AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
BATCH #14

1. SUBJECT CLASSIFICATION

A. PRIMARY: Agriculture — AN20-0000-GG50

B. SECONDARY: Farm equipment--Tropics

2. TITLE AND SUBTITLE
Selective research for mechanization of rice paddies

3. AUTHOR(S)
Khan,A.U.

4. DOCUMENT DATE: 1969

5. NUMBER OF PAGES: 16p.

6. ARC NUMBER
ARC RP631.3.K45

7. REFERENCE ORGANIZATION NAME AND ADDRESS
IRRI

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

10. CONTROL NUMBER
PN-RAA-735

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Farms,small
Product design
Rice
Tropics

13. PROJECT NUMBER

14. CONTRACT NUMBER
CSD-834 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

RP
6513
K45

Farmer & Equipment Business
Requirements for Rice
CSD-834
project File
Ag 6.2

SELECTIVE RESEARCH FOR MECHANIZATION OF RICE PADDIES

By

AMIR O. KHAN
Head, Agricultural Engineering Department
The International Rice Research Institute
and
roject Leader, AID/IRRI Research Contract No. csd-834

Los Baños, Laguna, Philippines

April 1969

ELECTIVE RESEARCH FOR MECHANIZATION OF RICE PADDIES

Amir U. Khan*

The introduction of high-yielding rice varieties has raised exciting possibilities for tropical farmers and the need for mechanical cultivation has acquired new significance. The shorter growing season of the improved varieties, coupled with their higher yields, provide incentive for multiple cropping. If the rice farmer is to keep the land in near-continuous production, power equipment suited for lowland conditions must be made available. Equipment is needed to enable the tropical Asian farmer to cope with the high labor-consuming operations of land preparation, transplanting, weeding, harvesting, and threshing. In addition, recent increases in rice yield have created problems of drying and processing which require engineering attention.

According to the International Rice Commission[1/] the countries of Southeast Asia and Far East Asia expend 5 to 7 hours of labor to provide 20.4 kg of rice, while in areas where rice production is highly mechanized, the labor requirement is in the range of only 5 to 7 minutes, a reduction by a factor of 60. Matsubayashi[2/] found that in Japan, the major labor-consuming operations are land preparation, 15%; transplanting, 15.3%; weeding, 15.4%, and harvesting and threshing, 33.5%, and that the labor required for the peak months is about 60 times that of the lowest monthly requirement. A recent study on farm labor requirements in Laguna Province and the Central Luzon area of the Philippines[3/] indicated that, on the average, 32%, 23%, and 27% of the total labor are required for land preparation, transplanting, and harvesting-threshing, respectively.

Lack of Suitable Equipment

The technical aspects of agricultural mechanization are often overshadowed by economic and social considerations. However, in spite of somewhat similar socio-economic conditions in the tropical countries, the mechanization of areas growing lowland paddy has been relatively slower than that of dryland cereal crops. A good example is seen in East and West Pakistan. While some progress has been made in the mechanization of the dryland crop areas of West

---

*Head, Agricultural Engineering Department, The International Rice Research Institute, Manila, Philippines, and Project Leader, AID/IRRI Research Contract No. csd-834.

1/International Rice Commission. Report of the First Meeting of the Working Party on Agricultural Engineering Aspects of Rice Production, Storage and Processing, Saigon, 10-15 November 1960. 44 pp.

2/Matsubayashi, M., R. Ito, I. Namoto, T. Takase, and N. Yamada. Theory and Practice of Growing Rice. Tokyo, 1956, Fuji Publishing Co. 502 pp.

3/Semi-Annual Substantive Report No. 5, Contract No. AID/csd-834, July - December 31, 1967. The International Rice Research Institute, Manila.

Pakistan, lowland rice cultivation in East Pakistan is almost completely non-mechanized. This disparity is, to some extent, due to the greater shortage of suitable agricultural equipment for lowland rice cultivation.

The equipment developed in the temperate countries for dryland cultivation is often not suited for lowland cultivation in the tropics. Some of the equipment developed for lowland work in Italy, California, and the Southern United States are also not suited to the scale of farming generally found in the tropics. The Japanese farm machinery manufacturers lead in the development of equipment for small-scale lowland rice cultivation. However, due to the demands of the Japanese home market, such equipment are increasingly becoming too sophisticated for the tropical farmers. The Japanese equipment also encounter problems with the heavy deep clay soils and other conditions in the tropics. It is essential, therefore, that a major research effort be directed toward the development of suitable agricultural equipment to mechanize lowland rice cultivation in the developing countries.

In Asia the 5 to 25-acre landholdings constitute a major portion of the total arable land and support a large segment of the rural households. This large group of holdings has sufficient means to support agricultural mechanization at an intermediate level. It is ironic, however, that this group has the least access to suitable farm equipment.

The development of simple power-operated equipment for the 5 to 25-acre holdings offers the greatest potential for mechanization and is a great challenge to the equipment development engineers. This is particularly so because development research in the advanced countries is concerned mostly with sophisticated equipment for larger farm holdings. The development of relatively labor-intensive agricultural equipment for an intermediate level of mechanization also will not create rural labor surpluses and unemployment problems as predicted by some authorities.

Current Research Level

A review of agricultural machinery research in the developing countries brings to light some interesting facts. Many developing countries have established agricultural engineering research centers in their universities and departments of agriculture. These centers are often well-equipped and are staffed by highly qualified engineers. A few such centers have been functioning for periods of 15 to 20 years. It is unfortunate, however, that, generally, the research efforts of these centers have not resulted in any significant impact on the mechanization of agriculture in farmers' fields. It is also interesting to note that the existing locally developed agricultural equipment which are popular are generally the result of work done by technicians, farmers, and small manufacturers.

There are many publicly owned research centers in the developing countries engaged in the improvement of manual and animal-drawn implements. Relatively less attention is being directed to the development of suitable small and medium-sized power-operated equipment. Due to the limitations of available power per man or per animal, only marginal improvements in output can be

expected from such improved equipment. The extension of marginally improved equipment in the field is a very difficult problem.

The research on power-operated agricultural equipment at a few centers is generally limited to equipment surveys and test, evaluation and theoretical function analysis type of studies. Such types of research cannot contribute significantly to the mechanization of agriculture in the tropical countries. The effectiveness of agricultural machinery research in the developing countries will depend on its impact on farmers' fields rather than on an increase in knowledge about mechanization. There is an urgent need for an assessment of machinery research objectives and the formation of fresh guidelines for the agricultural engineering research establishments in the developing countries.

Research Orientation

Agricultural equipment research is such that the results cannot be extended directly to the farmers. This aspect of machinery research extension has not been fully recognized by the various public agricultural engineering research organizations in the developing countries. The extension of machinery research is accomplished mostly by incorporating the results into the designs of new agricultural machines which can be made available to the farmers through normal commercial channels. The development of new agricultural equipment for tropical conditions, therefore, assumes added significance as a tool for the extension of machinery research to the farmers.

Broadly speaking, agricultural machinery research is conducted with varying emphasis by many types of research organizations in the advanced countries. The educational institutions and the private and public research institutions emphasize basic and applied research. Whereas, the agricultural machinery manufacturing industry emphasizes machinery design and development. This is an effective national pattern for machinery research in which industry utilizes the results of research from other institutions to develop new agricultural machines. The machines in turn enable the farmer to apply in the fields the results of machinery research. There is no reason why this pattern of research cannot be adopted in the developing countries; however, this would require some adjustments.

The development of new machinery is expensive and can be economical only when the demand is substantial enough to warrant mass production. The struggling agricultural machinery industry in the developing countries has not yet reached the stage when it can support organized machinery development research. The research organizations in these countries will have to initially shoulder this responsibility which involves a shift from the conventional academic approach to research. In the long run, the manufacturers will be able to effectively handle the development, manufacture, and extension of new agricultural machines in the developing countries.

It is difficult to visualize a country which could mechanize its agriculture with mostly imported equipment. A study of some of the smaller but agriculturally mechanized countries would indicate that the major portion of their agricultural machinery requirements are produced locally. The shortage

of foreign exchange and the strong desire for industrial development are bound to encourage the local manufacture not only of the simple but also of some of the sophisticated agricultural machines. The long-range economic and social implications of displacing field labor by agricultural machines would also necessitate the design, development and manufacture of machines within the developing countries in order to provide alternative industrial employment. Indications are that the growth of the agricultural machinery manufacturing industry in the developing countries will proceed along with the mechanization of agriculture. Already the local production of tractors, a key farm equipment, has shown remarkable progress in a country like India where the number of tractors produced annually increased from 880 units in 1961 to 11,394 units in 1967 (Fig. 1). This growth also reflects the progress in the indigenous production of agricultural implements and other machinery in India. Another example of successful local manufacture is found in Taiwan where two companies are producing power tillers and implements with mostly indigenously produced components.

Lack of Communication

It is regrettable that there is a lack of dialogue between those who are conducting agricultural machinery research in the developing countries and the manufacturers who can utilize the results of such research. The design of an equipment to do a specific agricultural function is meaningless if it is not made available to the farmers through normal commercial channels. The research engineers from the public institutions will have to acquire skills in the development of new agricultural machines for commercial manufacture and sale. The manufacturers for their part will have to cooperate by supporting the development of agricultural machinery for commercial production at the public research institutions. A cooperative research program between the public institutions and the manufacturers would be more effective than the present independent approach to machinery research found in the developing countries.

Contract Research at IRRI

Since 1965 The International Rice Research Institute has been engaged in a project on "Farm and Equipment Power Requirements for the Production of Rice and Associated Food Crops in the Far East and South Asia" under AID/WOH Research Contract No. csd-834. In 1967, a recognition of some of the above mentioned aspects of machinery research resulted in the orientation of the activities under the contract toward the manufacturers of agricultural machinery. This led to two types of research activities:

1. Agricultural Machinery Development for manufacture within the tropical countries. This activity envisages the complete development of an agricultural machine from the basic concept to the final production model, and includes provisions for technical assistance in setting up manufacturing programs.

2. Applied Machinery Research to assist others in the development of agricultural machinery for rice cultivation in the industrialized countries. The emphasis is on the specific problems of mechanization and not on the development of a machine for commercial production.

Along these broad guidelines, a number of machinery development and applied research projects has been undertaken, some of which are described below.

Drum-Type Power Thresher

The development of a low-cost, power-operated paddy thresher was undertaken to meet the requirements of the small farmer and the small-scale custom thresher operator. In areas of high humidity, the threshing of freshly harvested paddy rice is done manually or by animals since available threshers cannot operate well under wet crop conditions.

The design of the drum-type thresher developed under the AID Research Contract has been released to manufacturers in the Philippines and the thresher is being commercially produced in the country. Figure 2 shows the schematic drawing of the thresher and Figure 3, a commercially produced machine in the Philippines. Figure 4 shows the drum thresher at various stages of production at G. A. Machineries, Inc., Bulacan, Philippines. A number of these threshers has been shipped to other Asian countries for performance tests and evaluation. Inquiries from manufacturers have been received from many countries and it is hoped that, upon the satisfactory completion of the performance tests, local manufacture in these countries would be initiated.

Table-Type Power Thresher

A light-weight thresher (Figs. 5 & 6) which could be lifted manually and brought to fields with no access roads was developed. A novel concept of a flat circular threshing surface which would permit threshing all around its periphery was used in the design. The fan is built integrally below the threshing surface and a 4-hp aircooled engine is used to power the thresher. The machine is compact and can be built in the developing countries at a fairly low cost. This thresher is undergoing tests in the Philippines and will soon be released to the manufacturers in the developing countries.

Rotary Power Weeder

Small tractors are being introduced for plowing, harrowing, and puddling. These tractors are unable to function properly for weeding because of the soft field conditions and the lack of headland for turning. The burying of weeds under the soil is generally done at a very shallow depth by manually operated rotary weeders. A ground-supported mechanically powered weeder would sink deeper than the desired weeding depth in the soft paddy fields. Also, an uncultivated land area is needed to enable the machine to turn at the end of the rows in small-sized rice paddies. An attempt was therefore made to develop a portable, light-weight, power-operated weeder which could provide maximum field coverage at shallow, practical weeding depths. A portable, light-weight machine can be lifted off the field for turning at the end of the rows without damaging the rice plants.

Figures 7 and 8 show the three- and the five-row power weeders which were developed to study the feasibility of this new design concept by using light-weight aircooled engines. The three-row machine weighs 19 kg and the

five-row machine, 24 kg. During operation, about one-half of the weight of the weeder is ground-supported. The weeding performance of the machine is comparable to that of manual rotary weeders. The three-row machine requires 17 man-hours/ha for weeding as compared to 70 man-hours/ha for the manual rotary weeder and 120 man-hours/ha for handweeding.

Manufacturers from the Philippines and Japan have shown interest in these machines. Information and drawings are being forwarded to the interested parties.

Tractor Tillage and Mobility Studies under Soft Wetland Conditions

Adequate traction is difficult to achieve under submerged wetland conditions, hence, bogging of tractors is a serious problem. Non-traction dependent tilling devices such as rotary tillers show considerable promise under these difficult conditions.

A conventional rotary tiller provides some push to the tractor during operation but the pushing reaction is not sufficient to improve the mobility of the tractor. The designs of conventional rotary tillers are based on dryland requirements where tillage is the primary objective. The conventional rotary tiller blades do not provide adequate ground support and the weight of the machine is supported by the tractor rear tires. This results in excessive ground contact pressures and deep wheel tracks which accentuate tractor bogging. The velocity of the tiller blade also affects the vertical and horizontal reaction from the ground on the tiller.

An experimental rotary tiller for soft wetland (Fig. 9) was built to study the effect of blade shape, blade angle, tiller diameter and blade velocity on vertical and horizontal ground reaction. The machine has shown improved performance and reduced tractor wheel slippage under extremely soft field conditions. Further tests are underway to establish the basic design information which would be useful in developing special rotary tillers for wetland areas.

Anhydrous Ammonia Application with Power Tillers

The recent popularity of small tractors and power tillers for tropical rice cultivation prompted the initiation of a study to evaluate the feasibility of using such tractors for applying anhydrous ammonia. Figure 10 shows the anhydrous ammonia applicator developed for a small walking tractor. The applicator was tested on puddled soil and no mechanical problems or loss of ammonia was encountered. The machine will undergo further trials during the forthcoming season.

Stripper-Harvester Combine

Efficient handling of paddy from the field to the storage has always intrigued engineers. The current practice of harvesting and then threshing creates difficulties for the tropical farmer and results in excessive grain loss. The use of conventional combine harvesters for paddy has not found widespread acceptance in the tropical areas. The conventional combine is too expensive for the small and medium-sized farms in the tropics and these machines often encounter serious mobility problems in the wet paddy fields.

A conventional combine consists of four major sections, namely, a cutterbar, an elevator mechanism, a threshing cylinder, and a grain-straw separating and winnowing section. A stripper combine, threshing directly from standing crop, could dispense with the cutterbar and the elevator mechanism of a conventional combine. Such a design will permit light-weight, low-cost machines which could be better suited for harvesting rice in the wet tropical countries.

The design of a stripper combine harvester which is offset mounted on a 6-hp walking tractor has been initiated (Fig. 11). The machine differs from other experimental stripper-harvester designs in that it bends the plants prior to the threshing action to improve the collection of threshed grain and to reduce the grain scattering losses. The first machine has been designed without a straw-grain separating mechanism (Fig. 12). Once the stripping mechanism is developed, a self-propelled stripper will be designed with a rotary straw-grain separator mechanism.

Tractor PTO-Driven Thresher

The introduction of combines in the advanced countries led to a decline in the use of threshers. In the developing countries, however, there is a need for suitable tractor PTO-operated threshers. The threshers originally designed in the early stages of agricultural mechanization were very bulky and cumbersome. There is a need to develop throw-in type of threshers which would be light enough to be mounted on the three-point linkage of standard 35 to 60-hp tractors. Such threshers could be conveniently moved from one location to another and used for custom threshing in many developing countries.

A light-weight thresher design was therefore initiated to meet this requirement. The design (Fig. 13) uses a spike-toothed drum which is so designed that the threshed material and straw are delivered out of the drum in an axial direction. The threshed material is then separated and winnowed in a rotary screen separator.

The machine is now under construction and will be tested in the near future.

Conclusion

The diffusion of research at the field level is a slow process in the developing countries. It may take several years of continued effort before a research result could be accepted in the field. A selective approach to agricultural machinery research, however, shows encouraging possibilities of reducing the time lag between research and field application. In a relatively short period of eighteen months, the drum thresher described earlier was designed and developed from a concept to a commercially produced machine. The expeditious introduction of agricultural mechanization necessitates a high priority on the development and manufacture of suitable agricultural machines not only for the wet land but also the dry land areas of the developing countries.

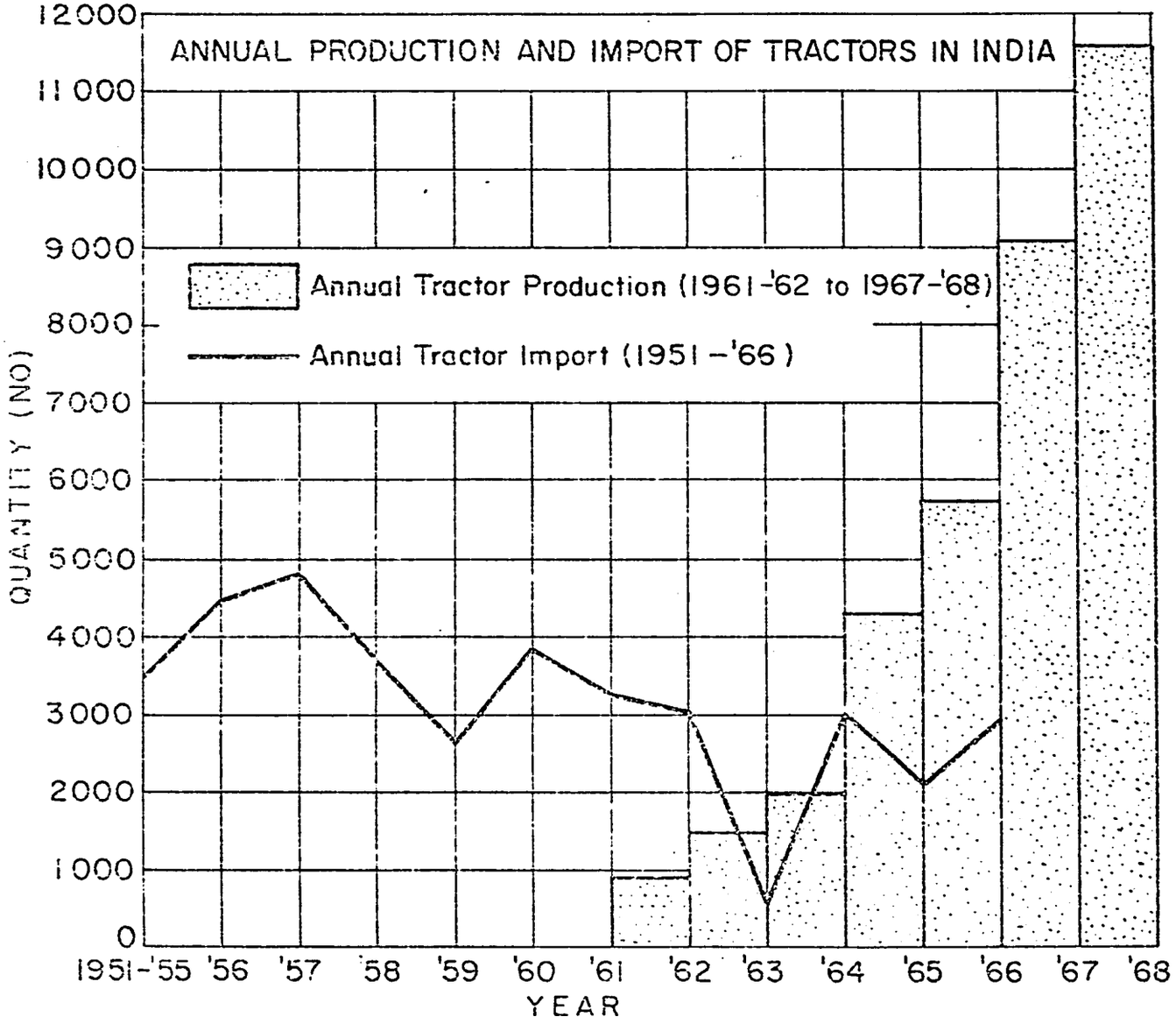


Fig. 1. Annual tractor production and tractor imports, India. Machinery Division, Ministry of Food and Agriculture.

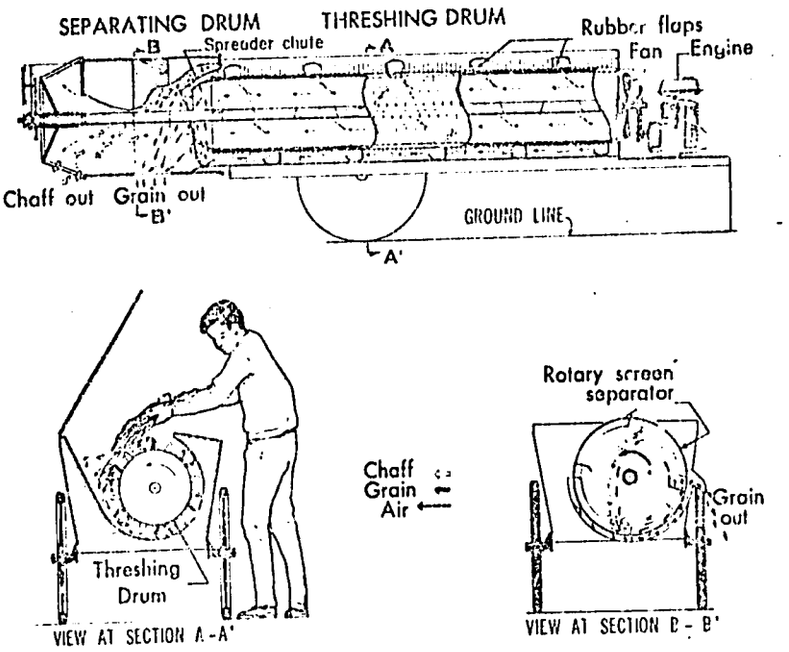


Fig. 2. Schematic drawing of the power-operated drum-type thresher.

Fig. 3. A commercially produced drum-type thresher in the Philippines.

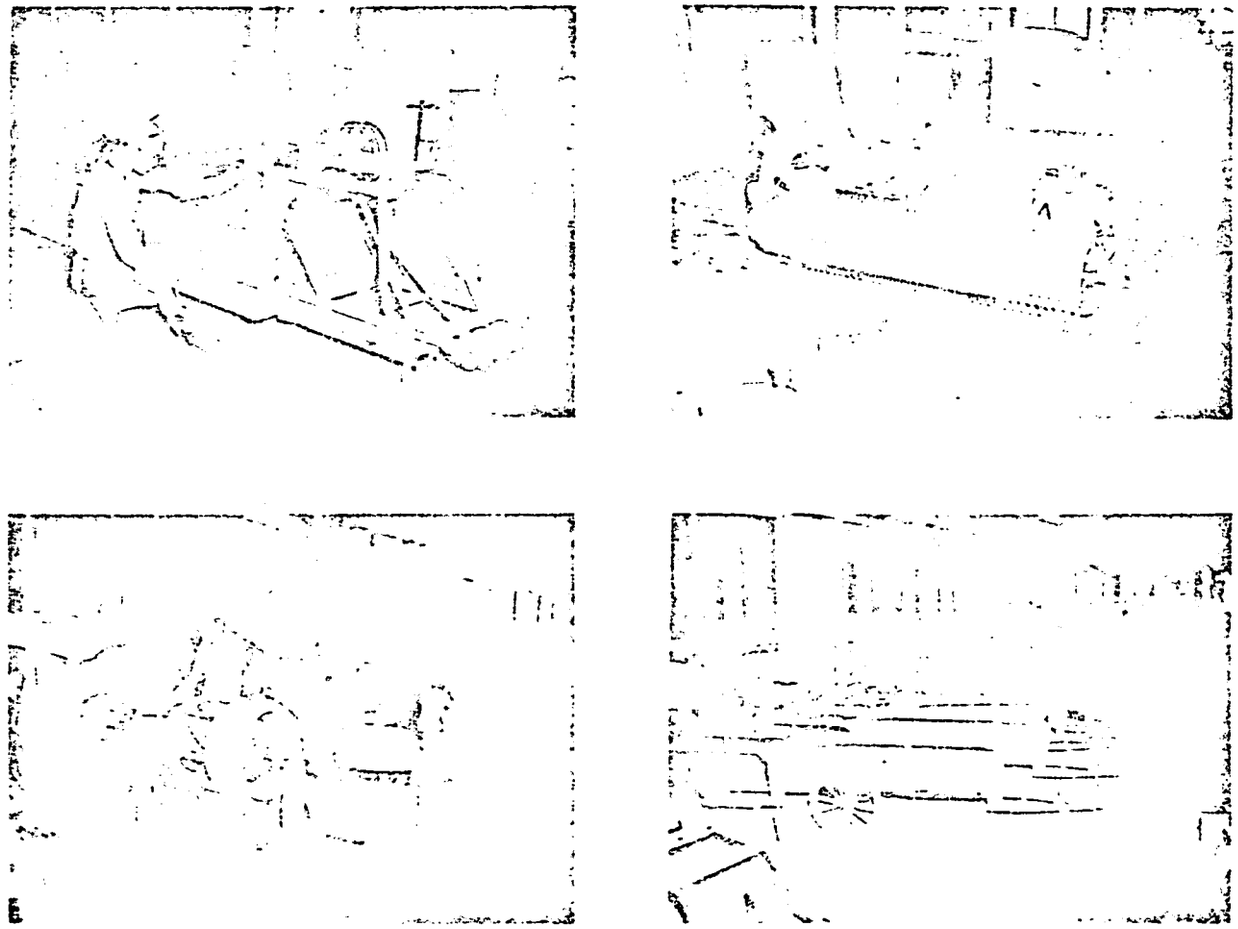


Fig. 4. The drum-type thresher under various stages of production at G. A. Machineries, Inc., Valenzuela, Bulacan, Philippines.

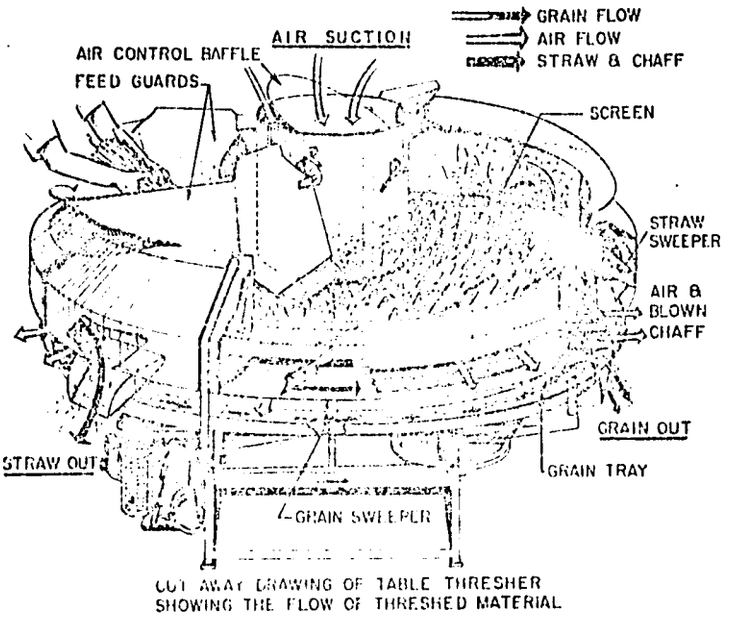


Fig. 5. Schematic drawing of the table-type power thresher.

Fig. 6. A prototype table thresher.

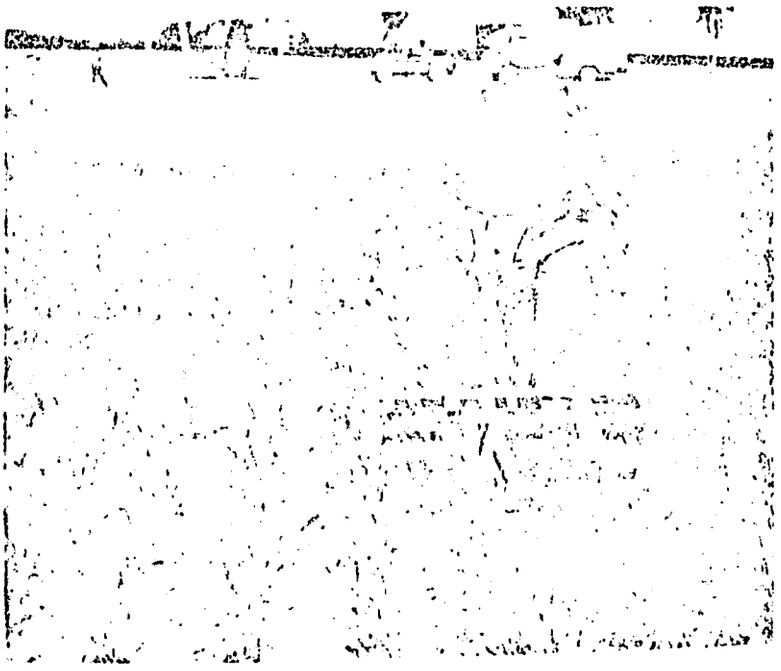
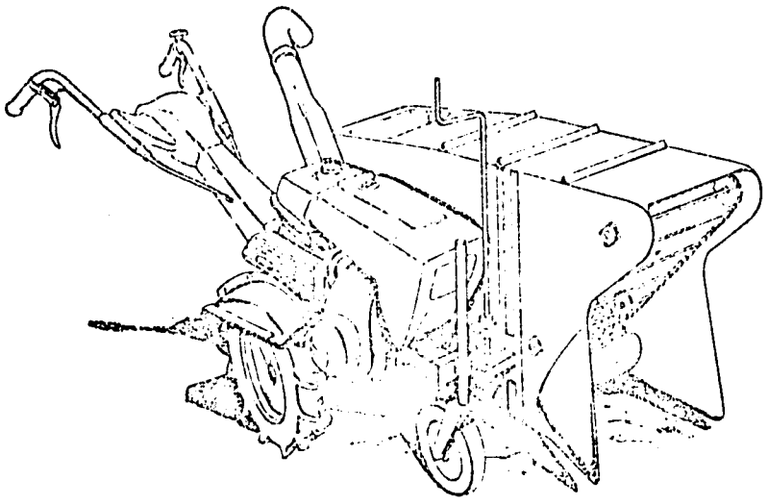


Fig. 7. The experimental three-row power weeder.

Fig. 8. The experimental five-row weeder.

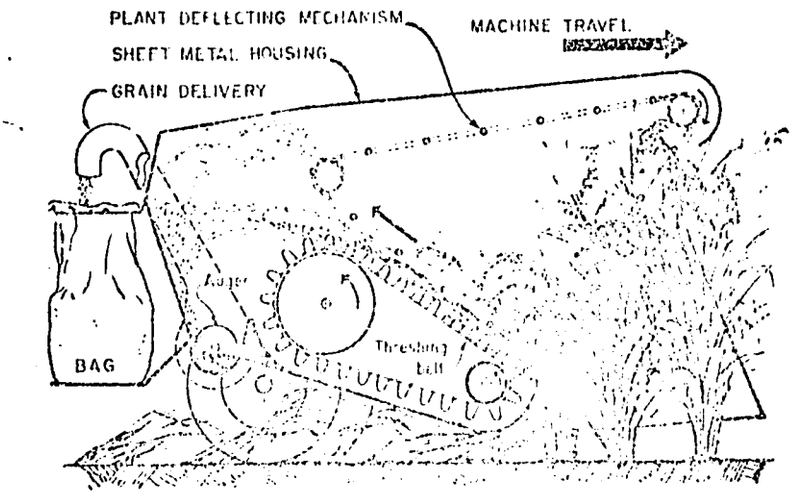
Fig. 9. Experimental PTO-driven wetland rotary tiller mounted on a standard tractor.

Fig. 10. Experimental anhydrous ammonia applicator mounted on a 6-hp walking tractor.



PADDY STRIPPER MOUNTED ON
SMALL WALKING TRACTOR

Fig. 11. Design of the stripper-harvester combine, offset mounted on a small walking tractor.



SCHEMATIC DRAWING OF PADDY STRIPPER

Fig. 12. Schematic drawing of the paddy stripper.

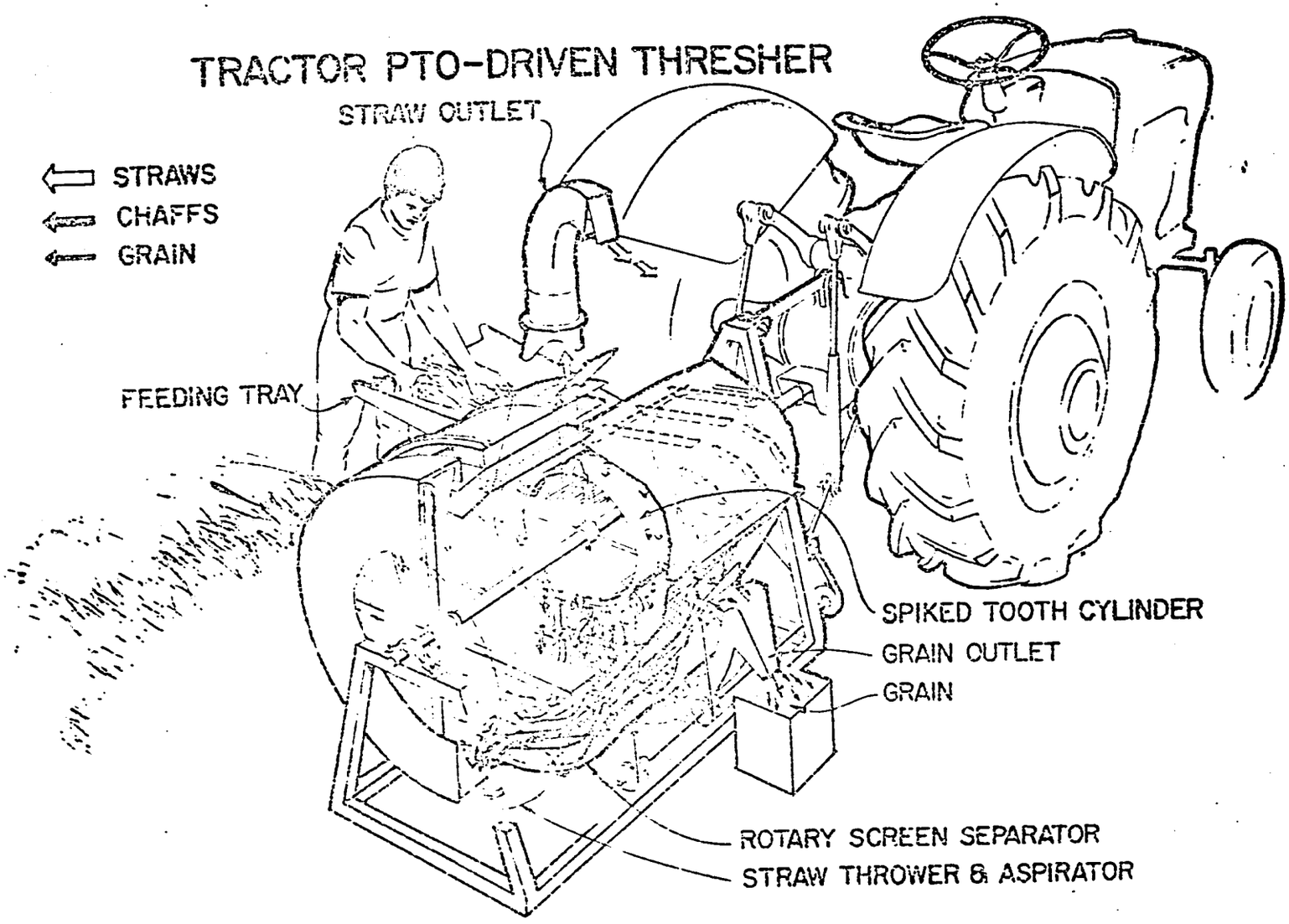


Fig. 13. Drawing of the tractor PTO-driven thresher.