is difficult under submerged wetland conditions, hence, mobility and bogging of large tractors is a serious problem. Non-traction dependant tillage devices such as rotary tillers have shown considerable promise under these difficult field conditions.

The Department has in the past worked on the development of lightweight wide rotary tillers for use with 40- to 50-HP tractors. Figure 5a shows a schematic drawing of such a tiller. A conventional rotary tiller provides a pushing reaction on the tractor of approximately 50 lb per foot of tiller width under wetland conditions. This work has indicated that

conventional rotary tillers provide more than adequate degree of tillage under wetland conditions but inadequate pushing reaction to the tractor. Conventional rotary tiller blades are designed for tillage and do not significantly contribute in supporting the tractor-tiller weight during operation. Two major problems encountered in the use of conventional rotary tillers on wetland are:

(a) Inadequate tractor mobility and increased tractor bogging

(b) Excessive ground contact pressures under the tractor rear wheels result in deep wheel tracks and uneven field surface.

A project was initiated to find means of improving tractor mobility by increasing the forward tiller reaction and reducing ground contact pressures by supporting part of the tractor-tiller weight on the tiller.

Figure 6 shows the difference in soil reaction on a conventional tiller rotor and an experimental push-type tiller rotor. The horizontal component of the soil reaction is greater with a larger diameter tiller rotor for the same depth of tillage. Figure 5b shows the schematic drawing of an experimental push-type wetland rotary tiller with an alternate cutting and supporting blade arrangement for increased ground support and forward push. The experimental tiller is designed to be used with special tractor cage wheels which would have a similar blade arrangement for tillage and support.

Field tests with walking rotary tillers indicate reduced tractor bogging at lower tiller blade speeds. Little is known about the effect of blade speed on forward tiller reaction. It is believed that low blade velocities result in reduced energy transfer to the soil and an increased soil reaction on the balde. The blade velocity could perhaps be used to

vary the forward tiller reaction and obtain a desired degree of tillage or mobility under soft wetland conditions. Maximum mobility may be achieved at low tiller blade velocities whereas maximum tillage at high tiller blade velocities.

An experimental PTO-driven 40 inch diameter push-type wetland rotary tiller (Figure 7) using alternate cutting and supporting blades was designed and built to study the performance under wetland conditions. Special tractor cage wheels for use with this tiller are under construction. The experimental tiller is driven through a mechanical step transmission which provides peripheral blade velocities of 500 to 900 feet per minute. Conventional rotary tiller blade peripheral velocities vary from 900 to 1500 feet per minute. A hydraulic stepless variable tiller drive arrangement is being investigated to permit stepless speed changes during field operations. The experimental machine will be tested in the near future.

PROJECT NO. 4: Use of Mechanical Power for Rotary Weeding.

Control of weeds is a problem in rice production and has a significant effect on rice yields. A joint UPCA-IRRI experiment had shown that weeds reduce rice yields by as much as 36%. IRRI's available data show that an average 120 hours are required to hand-weed one hectare. A push-type rotary hand weeder reduces this labor requirement to 70 hours per hectare. High costs and application problems limit the use of herbicide for weed control in many areas.

Planting of rice in rows has made it possible to use rotary hand weeder and reduce the labor requirement. However, the push-type manual rotary weeder has to be pushed two to three times to obtain satisfactory weeding performance. It is desirable to multiply the human effort by the

use of mechanical power.

Small tractors are adequately replacing humand and animal labor for plowing, harrowing, and puddling operations but are unable to function satisfactorily for weeding because of the extremely soft field conditions. The turning of weeds under the soil is generally done at a very shallow depth by manual rotary weeders. A mechanically powered machine, which is ground-supported for locomotion, tends to sink deeper than the desired weeding depth and also requires uncultivated headland area for turning at the end of the rows.

It was felt that the problem could be solved by using the operator to support the weight of the machine to provide the desired mobility and turning capability. Many Japanese manufacturers have developed small light-weight portable engine-driven saws mounted on the operator.

It was decided to study a similar possibility for the application of power to weeding. Improved mounting and better balance of machine would have to be achieved for a multi-row weeder as it would be heavier than the portable saws. The weeding head design should provide adequate flotation to avoid bogging in soft areas. It should have enough slicing and cutting action to scrape the top soil for a thorough mixing and burying of weeds in the mud. A multi-row weeding rotor should provide adequate clearance for the rice plants to pass under the axle without damage to the plants. Handling characteristics and operator comfort during weeding and turning at the end of the rows need to be studied.

A three-row prototype power weeder (Figure 8), using a light Japanese portable power saw engine, was designed to study this possibility. The machine weighs 24 kg. Many different shapes of blades have been tried to achieve proper weeding performance. Tests have shown satisfactory weeding performance, however, the load distribution and mounting arrangement on the operator needs to be improved. Work is underway on finding better

ways to mount the mechanical weeder on the operator. Further experimental and test work is underway to evaluate and improve mechanical weeding.

PROJECT NO. 5. Anhydrous Ammonia Applicator for Power Tillers.

A knapsack type single row anhydrous ammonia applicator was designed by the IRRI Agricultural Engineering Department in 1965. This applicator has been used in experimental work by the Agronomy Department. Results indicate that anhydrous ammonia (82% N) is a promising fertilizer materiel for flooded rice fields. A single row manually operated machine is however not suitable for practical field application of anhydrous ammonia by the farmers.

Small power tillers are getting increasingly popular in many rice growing areas. A project to develop a power tiller mounted anhydrous ammonia applicator attachment has been initiated to permit economical field application by farmers. The applicator attachment consists of a front mounted ammonia tank and a rear mounted 6-tine comb harrow type applicator assembly with the control and regulator valve assemblies. The equipment is designed for easy attachment and removal to a 6-HP walking tractor. Field tests and development is underway and will be continued until satisfactory results are obtained and proper functional parameters are met. Economic study on the feasibility of such a machine will be subsequently conducted.

General Activities

Efforts in increasing manufacturers' interest in rice mechanization will be continued during 1968. The designs of machines developed under this contract will be distributed to interested manufacturers.

Senior staff members plan to read papers and take active parts in various international professional meetings. Results from the research activities will be published in major professional journals to provide wider dissemination of research results.

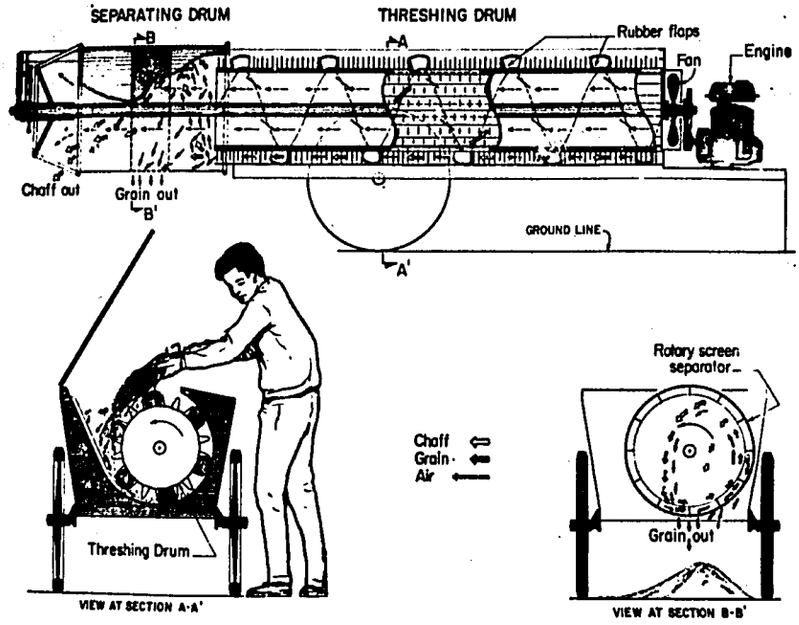

FIG. 1. Schematic drawing of drum type power thresher.

FIG. 2. First prototype drum type power thresher.

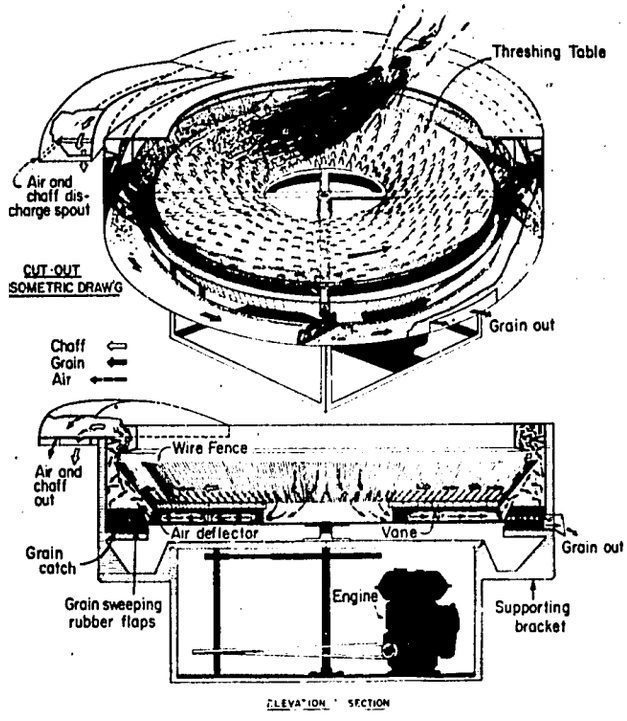

FIG. 3. Schematic drawing of table type thresher.

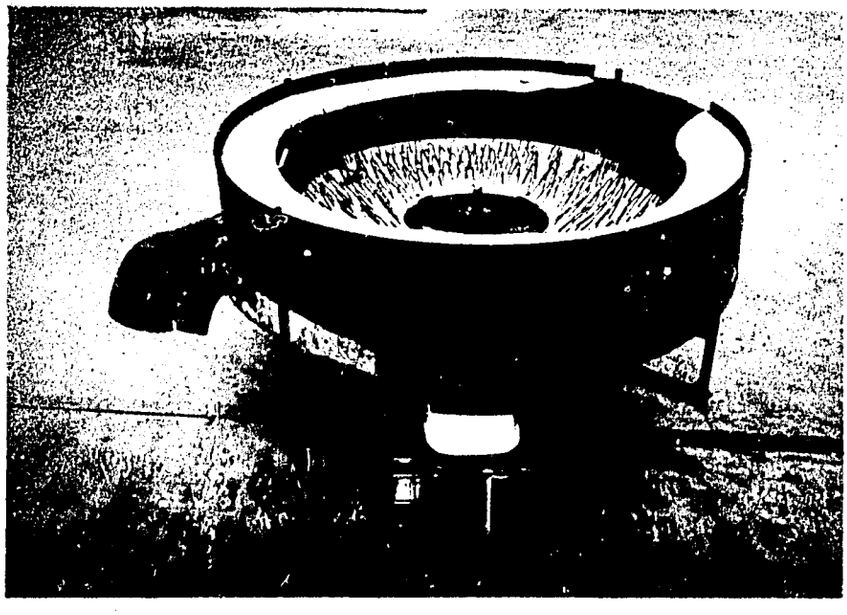

FIG. 4. Prototype table type thresher.

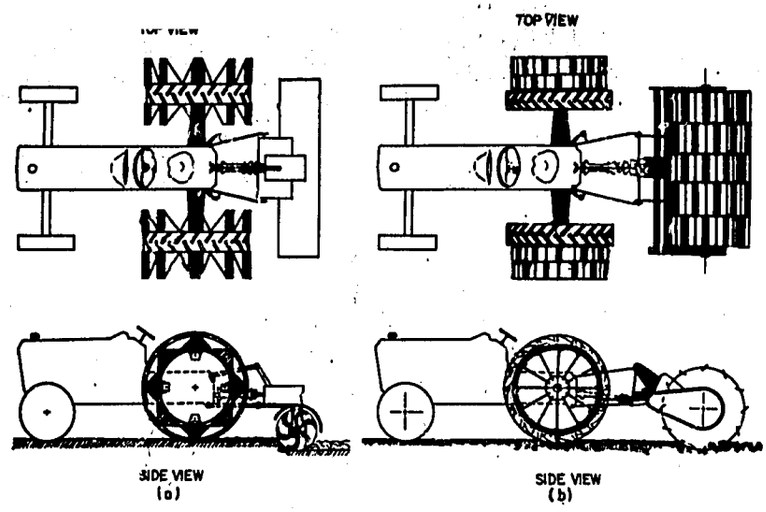

FIG. 5. Schematic drawing of a conventional (a) and an experimental (b) push type wetland rotary tiller.

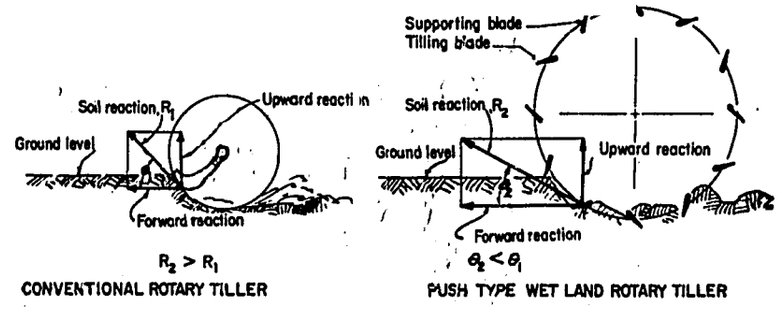

FIG. 6. Schematic drawing showing effect of tiller diameter and blade arrangement on forward reaction.

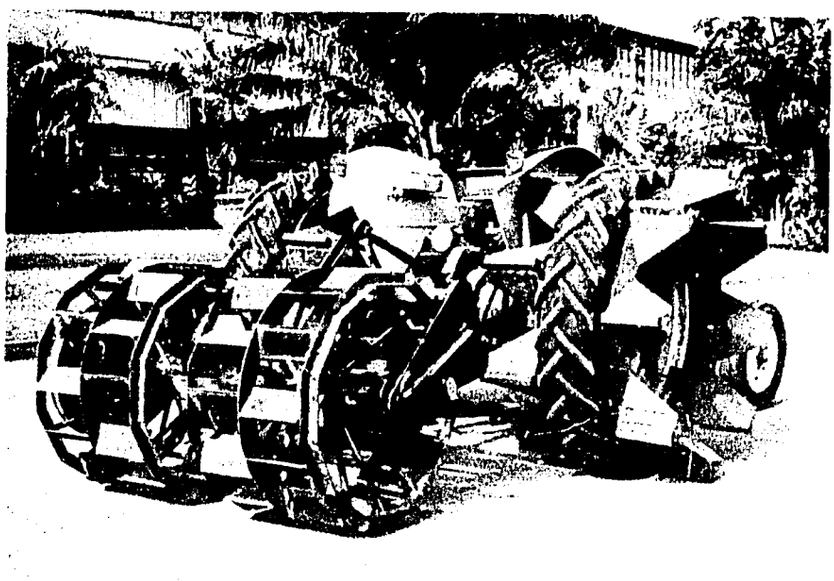

FIG. 7. Experimental push type wetland rotary tiller.

FIG. 8. Experimental power weeder.