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MECHANIZATION TECHNOLOGY FOR SMALL TROPICAL FARMS

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The authors believe that the mechanization of tropical agriculture can be achieved only through a concurrent growth of the farm equipment industry in the region. The general lack of efforts on the development of appropriate agricultural machines for indigenous production is a serious bottleneck in the establishment of a viable farm equipment industry in the region. IRRI's agricultural engineering program is therefore sharply focused towards providing suitable agricultural equipment which meet two important criteria. One, the machine must meet the functional requirements of a substantial segment of the tropical farmers to ensure a sizable market. Two, machines must be suitable for local manufacture with the available manufacturing technology in the region.

Most Asian countries have small manufacturing establishments and machine shops which are equipped with standard machine tools and other metal fabrication equipment. The machines being developed at IRRI, therefore, are designed for manufacture by the available low-volume, labor-intensive production methods in the region. Some of the department's field machinery development projects are described briefly.

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MECHANIZATION TECHNOLOGY FOR SMALL TROPICAL FARMS

by

A. U. Khan and J. S. Policarpio[1/]

The IRRI Agricultural Engineering Department is primarily engaged in the development of an appropriate mechanization technology for tropical agriculture. The department's program has been patterned somewhat along the lines of the R&D activities followed by larger farm equipment manufacturers in the industrially advanced countries. The non-academic approach to agricultural engineering research is based on the hypothesis that widespread mechanization of tropical agriculture can be possible only with the establishment of an indigenous farm equipment industry in the region.

In the industrialized countries of the temperate region, farm equipment industry in the private sector has played a rather significant role in the mechanization of agriculture. The public agricultural engineering research institutions have contributed generally to the broadening of the knowledge of mechanization. The farm equipment industry in these countries have been able to successfully bridge the gap between research and its application at the farm level. This has been possible through the manufacture and marketing of agricultural machines which have been developed specifically to meet the overall set of farming conditions in their communities.

There is a widespread belief that the problems of tropical agricultural mechanization are primarily of a socio-economic nature since mechanization technology is already available from the temperate regions. The result of this oversimplified assumption has been that for over two decades, most efforts to mechanize tropical agriculture has been channeled primarily towards the introduction and utilization of agricultural machines from the temperate regions. The development of

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an appropriate mechanization technology, that could be compatible with the overall set of agro-climatic and socio-economic conditions of the tropical region, has so far received very little attention.

In the developing countries, the farm equipment industry does not have the resources for the development of an appropriate technology. For understandable reasons, manufacturers from the industrially advanced countries have not found it attractive to develop suitable equipment for tropical agriculture. Public funds for mechanization research in the developing countries have been principally used to collect information or conduct research of a theoretical nature. The development of suitable equipment for tropical agriculture has therefore been grossly neglected.

We believe that the mechanization of tropical agriculture can be achieved only through a concurrent growth of the farm equipment industry in the region. The general lack of efforts, on the development of appropriate agricultural machines for indigenous production is a serious bottleneck in the establishment of a viable farm equipment industry in the region. IRRI's agricultural engineering program is therefore sharply focused towards providing suitable agricultural equipment which meet two important criteria. One, the machine must meet the functional requirements of a substantial segment of the tropical farmers to ensure a sizeable market. Two, machines must be suitable for local manufacture with the available manufacturing technology in the region.

In Asia, medium-sized landholdings of from 2 to 10 hectares constitute the largest proportion of total land under paddy cultivation.[2/] As a group, farmers in this size category have the potential to support an intermediate level of mechanization. The Institute's program of machinery development is specifically focused on the requirements of the medium-sized tropical farm holdings which are too large to work economically with traditional equipment but are too small to acquire the sophisticated high-cost equipment imported from the temperate regions.

Most Asian countries have small manufacturing establishments and machine shops which are equipped with standard machine tools and other metal fabrication equipment. The machines being developed at IRRI, therefore, are designed for manufacture by the available low-

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[2/] Asian Productivity Organization. Proceedings of an Expert Group Meeting on Agricultural Mechanization, December 12-18, 1967, Tokyo.

volume, labor-intensive production methods in the region. Some of the department's field machinery development projects are described briefly as follows.

Power Tiller

In the developing countries the prohibitive cost of imported power tillers is a limiting factor in the mechanization of agriculture. A simple, lightweight power tiller (fig. 1) was developed which utilizes many readily available components and can be produced by simple production methods. The single-axle tractor has an enclosed oil bath chain transmission with standard sprockets and roller chains. The chain transmission is simple to fabricate and does not require precision alignment. The transmission cover is designed for easy fabrication by manual methods. Except for the engine, most components can be fabricated in small machine shops. A 5 hp aircooled engine is used to power the tiller. Two firms have started the manufacture of this tiller in the Philippines. The locally produced power tiller is marketed at less than half the price of comparable imported power tillers in the Philippines.

Row Seeders for Pregerminated Paddy

Manual transplanting of paddy is a high-labor consuming operation. Row seeding of pregerminated paddy on puddled soil car save labor and permit the use of row-crop equipment such as rotary weeders, binders, and combine harvesters. Two types of row seeders for sowing pregerminated paddy on puddled soils have been developed. In one machine (fig. 2), a single hopper has a ground-driven fluted roller and a brush cut-off mechanism which gently meters pregerminated paddy into the seed tubes. The second machine (fig. 3) has six independent hoppers with metering rollers. Both machines are equipped with a single wheel for transport on field levees and turning at the end of seeded rows. Five man-hours per hectare are required for seeding with these machines as compared to 120 man-hr/ha for manual transplanting. These seeders are manufactured by two firms in the Philippines.

Rotary Power Weeder

Ground-supported power weeders have not been successful for paddy cultivation because these machines need open headlands for turning at the end of the rows. A portable three-row power-driven weeder was developed for small paddy fields. A lightweight 1 hp engine powers the weeding rotor through a worm gear reduction box. Sheetmetal shields protect the rice plant from the rotor. Seventeen man-hours are required to weed 1 hectare as compared with 70 man-hr/ha for

manual rotary weeding, and 120 man-hr/ha for handweeding. A firm in Japan is now mass-producing this machine (fig. 4) and has developed a series of attachments which permit its use for quite a few other agricultural operations in soft paddy fields.

Table Thresher

In many areas, paddy fields have no access roads and harvested paddy must be manually transported to the threshing locations. This requires considerable labor and results in high scatter loss. A portable thresher (fig. 5) was developed which could be carried by four persons. The use of a flat circular threshing table permits simultaneous feeding of paddy by four persons. This makes a more effective use of the threshing surface as compared to conventional cylindrical threshing drums. Threshing spikes were mounted in a spiral self-cleaning arrangement on the circular threshing surface. A flat rotating screen around the threshing surface separates the threshed grain from the chaff. A radial fan under the threshing surface provides air for winnowing the grain falling through the screen. The machine can thresh both dry and freshly harvested wet paddy crop with an output of about 350 kg of paddy per hour. The thresher is being manufactured in the Philippines and a number of these threshers have been shipped to other Asian countries for evaluation.

PTO-Driven Thresher

A three point linkage-mounted multicrop thresher for 30-60 hp tractors is being developed to meet the demand for a high-output, mobile thresher for custom operations. The PTO thresher (fig. 6) uses a spike tooth cylinder with adjustable baffles in the cylinder housing to axially move the threshed material. The baffles can be adjusted to suit different crops and moisture conditions. The machine has a three-screen rotary separating and cleaning system which is lighter than the straw walkers and oscillating screens used with conventional threshers. A final production prototype unit incorporating many design improvements is now being fabricated.

Axial-Flow Multicrop Thresher

The need for a lightweight thresher with low power requirement and high output per man-hour prompted the development of a single-drum axial-flow, throw-in type thresher (fig. 7). Performance tests at IRRI indicate that the throw-in method of feeding requires less labor than the hold-on method. The single-drum, axial-flow design results in a simpler power train design and permits easy fabrication. The threshing cylinder is installed in a full-length, oval-shaped concave.

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The concave is built in two parts, one upper and one lower, and is made of standard 3/8-in. perforated sheetmetal. The threshing cylinder is installed in an offset position along the major axis of the oval concave. This provides a 7.62-cm (3 in.) space between the threshing cylinder and the concave on the top end of the cylinder. Spiral louvers are installed in this 7.62-cm (3 in.) space which move the threshed material in an axial direction when it is thrown against the louvers by the threshing cylinder. A blower winnows the light impurities from the grain as it falls under the concave. A 22.86-cm (9 in.) rotary screen separator removes any heavier impurities which cannot be removed by the air. A threshing output of 660 kg/hr with 1 percent combined separating and threshing loss and a cleaning quality of 95 to 98 percent has been obtained with the machine. The machine is powered with a 6 hp engine. The final production prototype unit has just been completed and is being evaluated.

Stripper Harvester

Conventional rice combines are heavy and bulky because the plants are cut and the straw is handled through the machine during harvesting. The handling of straw through the harvester consumes excess power. In the past many attempts have been made to develop stripper harvesters to thresh paddy from standing plants, but excessive loss of grain has been a major problem. A stripper harvester is currently under development (fig. 8) at the Institute. It is a self-propelled, four-row machine which is equipped with gathering bars to gently bend the plants into the machine prior to threshing. The plants are pressed by the gathering bars against an inclined threshing belt. The panicles continuously slide down along the threshing belt as the harvester moves forward. The backward deflection of the plants prior to threshing directs the threshed grain to the rear of the machine and facilitates grain collection. A 7.5 hp power tiller is used as the prime mover for this harvester. The field stripper can harvest all grains from tall and upright varieties under average dry season harvesting conditions. A half-track system is being added to the wheels to improve wet season mobility and simple plant-lifting mechanisms are being installed to guide the lodged plants into the machine.

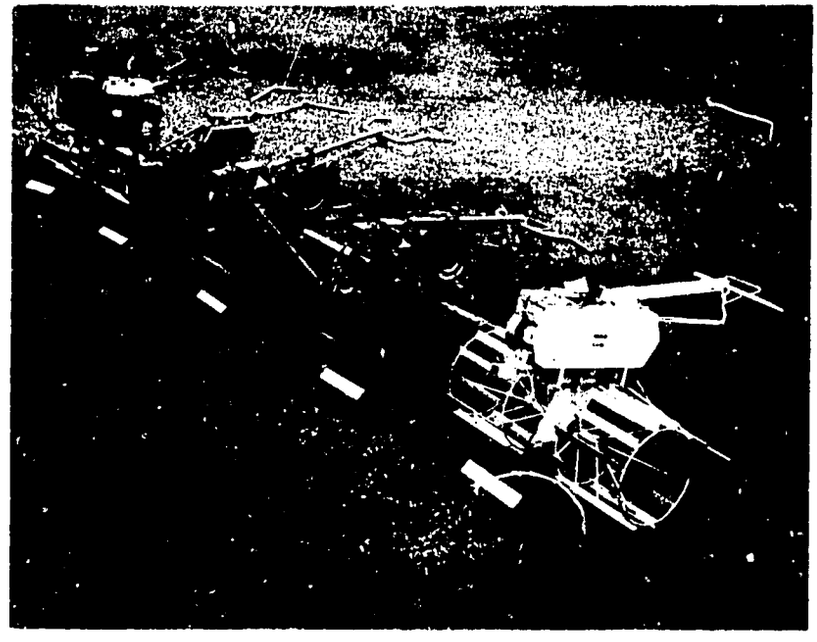
Rotary Power Grain Cleaner

Grain cleaners are used following threshing, before and after drying, and prior to milling and processing of paddy. The only equipment popularly used in tropical countries for grain cleaning are simple winnowers. Grain cleaners used in the advanced countries use oscillating screens in combination with high-velocity air. A simple rotary screen grain cleaner (fig. 9) has been developed. It uses two

concentric cylindrical screens which reduce mechanical drive problems and improve screening of high-moisture crops and large impurities. A blower provides air through the tumbling grain in the outer cylinder to remove lighter impurities. The machine is driven by a 3 hp air-cooled engine and has a cleaning capacity of up to 3.0 tons per hour. The cleaner is being manufactured in the Philippines and a few units have been sent to other countries for evaluation.

Low-Lift Bellows Pump

A low-lift, manually operated, portable pump (fig. 10) has been developed. The pump consists of two bellows mounted between two pivoted metal frames. The bellows alternately suck and exhaust water through a set of flap valves. The bellows are made of a combination of canvas and rubber-coated nylon fabric. Sheetmetal inserts are sandwiched between the two fabric layers at certain locations which require rigidity during the pumping operation. The operator stands on the two foot boards and shifts his weight from one foot to the other to operate the pump. The pump is 25 kg in weight and can deliver up to 194 liters of water per minute (51 gal/min) at 1-m (3.28 ft) head. It has been released to two manufacturers for production in the Philippines.



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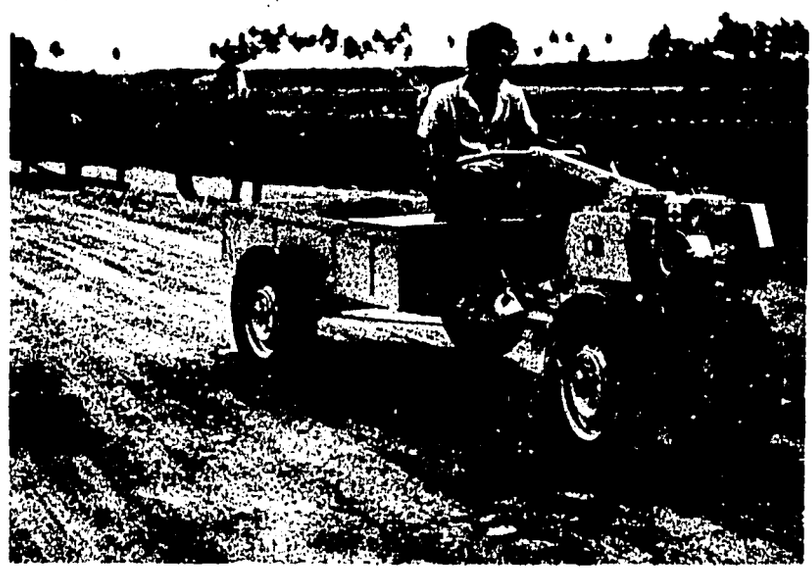

(b)

Fig. 1. IRRI designed 4-6 hp power tiller. (a) Different prototypes and commercial units. (b) Commercially produced power tiller with trailer attached.

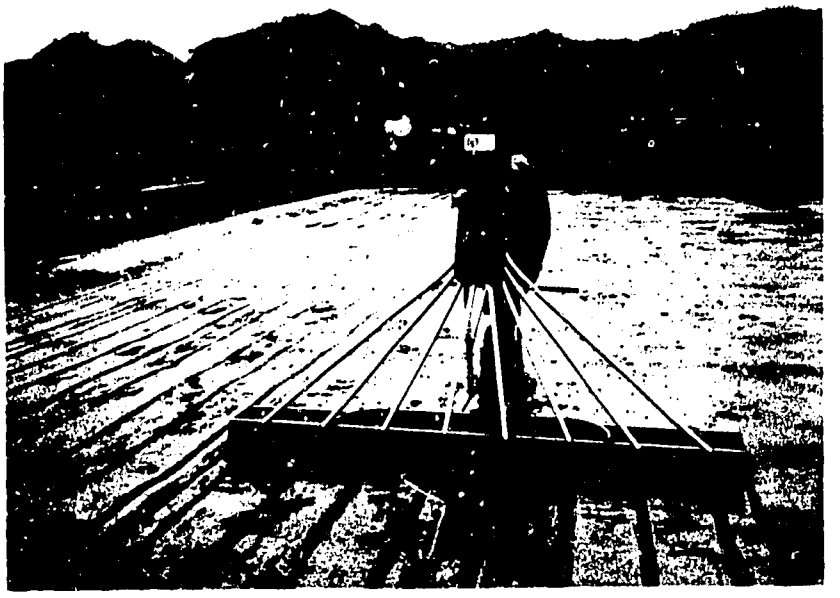

Fig. 2. Single-hopper row seeder for pre-germinated paddy.

Fig. 3. Multihopper six-row seeder for pre-germinated paddy.

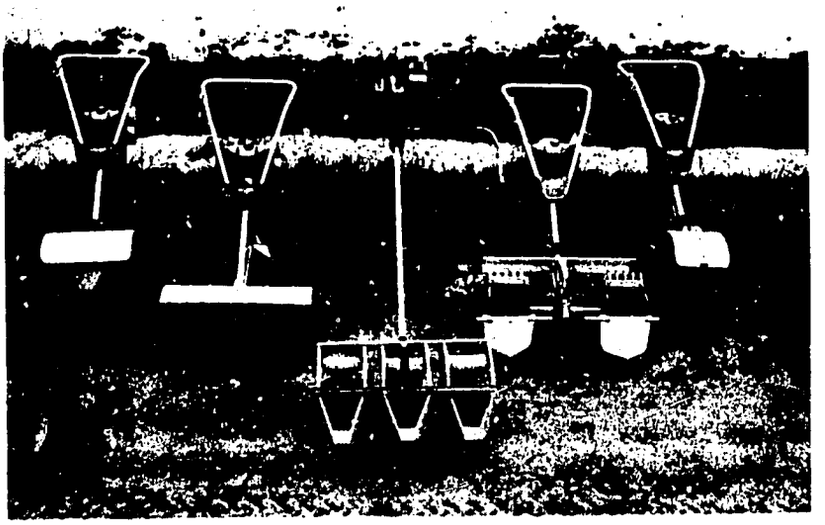

Fig. 4. IRRI prototype rotary power weeder and commercially produced Japanese versions.

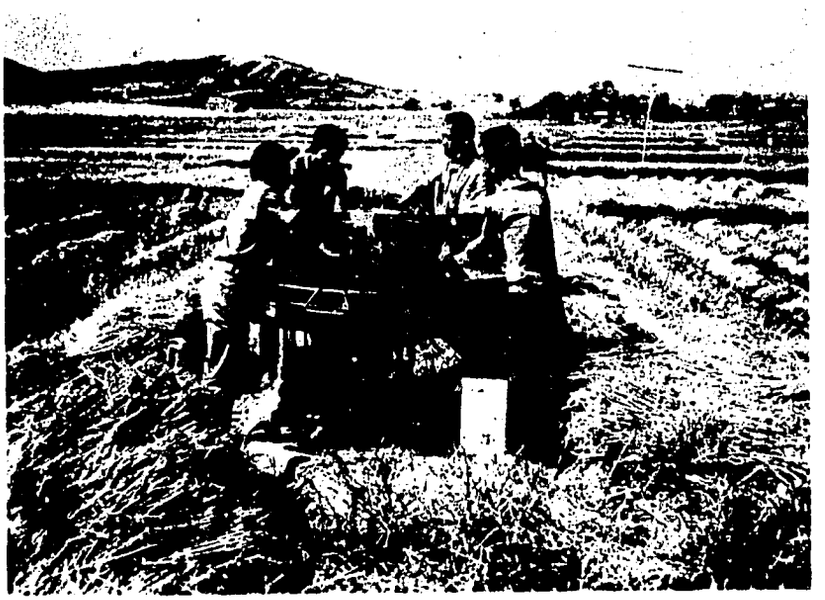

Fig. 5. IRRI paddy table thresher.

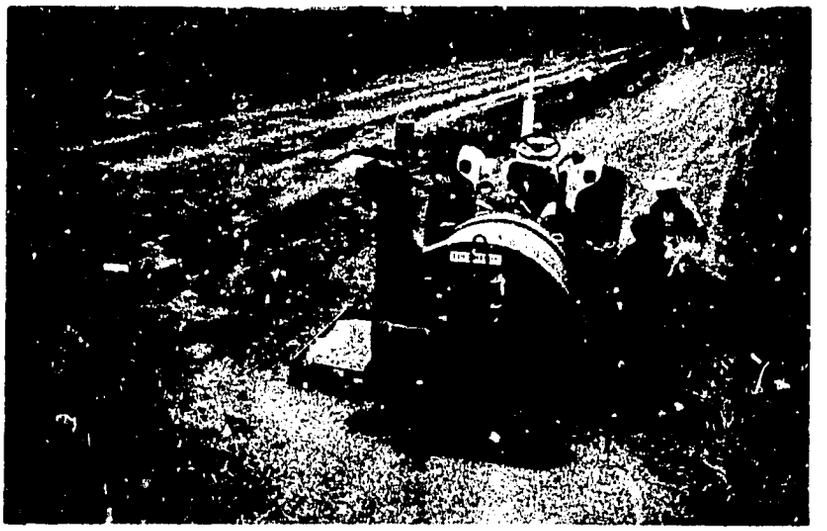

Fig. 6. Prototype PTO driven multicrop thresher.

Fig. 7. Prototype axial-flow multicrop thresher.

Fig. 8. Prototype IRRI paddy stripper-harvester.

Fig. 9. IRRI power grain cleaner.

Fig. 10. Prototype low-lift bellows pump.