AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
BATCH #28

1. SUBJECT CLASSIFICATION

A. PRIMARY
Serials

Y-AN20-0000-GG50

B. SECONDARY
Agriculture--Farm equipment--Tropics

2. TITLE AND SUBTITLE

Agricultural equipment development research for tropical rice cultivation; semi-annual progress report no.19,July,1974 to Dec.,1974

3. AUTHOR(S)

(101) IRRI

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1974	88p.	ARC RP631.3.I61

7. REFERENCE ORGANIZATION NAME AND ADDRESS

IRRI

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

(Research summary)

9. ABSTRACT

10. CONTROL NUMBER

PN-RAB-589

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Agricultural machinery
Intermediate technology
Rice

13. PROJECT NUMBER

14. CONTRACT NUMBER

CSD-2541 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

6

88

SEMIANNUAL PROGRESS REPORT NO. 19
JULY 1 TO DECEMBER 31, 1974

ON

CONTRACT NO. AID/CSD-2541

AGRICULTURAL EQUIPMENT DEVELOPMENT RESEARCH
FOR TROPICAL RICE CULTIVATION

BY

AMIR U. KHAN
AGRICULTURAL ENGINEER AND PROJECT LEADER

BART DUFF
AGRICULTURAL ECONOMIST

CHUL CHOO LEE
VISITING AGRICULTURAL ENGINEER

AGRICULTURAL ENGINEERING DEPARTMENT
THE INTERNATIONAL RICE RESEARCH INSTITUTE
LOS BAÑOS, LAGUNA, PHILIPPINES

(FOR RESTRICTED CIRCULATION)

TABLE OF CONTENTS

Title	Page
Introduction and Summary	1
Progress Report	3
Design and Development	5
Field equipment	
Steering clutches for 5-7 hp tiller	5
8-14 hp tiller	5
15-20 hp four-wheel riding tractor	6
Deep-placement liquid injector	7
Deep-placement granular applicator	8
Jet pump attachment	9
Tubular pump	10
Vertical-axis windmill	11
PTO thresher	12
Stripper harvester	13
Drying and processing equipment	
Oscillating grain cleaner	14
Solar heat collector for IRRI grain dryer	15
Improvement of Engleberg rice mills	16
Experimental single-pass rice milling machine	17
Test and Evaluation	19
Power tiller survey and evaluation	19
Comparative performance of wire-loop and rasp-bar cylinders	20
Custom threshing operations survey	20
Comparative evaluation of different threshers in the Philippines	21
Modified rotary grain cleaner	23
Evaluation of commercially produced machinery	23
5-7 hp tiller	23
Different types of huskers	24
Different types of polishers	25
Rice hull furnace	26
Evaluation of laboratory rice milling equipment	27
Compacted soil pan studies in continuously cropped wetland rice	28
Economics of Mechanization	30
Economic and technical evaluation of rice processing facilities in the Philippines	30
A. Survey of post-production practices in Central Luzon	30
Post-harvest practices	30
Laboratory analysis of paddy samples	31
Preference for alternative milling technologies	31
B. Utilization of improved rice processing facilities in Camarines Sur	32
Post-harvest practices of farmers	33

TABLE OF CONTENTS (cont'd)

Title	Page
The potential for mechanical threshers and dryers . . .	34
Utilization of warehouse and rice mill facilities	34
Work Plan	35
Personnel List	41
Tables	
Figures	

INTRODUCTION AND SUMMARY

The USAID/IRRI contract, "Agricultural Equipment Development Research for Tropical Rice Cultivation," terminated on December 31, 1974. This semiannual report No. 19 is the last of a series of reports which started in 1965 as a result of an earlier USAID/IRRI research contract on the mechanization of agriculture. Work on the development of appropriate machines will, however, continue at the Agricultural Engineering Department through the support from the IRRI core budget. The last seven years of efforts to develop and commercialize new agricultural machines have resulted in significant progress in the Philippines where a sizeable farm equipment industry has evolved. Production of IRRI-developed machines in other Asian countries has, however, not progressed as rapidly and this is receiving greater attention from the Institute. A new USAID/IRRI project is being negotiated for the industrial extension of the IRRI-developed machines in the other Asian countries. A separate terminal report discussing the major highlights of the two USAID/IRRI projects related to agricultural mechanization is being submitted along with this report.

The recommendations of an Advisory Group Meeting held in March 1974 on the activities of the IRRI Agricultural Engineering Department prompted the reorientation of the project activities. Since the project has been successfull in introducing many new field machines in Asia, the Advisory Group felt that more emphasis should be placed on developing new equipment to solve the rice processing and irrigation bottlenecks.

Work on the development of field machinery continued to make satisfactory progress during the period of this report. Endurance test and design changes were made on the 8-12 hp tiller Engineering drawings were released to five Philippine companies who are interested in producing this machine. This tiller is slightly larger and has many additional features than the 5-7 hp IRRI tiller that was developed previously The manufacturers are now adapting the IRRI power tiller to their production facilities and it is hoped that their prototype production units will be submitted to IRRI for endurance testing sometime in early 1975

Studies in the IRRI Agronomy and Entomology Departments have indicated substantial economy in the use of fertilizers and herbicides through placement at greater depth Suitable equipment was developed for deep-placement of fertilizers and herbicides to take advantage of these findings A single-row push-type deep-placement granular fertilizer applicator was developed and drawings were released to two manufacturers for trial production.

Due to the high cost of fuel, new projects on the development of equipment to collect wind and solar energy were initiated. The development of a low-cost tubular pump in conjunction with a vertical-axis windmill is well on its way A low-cost solar panel is being developed for use with the IRRI batch dryer which has become commercially popular in the Philippines.

Work on the evaluation and development of rice processing and milling machines was increased. A series of projects for evaluating rice hulling and processing machines were undertaken Many improvements on the Engleberg type

milling machines were evaluated and this project has now reached a stage where the improvements will soon be tried with existing Engleberg mills in the nearby towns. General mechanization research studies were continued to evaluate the needs and the current status of mechanization at the farm level through surveys and studies of threshers, threshing operations, and power tillers in different areas of the Philippines.

The activities in the economics section include two field surveys to examine the technical and economic characteristics of the rice milling and processing facilities. The farm level survey reveals that traditional practices are still being used by farmers in their harvest and post-harvest operations. Farmers using disc-cone hullers expect better and more head rice recovery while Engleberg mill users seem resigned to accepting more brokens and less head rice but a higher output of bran, brewer's rice and ground hulls for their livestock. On the mill level, there was a reported under-utilization of facilities and this was attributed to the lack of paddy, the poor quality of paddy brought in for milling, the defective engine and mill apparatus.

Significantly increased manufacturing activity occurred in the Philippines and Thailand during the period of this report. In the Philippines, 11 companies are now producing IRRI-developed machines. The 5-7 hp tiller and the axial flow thresher continued to exhibit maximum interest among the IRRI machines in the Philippines and other Asian countries. Eight companies are now manufacturing the axial flow thresher and almost all of these companies are having difficulty in keeping up with the demand The production of the three-row power weeder (mini-cultivator) continues to make progress in Japan.

Mr. Joseph K. Campbell, Associate Agricultural Engineer, who was on a one-year leave from Cornell University, returned to his permanent assignment at Cornell. Dr. Amir U Khan, Project Leader, who was on a one-year study leave at the Denver Research Institute, returned to the department in June.

While the USAID/IRRI project was terminated in December 1974, the Agricultural Engineering Department, IRRI plans to continue issuing semiannual reports on its machinery development program and these reports will continue to be sent to the organizations who have been receiving the earlier semiannual reports.

PROGRESS REPORT NO. 19
JULY 1 TO DECEMBER 31, 1974

The following personnel were responsible for the projects during this period:

Design and Development

Field machinery

1. Steering clutches for 5-7 hp tiller	S. Gutierrez
2. 8-14 hp tiller	S. Gutierrez,
3. Small four-wheel riding tractor	G. Espiritu, A.U. Khan
4. Deep-placement liquid injector	N. Navasero
5. Deep-placement granule applicator	N. Navasero
6. Jet pump attachment	J. Samuel
7. Tubular pump	G. Salazar, A.U. Khan
8. Vertical-axis windmill	G. Salazar, A.U. Khan
9. PTO thresher	G. Espiritu, A.U. Khan
10. Stripper harvester	G. Espiritu, A.U. Khan.

Drying and processing

11. Oscillating grain cleaner	S. Gutierrez, B. Ramos
12. Solar collector for IRRI grain dryer	N. Navasero, A.U. Khan
13. Improvement of Engleberg rice mills	J Arboleda, C.C. Lee
14. Experimental single-pass rice milling machine	J. Arboleda, C.C. Lee

Test and Evaluation

15. Power tiller survey and evaluation	B. Ramos, C.C. Lee
16. Comparative performance of wire-loop and rasp-bar threshing cylinders	J. Sarwa C.C. Lee
17. Custom threshing operation survey	B. Ramos, C.C. Lee
18. A comparative evaluation of different threshers in the Philippines	B. Ramos, C.C. Lee
19. Modified rotary grain cleaner	C. Padolina
20. Evaluation of commercially produced machinery	
a. 5-7 hp tiller	C. Padolina
b. Different types of huskers	S.H. No, C.C. Lee
c. Different types of polishers	S.H. No, C.C. Lee
d. Rice hull furnace	C. Padolina
21. Evaluation of laboratory rice milling equipment	J Arboleda, C.C. Lee
22. Depth of compacted soil layer as affected by different tillage equipment in continuously cropped irrigated rice	C. Padolina

Economics of Mechanization

23. Economic and technical evaluation of rice processing facilities in the Philippines	
a. Survey of post-production practices among rice farmers in Central Luzon	Z. Toquero, B. Duff
b. Utilization of improved rice processing facilities in Camarines Sur	J. Alkuino, B. Duff
24. Potential of mechanizing upland cropping operations	V. Cueno, B. Duff

Industrial Extension

25. Manufacturing development	Staff

DESIGN AND DEVELOPMENT

Field equipment

Steering clutches for 5-7 hp tiller

Power tillers with no steering clutch are difficult to turn and are hard on the operator. Most users of the IRRI 5-7 hp tiller have indicated a need for steering clutches to facilitate field operation. Attempts were made to develop an externally mounted steering clutch attachment (fig. 1) so that it could be installed on existing machines already purchased by the farmers. A set of steering clutches which could be bolted to the tiller cage wheel hubs was designed and evaluated. The clutches performed well for short periods. However, the sliding dog sleeve stopped functioning in puddled fields due to clogging with mud. A more compact steering clutch is now being developed. This clutch will be properly sealed to avoid clogging.

8-14 hp tiller

The design details of the 8-14 hp tiller have been reported previously. The handle bars on the prototype unit, which were made out of two circular tubes, were replaced with one tapering sheetmetal housing (fig. 2) enclosing the transmission lever linkages for improved appearance. The idler belt clutch was replaced with a disc-type friction clutch, built integrally with the transmission input pulley. A readily available automotive friction-disc clutch lining was used in the clutch design. The double-belt engine power transmission arrangement was replaced with a triple-belt arrangement to reduce slippage and prolong belt life. The standard automotive transmission, used with the earlier machine, was replaced with a specially designed four-forward and two-reverse speed spur gear transmission box. The travel speeds of the tiller are as follows:

Gear	Settings	Speed Km/h*	Total reduction at 1800 engine speed
Low	1st gear	1.65	152.5
	2nd gear	2.70	95.6
	Reverse	2.10	122.0
High	3rd gear	4.20	61.1
	4th gear	6.78	38.2
	Reverse	5.60	46.0

PTO = 315 rpm.

* Wheel diameter = 760 mm.

During endurance testing, problems were encountered with the steering clutches. The dogs of the steering clutches were designed to slide on a shaft with two flat keys. The keys interfered with smooth sliding due to the torsion loading. The shaft and the sliding sleeve were redesigned with six

splines which permitted smoother sliding and easy clutch disengagement The pivoted yokes activating the clutch sleeves were replaced with spring-loaded sliding forks. The forks were actuated through cams to provide higher mechanical advantage and reduce clutch-actuating force.

After 50 hours of additional operation, the left side bearing of the PTO shaft , which drives the rotary tiller, failed The PTO shaft sprocket was mounted too far from the support bearing resulting in high cantilever loading. This problem was remedied by redesigning the bearing housing which eliminated the overhanging drive sprocket. The power tiller was tested for 100-hour operation It was then disassembled to check for excessive wear and design weaknesses although none were found.

A survey of manufacturers interested in producing the 8-14 hp tiller was conducted in the Greater Manila area. Five companies were selected on the basis of their interest and capabilities to manufacture this machine. Except for Pacific Star, Inc., the other companies are already producing the IRRI 5-7 hp tiller and are interested in expanding their power tiller line. Drawings were released to the following companies who are in the process of adapting the IRRI design to suit their production facilities.

1. Durasteel Industries, Inc.
   Cainta, Rizal

2. IGRI Industrial Sales Corporation
   484 Araneta Avenue, Quezon City

3. IMAG Manufacturing Division
   Zuellig, Inc.
   64 Kitanlad, Quezon City

4. Marsteel Corporation
   555 Tandang Sora, Baesa, Quezon City

5. Pacific Star, Inc
   1033 Hidalgo St., Quiapo, Manila

15-20 hp four-wheel riding tractor

With the development of the two complementary sizes of power tillers, attention is now being focused towards developing a 15-20 hp riding tractor to offer a complete range of small prime movers for the Asian farmers. It is felt that a substantial demand for low-cost 15-20 hp riding tractors can be generated among medium-sized farmers and small custom tractor operators in Asia. During the last year, machine shops in Thailand have started the production of low-cost, indigenously designed four-wheel tractors. These tractors are crudely designed but are sufficiently low-priced and are finding a good market among Thai farmers.

The small riding tractors originating from the industrialized countries are scaled-down versions of larger tractors and are too expensive for

the LDC The traditional design approach is to build sufficient weight in the tractor so it can develop adequate traction. While this approach is well suited for dryland work with traction-dependent implements it results in too heavy a tractor for wetland operation

Work was started on the development of a low-cost 15-20 hp four-wheel riding tractor for both wet and dryland operation We are following an approach in which the basic tractor is lightweight for wetland work and has provision for adding substantial weight for dryland operation. As a wetland tractor, it would use non-draft dependent implements such as rotary tillers. To obtain increased traction for dryland work, the tractor will have provisions for quick attaching of low-cost concrete weights.

It was decided to try such a concept on an existing lightweight riding tractor before developing our own design. After a careful review of available riding tractors from Japan, Europe and America, the Economy tractor was selected for exploratory work because of its high clearance and light weight. This U S -made tractor has been designed for estate maintenance work and is powered by a 14 hp gasoline engine. It is a relatively lightweight (592 kg) tractor yet is sturdier than most garden tractors that are popularly used for home lawn mowing and yard work in the U S. The tractor has a good clearance which is preferable for use in the LDC. The tractor uses many standard off-the-shelf automotive components and this can facilitate local production in the developing countries.

The tractor and its implements were suitably modified for working in wetland fields. Extendible lug wheels, patterned after the earlier IRRI design, were installed. The orignal PTO-driven pulley was mounted too low and this reduced the effective ground clearance to only 15.2 cm. The mounting was modified to obtain a 33-cm effective ground clearance. Since power consumption per foot of rotary tiller width is lower for wetland work, the standard dryland rotary tiller was widened to 132 cm from 81.3 cm The modified rotary tiller covers the full width of the tractor and permits tilling close to the field levees (fig. 3) During preliminary trials under average wetland field conditions at the IRRI farm, the tractor has not encountered any mobility problems The tractor is quite mobile in wet fields even with a wheel sinkage of up to 35.6 cm. Further test and modification work is continuing on this machine.

Deep-placement liquid injector

Application of fertilizer in the root zone has been practiced on many upland crops to obtain more efficient utilization of fertilizer. This practice is, however, not applied in flooded rice fields due to a lack of suitable deep-placement equipment The IRRI Agronomy experiments indicate that fertilizer efficiency can be doubled by placing mudball-encapsulated fertilizer at 10-cm depth at the center of four plant hills Similarly, IRRI entomologists have found that gelatine-encapsulated insecticides placed 2.5 cm from the base of each rice plant provide insect protection for almost the entire crop season Many questions have been raised, however, regarding the application of these techniques at the farm level in Asia

The Engineering Department investigated various concepts for deep-placement applicators A liquid-fertilizer injecting machine, which consisted of a series of cam-actuated piston-type injectors mounted inside two large-diameter wheels, was tried (fig 4) The prototype machine, however, was found to be heavy, complex and prone to service problems. It was also not well suited for low cost fabrication by small machine shops.

Another applicator concept in which a ground-driven peristaltic pump simultaneously meters liquid fertilizer to four injector nozzles (fig. 5) was tried. The use of a peristaltic pump for chemical application offers some advantages since the chemical does not come in contact with any metal parts The pump was directly mounted on the axle of two large-diameter wheels. The simple pump mechanism consisted of four 9 53-mm I D flexible plastic tubes that were wound around a set of three rollers The four tubes were attached on one end to the feed tank and the other ends were connected to four injector nozzles A tensioning device maintained sufficient tension in the tubes to permit peristaltic pumping action when the rollers rotated with the axle. Feed rate was varied by changing the effective radius of the rollers' axis in the peristaltic pump The injector nozzles were mounted on small skids to limit the penetration to 10-cm depth Provisions were made to adjust wheel and injector spacing to suit different row spacings

A cooperative experiment with the IRRI Entomology Department was conducted to evaluate the performance of this machine with other chemical placement methods Observations indicate that the insecticide injected by this machine is equally effective with other manual root-zone placement methods (Table 1) Further work on comparative performance of this machine with the mudball-encapsulated fertilizer placement and other deep-placement equipment is being continued

Deep-placement granule applicator

A push-type deep-placement granular fertilizer applicator, patterned after a Japanese machine, was developed for flooded rice fields. This single-row machine (fig 6) has a 5-kg capacity hopper with a fluted roller ground-driven metering mechanism and a sliding gate feed regulator. The hopper assembly is mounted on a small skid with a centrally placed 10-cm deep furrow opener, through which fertilizer granules are delivered to the furrow bottom. Two small furrow closers are mounted under the skid to seal the fertilizer in mud.

During trials on fairly deep puddled fields, some wetting of the fertilizer, in the vicinity of the feed opening, was observed in the hopper. The wet fertilizer clogged the roller flutes and affected the application rate. The wetting occurred mainly because some of the mud and water picked up by the wheels seeped into the hopper through the axle hole. In addition, the hopper bottom was too close to the skid and it came in contact with water wherever deep water spots were encountered in the field. High relative humidity near the field surface and the hygroscopic action of the fertilizer further aggravated the problem

The vertical clearance between the skid and the hopper as well as the side clearance between the wheels and the hopper were therefore increased, which resulted in considerable improvement. The machine can meter urea at rates ranging from 20 kg to 200 kg per hectare. Five prototype machines have been obtained from a local manufacturer and these units are now being field-tested. Drawings have been provided to two manufacturers who are interested in producing this machine in the Philippines.

Jet pump attachment

The jet pump, also known as eductor, is basically a simple device with no moving parts. It transfers energy from a high-pressure stream to pump additional liquid and deliver the combined flow at some intermediate pressure Water jet pumps have been extensively used on the suction side for increasing the suction lift capability of centrifugal pumps. Although it is known that jet pumps can be used for increasing capacity of conventional pumps, their applications have been generally limited to temporary dewatering on reclamation projects and for rapid drainage of flooded compartments in combat ships Low-cost jet pumps could be effectively used to improve the output of centrifugal pumps used by rice farmers for lowlift irrigation A lowlift pumping arrangeme t using a jet pump attachment for centrifugal pumps has been described in the previous report. Such an attachment converts some of the unutilized pressure energy of the centrifugal pump delivery into additional output.

During the present reporting period, data on an experimental jet pump of area ratio 0.125, operating as a capacity booster, was obtained. Figure 7 shows the laboratory set-up of the experimental unit A self-priming centrifugal pump driven by a 5 hp electric motor was used as the primary pump Figure 8 shows the performance of the jet pump at three different initial suction heads and two primary pump speeds. The following observations are made from the test data:

1. The head-capacity relationship curve of the jet pump exhibits a characteristic shape which is similar to that of centrifugal pumps particularly in the useful range of its operation.

2. The various initial suction heads imposed do not seem to influence the shape of the curve significantly, although some departure could be observed whenever the suction head was more than the delivery head itself.

3. The maximum jet pump discharge was more than four times the primary pump input. This flow was about three times the maximum capacity obtained from the primary pump.

4. Normally in a centrifugal pump, the flow varies in direct proportion to the operating speed whereas the total head varies as the square of the speed. The jet pump performance also followed a similar trend when the primary pump speed was changed.

5. When using the jet pump as a capacity-boosting device, a simple output/input ratio could be more meaningful in computing its efficiency. On this basis, the maximum output of 775 liter/min obtained at 2.38-m head represents an efficiency of about 40 percent.

Conventional jet pumps operate with a foot valve. It was found that the jet pump could be self-primed even under high head conditions by momentary insertion of a perforated screen or metal brush into the mixing chamber. A design for a low-cost jet pump attachment (fig. 9) has been developed. A Y-shaped design is used to introduce the pressure zone in the suction chamber. This unit obtains most of its lift through suction and functions without a foot valve. It is believed that efficiency of the experimental unit could be further improved by proper proportioning of its components and this is being investigated.

Tubular pump

Almost one-half of the total area for rice production in the tropical countries depends on rainfed irrigation. To supplement rainfall, simple pumps which farmers could afford are urgently needed. A low-cost water pump which could be driven by a variety of sources such as animal, wind or mechanical power would be useful for lowlift applications. A project to develop an inexpensive self-priming pump which could be fabricated by small shops using locally available materials was initiated.

From discussions with Dr. John D. Isaacs of the Scripps Oceanographic Institute, La Jolla, California, it was learned that they have tried a simple pump of tubular construction that operated on the centrifugal principle. Their pump consisted of a vertical suction pipe connected on its upper end to a straight horizontal delivery pipe. The pump had a foot valve and was primed by filling the pipe with water through the open end of the delivery pipe. A recurvant tip was provided at the delivery end to keep the horizontal pipe full of water under no-flow conditions of rotation.

Performance of four different tubular pump designs were studied on a test stand (fig. 10). The test stand was equipped with a 1/2 hp Reeves variable-speed electric motor. The first pump (fig. 10a) consisted of a 25 mm diameter x 1.2 m long suction pipe connected to two horizontally opposed 25 mm diameter x 0.6 m long delivery arms with a backward curve in the rotational plane. A foot valve was installed at the bottom end of the suction pipe. The delivery ends formed a tubular loop and water was released through the openings on the trailing side of the tube. At 70 rpm, the pump delivered approximately 26.5 liter/min at 1.2-m head. When the foot valve was removed while the pump was still in operation, the pump delivered 37.8 liter/min.

Foot valves are often a source of problem particularly when pumping dirty water. Since it is also a relatively expensive part, it was eliminated in the second design (fig. 10b). The volume and shape of the two horizontal delivery arms were changed to permit sufficient storage of water for self-priming. A glass window was installed in one of the arms to observe pump operation. It was found that the pump started functioning when the water in the arms was reduced to about two-thirds of the original volume. This pump was self-priming but lost prime after repetitive starts. The excess weight of water rotating in the delivery arms consumed power. Also, the unusual shape of the delivery arms was not suitable for low-cost fabrication.

In the third design (fig.10c), a central container was used to store sufficient water for self-priming. The container had a plastic window through which the pumping action was observed. The pump, which used a standard tubular arm, gave a similar performance as the unit in fig.10b. But it was observed that whenever the pump was about to stop, some air bubbles entered the central container from the two delivery arms It was hypothesized that the centrifugal force in the delivery arms is low when the pump is about to stop and at such moment air is sucked through the delivery arms which affects the replenishment of water in the container. Interestingly, at very high speeds, water falling from the suction tube into the central container created turbulence which expelled some air bubbles through the water being pumped out of the delivery arms. Thus when operating at very high speeds, air in the central container was gradually exhausted and the water was fully replenished.

In the fourth design (fig.10d), two 3/4-liter containers were added near the discharge outlets and the central container was eliminated. These outer containers were designed to store sufficient water during operation and to release it back into the delivery arms as the pump stopped. The outlets of the outer containers were placed on the inner side so the stored water could not be released whenever the pump was about to stop This change eliminated the problem of air entering into the system The total volume of the two containers to make the pump self-priming was found to be slightly larger than the volume inside the suction tube above the water level. This unit was self-priming and no problems were encountered when the pump was intermittently operated.

A 1.4-m arm pump was fabricated for installation with a Savonius rotor windmill at the IRRI farm. This pump (fig 11) is now being tested on a test stand. Further tests are being continued and head-capacity curves over a wide range of pump speeds are being obtained.

Vertical-axis windmill

The omnidirectional feature of the vertical-axis windmills eliminates wind-orienting mechanisms and this simplifies their design. Because of their low cost, such windmills offer greater potential for the developing countries than propeller-type machines. The efficiency of vertical-axis windmills, however, is lower than the propeller-type machines Many attempts have been made to improve the vertical-axis windmills and consequently a number of rotor designs have evolved. The most popular example of such windmills are the Savonius rotor and the recently developed National Research Council of Canada (NRC) design.

The NRC data show that the efficiency of their windmill is comparable to the horizontal-axis windmills This rotor consists of thin airfoil-section blades mounted on a vertical shaft in a semicircular shape. Reported data indicate that the NRC windmill is most efficient when the blade tip speed equals six times the wind speed. The drawback of this windmill is that it is not self-starting. Attempts are being made in Canada and the U.S to develop devices which could provide initial take-off speed to the NRC mill. This is

also a high-speed windmill requiring automatic speed control mechanisms and reductions for driving lower-speed machines.

A project was started to evaluate the two vertical-axis rotor designs and to try some new rotor concepts. A windmill test stand was built for mounting on a pick-up truck to simulate different wind speeds by driving the truck at various speeds. A 1.5-m diameter NRC-type, two-bladed rotor was installed on the test stand (fig. 12). Preliminary trials indicate that the rotor is not self-starting even at wind velocities of up to 96 kph. A 12-volt electrical starter was installed on the test stand to provide the initial take-off speed. With this arrangement, the rotor can accelerate from a take-off speed of 480 rpm to 900 rpm no-load speed at 32 kph wind velocity. The tip speed ratio at 900 rpm was greater than 8. If the initial speed is less than 480 rpm, the rotor slowly decellerates to a stop. Tests are now being continued to determine the power generated by this rotor at different wind velocities. Comparative tests are also planned for various versions of the Savonius rotor and some other experimental rotors with identical projected area. Once an efficient rotor design has been established, a windmill will be fabricated for coupling with the lowlift tubular pump that has been described elsewhere in this report.

PTO thresher

The PTO thresher being developed in the department has a high threshing output, however, its grain cleaning operation is not satisfactory. Different rotary screen and blower arrangements have been tried previously with limited success. During the present reporting period, attention was directed towards studying the relative position of the outlets of the three rotary screens and the intake opening of the straw thrower. It was hypothesized that the straw thrower intake opening has a central zone through which air is sucked during operation. This is surrounded by a neutral zone where little or no air movement occurs. Finally there is a pressure zone around the periphery of the air intake where air is blown outward from the straw thrower.

The boundaries of the three zones have not been determined previously. In order to achieve smooth transfer of chaff and straw from the three rotary screens to the straw thrower, it is necessary that the screen outlets are properly positioned with the straw thrower intake. The material from the rotary screens must be delivered into the central suction zone or the neutral zone of the thrower intake. Delivery into the pressure zone will not be satisfactory since chaff and other lighter impurities would be pushed backwards due to the blowback effect.

Experiments were conducted to demarcate the three zones in the intake opening of the straw thrower. A series of pressure taps were installed radially (fig. 13) at the rear wall of the straw thrower housing. These were connected to a manometer and measurements indicated that above atmosphere pressure was present on station No. 6 onwards (fig. 13) which was only 37.20 cm away from the straw thrower center. Thus the neutral zone had a diameter of about 74.4 cm. The second and the third rotary screens in the present machine are of 80 and 96.5-cm diameters, respectively, which indicate that

chaff and light materials from the two outer screens are being delivered into the pressure zone. Attempts are now being made to enlarge the neutral zone in the straw thrower intake by reducing the size of the thrower blades and changes in the housing design.

Stripper harvester

The details of the prototype six-row stripper harvester (fig. 14) have been described in the previous report. During field trials, it was found that the 19 hp HIRTH engine was overloading when the harvesting mechanism was operating. Also, the engine pulley was overheating. Cooling fins were incorporated in the engine pulley to reduce heating and belt wear. The HIRTH engine was replaced with a Thailand-made two-stroke, two-cylinder WINNER engine rated at 30 hp. The WINNER engine operates at a slightly lower speed and necessary changes were made in the transmission to maintain proper speeds of the ground wheels and the harvesting mechanisms.

In earlier field trials difficulty was encountered in maintaining a constant threshing belt velocity as it was driven through a hydrostatic transmission. This transmission was replaced with a positive chain drive which provided a uniform threshing belt velocity of 6.01 m/sec. The gathering bar velocity was also found to be low and the drive sprockerts were changed to obtain a faster range of gathering bar velocities of 1 to 3 times the ground speed.

During initial trials grain loss was observed with the chaff. Grains were also spilling from the sides and far end of the oscillating grain cleaner. The side walls of the oscillating cleaner were only 2.54 cm high and was increased to 7.62 cm.

After these alterations, grain with chaff was fed into the header while the stripper was operating and the machine was stationary. No grain was thrown out from the oscillating grain cleaner, although some grains were observed dropping from the elevator housing. The opening between the elevator housing and the oscillating grain cleaner outlet was closed to eliminate grain loss.

The modified harvester was tested on a simulated field in which bundles of freshly harvested paddy were clamped in two rows on wooden planks anchored to the ground. The height of the paddy plants was approximately 58 cm from the wooden planks. The harvester header was lowered so the lifting fingers could enter the plants at about 4 cm from the wooden planks to lift even the lodged plants.

The following observations were made during the tests:

1. Increased gathering bar velocity improved performance to a point that only the empty rice kernels were left on the plant.

2. The lifting fingers hit the panicles in their maximum height position, which resulted in some threshing loss.

3. The fairly high velocity of the gathering bars created a solid obstruction which restricted the panicles from entering the space between the bars. This also caused some threshing of the grain which was lost to the ground.

4. Since threshing starts immediately at the front end of the threshing belt, some of the threshed grain bounced out and fell on the ground. If the panicles were to enter the space between the gathering bars, threshing may start a little beyond the front end of the threshing belt and this may reduce shattering loss.

5. Scatter loss occurred through the opening between the grain auger and the grain conveyor. A canvass shield was installed to seal this opening.

6. The machine had excellent maneuverability on relatively dry ground. However, under heavy clay conditions, a layer of clay was found to build up on the tires, which had standard tread design, resulting in high wheel slippage. Tires with self-cleaning lugs are being installed

7. It was observed that grain accumulates inside the shield at the front end of the threshing belt. This accumulated grain can be thrown out by the moving threshing loops and could increase scatter losses.

Further testing and development work is continuing

Drying and processing

Oscillating grain cleaner

Paddy threshed by either manual or animal methods is generally cleaned by dropping it to natural wind in the tropical countries Mechanically threshed paddy is often cleaned by winnowers to remove empty kernels and light other light impurities after it has been dried The local winnowers do not satisfactorily separate the empty grain and impurities from the paddy in a single pass and repeated recycling of grain is often necessary The rotary grain cleaner developed earlier in the department has received many favorable comments but it is expensive and has not been commercially successful.

The prototype oscillating grain cleaner briefly described in earlier reports was further improved. The modified cleaner (fig 15) consists of a hopper with a simple metering mechanism mounted on top of two 90 cm x 100 cm oscillating screens with 1.27 cm and 0.95 cm perforations. Two 25 4-cm diameter blowers winnow the grain that falls through the screens A 10.15-cm diameter auger conveys the winnowed grain to the thrower for bagging The cleaner is equipped with a 3 hp aircooled gasoline engine. Initial tests on the prototype machine indicated a cleaning output of 3 ton/h with 98 percent purity when the full-width 90-cm screen was used The output was reduced to 2.5 ton/h when one-third of the screen width was blocked It was felt that the cleaner output was still far too much for farm operations. Since there is also a need for large-capacity cleaners at rice mills, it was felt that a

market research study should be carried out to establish the output and other design parameters for different grain cleaners that could find commercial demand in the region

A survey of rice millers and farmers was conducted in the Laguna Province to determine the market potential for grain cleaners Almost all rice mills are milling rice on a custom basis. With a few exceptions, the mill owners are reluctant to install grain cleaners They mentioned that the grain that is brought to them for milling is already cleaned by the farmers. The survey of threshing floors in the province, where manual threshing and subsequent winnowing is a common practice, indicated a need for a portable cleaner with an output of about 1 ton/h and light enough to be carried by two persons Additional surveys are being conducted to establish the desirable cleaner specifications for use at the threshing floor where a large amount of paddy is threshed in the Philippines and other Asian countries A market research on cleaner demand is continuing and further development work will be continued after the completion of this study

Solar heat collector for IRRI grain dryer

A project was started to study the possibilities of developing a solar heat collector for use with the IRRI batch dryer which is now commercially manufactured by four companies in the Philippines An experimental solar heat collector was fabricated to fit the existing blower housing of the dryer The collector consisted of two corrugated G I. sheets painted with flat black enamel, mounted on a plywood structure The top surface of the collector box was covered with a thin transparent plastic film The corrugated metal sheets were sandwiched between the top plastic cover and a plyboard bottom with a 5-cm clearance on both sides A centrally located flaring air duct connected the collector to the circular blower housing which permitted tilting of the collector panel for proper orientation with the sun

Two 1 38 m x 2 75 m wooden wing panels with aluminum foil reflecting surfaces were hinged to both sides of the collector box (fig 16) These reflector panels can be opened and set at a fixed angle to reflect incoming rays to the central collector panel The aluminum foil reflector panels were used since the cost of a large collector panel to cover an approximate 10-sq m area would have been prohibitive The solar heat collector was tested on a clear sunny day. It increased the ambient air temperature from 32.22°C to 35°C at 75 cu m/min of free air delivery by the blower Further testing of this unit is being continued to determine its capacity for grain drying, ease of handling and installation It is felt that the plywood construction would be too expensive for a solar collector and so alternate materials for a low-cost panel are being explored A low-cost plate collector made entirely from dull-black painted corrugated cardboard with thin transparent polyester plastic cover is being developed Its cost and operating efficiency will be compared with the plywood collector

Improvement of Engleberg rice mills

Results of previous work done on the improvement of the Engleberg rice mill indicate that the modifications made on the cylinder, discharge regulator, screen and top cover insert resulted in consistently high total and head rice milling recovery

Additional modifications and tests were made to determine whether the performance of the machine could be further improved (fig. 17) The modifications made were

1 A new cylinder cover designed to be fitted with a screen that is either semicircular or bent lengthwise with three or four sides. A perforated screen top cover could improve husk-bran separation and reduce friction and pressure in the machine The corners on the bent screen could function as lugs or ribs during milling.

2 Three new blades with 2 38-mm, 3.18-mm, and 4 76-mm depth of cut, and each of lengths 23 cm from the discharge end were made (fig 18) A length of 7 6 cm remained uncut at the feeding section to provide closer blade adjustment for efficient feeding. The cut on the blade could provide wider blade-cylinder clearance to reduce friction and pressure during milling.

Tests were conducted using the above modifications and compared with additional tests of original modifications and the sectionalized cylinder previously reported

A screen with wider perforations (1 19 mm wide) than previously used available commercially was also included in the tests.

A dummy sample was milled prior to each test run Three 5-kg samples of IR1561 were used for each test and the data taken were milling time, rice temperature, weight of milled rice, and other observations Subsequent subsampling of the milled rice for laboratory analysis was made A Kett whiteness meter was used to determine the milling degree. This instrument is basically a reflective index meter graduated 0-100 with a standard milk-white glass plate set at 77.

The results of the test, shown on Table 2, indicate that:

1. For almost the same milling whiteness, the laboratory milled paddy sample had a higher total and head rice recovery compared with all the tests made on the Engleberg mill

2 In all tests, the wider screen yielded the lowest total rice recovery (65 07%) The screen separated the fine broken grains together with the bran, reducing the total recovery by 4.46 percent compared with the original machine

3 In all the modifications made, the variation observed in the total milling recovery was small compared with the head rice yield.

4. The original modifications maintained the high total and head rice yield.

5. The head rice recovery decreased with increasing number of bends on the perforated screen cover. The head rice from the semicircular screen cover was 30.80 percent while that from the perforated screen bent to four sides was 24 23 percent. It was observed that the change of the cylinder cover from solid to perforated screen resulted in a cleaner milled rice

6. The test blades yielded higher head rice recovery, indicating that wider blade clearance at the milling section will result in improved grain quality. A decrease in the milling capacity, however, was observed

7. The performance of the sectionalized cylinder was poor

The original modifications, the semicircular screen cover and the new blades yielded higher head rice recovery. Further tests will be made to verify and combine these results to produce a more efficient machine

Experimental single-pass rice milling machine

The single-pass rice milling machine of the Engleberg type removes the hull and bran in one operation by subjecting the paddy to high friction under pressure (fig. 19) However, its performance is characterized by large amount of broken rice, excessive bran production, and high power requirement It is even reported (Ruiten, 1973) that this mill was originally designed as a coffee pulper but redesigned for milling paddy In this machine the degree of milling is controlled by the clearance between the adjustable steel blade and the rotating fluted cylinder as well as the slide valves at the inlet and discharge openings Although the speed and configuration of the rotating cylinder, kind of top cover, and the clearance of the perforated screen affect milling performance, they remain fixed in commercial units

Our studies on the Engleberg mill have indicated that the milling performance can be significantly improved by modifications on both the movable and fixed parts However, the effect of clearance between the perforated screen and the rotating cylinder could not be studied as it is always fixed in the existing rice mill An experimental single-pass rice milling machine was, therefore, designed and constructed to study the individual and combined effects of the parts affecting milling performance It also incorporates some features found in Japanese rice mills

The experimental rice mill has the following specific features

1. Provision for an air jet stream to pass through the rotating cylinder and exhaust at the milling section to cool the machine and the grains being milled. It also helps in cleaning the milled rice by blowing bran through the perforated screen

2 A continuous single-pass screw thread at the feeding end of the cylinder at close clearance with the cylinder casing for positive grain axial thrust

3. A sectionalized cylinder to determine the separate effects of the feeding, milling and discharge sections on milling performance.

4. A weight-loaded gate for side or axial grain discharge.

5. Two semicircular screens with adjustable supports to increase bran separation and vary the clearance with the rotating cylinder.

6. Adjustable blade at the milling section relocated at the top to make full use of the two semicircular screens in bran separation.

7. A sectionalized rice mill casing for easy assembly and disassembly for inspection, measurements or repairs.

The basic parts of the experimental rice milling machine has been constructed (fig. 19). Visual observations of preliminary test run indicate a promising result with the presence of more head grain in the milled rice.

A series of tests will be conducted on the machine to determine the individual and combined effects of the various adjustable parts. The result of the test will be used as the basis for modifying the existing Engleberg type mill. If favorable results are obtained, the experimental machine can be further modified as an improved model of the kiskisan rice mill.

H. V. Ruiter. 1973. Rice milling in the Philippines. Thursday Seminar, IRRI, Los Baños, Laguna, Philippines. March 29.

TEST AND EVALUATION

Power tiller survey and evaluation

A survey was conducted in selected areas in the Philippines to determine the technical and economic factors which influence the selection and utilization of power tillers. The data should help in establishing parameters for the design of new power tillers suited to similar tropical regions. Additionally, the survey looked into and evaluated manufacturing technologies employed by local manufacturers to find areas that can be improved and can utilize technical assistance from our department. Therefore, the survey was conducted both at farmer and manufacturer levels.

The surveys were made in Southern Luzon (Laguna and Camarines Sur) and Mindanao (North Cotabato).

The types of power tillers surveyed in the country were of either chain-sprocket or gear driven transmission (Fig. 20). Machine size ranged from 4 to 14 hp. The smaller tillers were mostly equipped with gasoline engines while the higher horsepower (8 to 14) units were driven by diesel engines. The spiral plow, moldboard plow, and comb harrow were generally used with the lower horsepower tillers; rotavators were found with the larger units.

The power tiller brands surveyed, other than those locally manufactured, were mostly of Japanese origin (Table 3). The only exception was the English-made Landmaster, which was also the most popular brand among 75 respondents in Laguna. However, all tillers surveyed in Camarines Sur were of local manufacture. The farmer's choice of a power tiller was found to be influenced mainly by the presence of local dealers and by the brand first introduced in the area (Table 4). Lower costs and availability of parts were rated the least in their choice, although the cost of imported tillers averaged approximately four times that of locally manufactured machines (Table 5). This probably indicates the lack of competition in the market.

Most local- and foreign-made tillers use a belt drive from the engine to the transmission and the survey disclosed that it was this component which failed most frequently (Table 6). Imported power tillers have steering clutches and variable speed drives. Other than the engine parts, these components also had high frequency of failure. The principal problem that the farmers encountered when using the larger tiller was its weight (Table 7) which made it difficult to handle and operate in paddy fields.

Power tillers are now manufactured locally in many places. In Camarines Sur alone there were nine manufacturers. All firms indicated that their initial manufacturing efforts began from orders placed by interested farmers, and it was only in 1973 that they ventured into mass production. Figure 21 shows the sales pattern of these local machines, indicating the tremendous market potential which exists for low cost power tillers in the region.

Further analysis of the data is being made and preparation is also underway to extend the area covered under the present report.

Comparative performance of wire-loop and rasp-bar cylinders for threshing paddy

A dissertation project on the comparative performance of wire-loop and rasp-bar cylinders (fig. 22) for threshing paddy was undertaken. The variable parameters were peripheral velocity, concave clearance, crop moisture content, and feed rate. A belt conveyor was used to feed the weighed materials to the threshing cylinders within the specified time duration. The threshed grains which passed through the concaves, the unthreshed grains and those carried by the straw were separately collected.

Summary results obtained from the study are listed below:

1. In general, the threshing efficiency of both the wire-loop and the rasp-bar cylinders increased with increasing peripheral velocities (fig. 23). Although there was no significant difference in the efficiencies of the two threshing cylinders at the lower feeding rate, the wire-loop cylinder gave a higher efficiency than the rasp-bar at the higher feeding rate. This difference in efficiency was pronounced only at lower peripheral velocities and became indistinguishable above a transient velocity value of about 18 m/sec.

2. The threshing efficiency for both cylinders was higher at a higher moisture level for low peripheral velocities. However, the rasp-bar cylinder performed better than the wire loop at the higher moisture level and at high peripheral velocities (fig. 24).

3. The rasp-bar produced greater hulling than the wire-loop at all peripheral velocities and moisture levels (fig. 25). With increased peripheral velocities, the percentage of husked grains increased exponentially above the transient velocity. It was also found that the quantity of grains carried with the straw was between 25 to 40% for both cylinders.

In conclusion, it may be stated that the overall performance of the rasp-bar exceeded that of the wire-loop at high peripheral velocities especially when the feeding rate was low and the crop was wet. The wire-loop cylinder on the other hand gave better performance when the crop was relatively dry, at all peripheral velocities. There is also less damage to the grains under such conditions with this cylinder.

Custom threshing operations survey

A survey of custom threshing operations was made in various regions in the country to gather information on the technical aspects and social implications for developing appropriate threshers suited to tropical conditions. The study would give much needed feedback information to designers and manufacturers.

This is a partial report of the study, covering Southern Luzon (Laguna and Camarines Norte) and Mindanao (North Cotabato). Farmers using traditional methods of threshing as well as those who own or hire mechanical threshers were interviewed.

Socio-economic factors affecting the degree and extent of custom threshing were observed in the areas surveyed. In Laguna, a person must weed the paddy field free of charge to have the right to harvest the grain. After threshing and cleaning the person however receives 15% of the clean paddy as his share. This practice accounted for the sole use of manual labor for threshing (table 8) which deprived the farmers or landowners in the region of the choice of any threshing equipment. But the farmers indicated that labor is abundant in the area and that this practice assures the prompt harvesting of the crop. In North Cotabato owners of power tillers hired for rice land preparation have the right to thresh the grain. Farmers have to separately hire labor for the harvesting operation. The tiller owner, who usually owns a thresher, receive payments for the two operations after the grain is cleaned. The threshing fee alone is 8% of the cleaned paddy.

Most farmers interviewed in Camarines Norte and North Cotabato used mechanical threshers. Although many were tenants with majority farm holdings of 0.1 to 6 hectares (table 9), a substantial percentage of them were thresher owners. This accounted in part for the lesser demand of custom threshing in the area.

Some problems that hindered the wider use of mechanical threshers were also identified in the study. One was the lack of a functional and economical machine that can thresh high moisture paddy. Wet season harvest was often difficult to thresh because the machines usually clogged and did not do a good cleaning job. Another was the heavy machine weight. A highly mobile machine that can be carried by 3 to 4 men in the field was found desirable. It is interesting to note that farmers in Camarines Norte used only the simple single-drum type threshers. Farmers interviewed indicated that they use whichever machine was available. The presence of manufacturers in the area producing the particular machine served to corroborate this finding.

Selected areas in the Visayas and Northern Luzon will also be studied. Preparation is underway for the continuation of the survey in this project.

Comparative evaluation of different threshers in the Philippines

A field study of rice threshers used in the country was made to determine the type best suited for small- and medium-size farms. This report covers only the performance data obtained from tests conducted in Southern Luzon and Mindanao provinces. All tests were conducted at farmers field to ascertain actual machine performance.

The following procedure was followed in conducting the tests:

1. Prior to each test, a study of the machine characteristics and manufacturers' data was made. Other pertinent observations were also recorded.

2. Preliminary threshing operation of 1 to 3 minutes duration was made to stabilize machine operation and feeding rate. This was followed by test runs where data on test duration, threshed grain, straw, chaff and other unfore-

mation were taken.

3. On completion of each test run, separation, unthreshed and blower losses were recorded.

4. Grain moisture content, material length and grain-straw ratio were also measured.

Separation loss is the weight of the detached grain that went with the straw. Unthreshed loss is the weight of the grain that remained attached to the panicles after threshing. Blower loss is the weight of the grain collected at the blower exhaust. The percentage of each loss was based on the total weight output for the test duration.

Grain moisture content was measured with a grain moisture meter. The material length and grain-straw ratio were measured to approximate the material condition because it was difficult to measure straw moisture content in the field.

The threshing machines found in the area surveyed were all of the throw-in kind which could be classified into four general types (fig. 26), viz:

Type I	Single-drum, without blower and separator
Type II	Double-drum, with single blower and no separator
Type III	Double-drum, with single blower and separator
Type IV	Single-drum, with single blower and separator.

Types I and III machines threshed the material within a three-quarter turn of the drum circumference permitting faster feeding without choking the engine. In Types II and IV machines, however, the materials were retained longer which dissipated engine power.

All four types of threshers were tested. The harvested paddy used in the tests had a grain moisture content of 18 to 25% w.b., and grain-straw ratio of 0.46 to 0.65. Although the grain-straw ratio affected performance, this factor could not be controlled as available materials from the site had to be used for the tests.

Thresher efficiency was found to be directly related to (1) peripheral velocity of the threshing teeth, (2) length of material exposed to the threshing action, and (3) the concave clearance with threshing teeth. The capacity per horsepower was highest for Type I machine (table 10). But this machine did not completely thresh the grain as shown by the high unthreshed losses. Also, the lack of a separating mechanism and the smallest concave area accounted for the highest separation loss of 56% in the machine. The losses for Types III and IV machines, with separating mechanisms, were only 4.0 and 2.7%, respectively. The presence of a blower affected the overall performance of the threshers (Type I has no blower). Blowers of Types II and III machines generated high air velocity to blow about 23 to 38 percent of the grain. Most farmers recycled the material accumulated near the blower exit to recover the lost grain. This process, however, consumed time, effort and fuel. The relatively

low purity of Type I threshing machines required further cleaning to make it acceptable for commercial purposes. Type IV machine had an optimum air velocity, allowing a blower loss of only 1.5%. Again grain output per man-hour was the highest in this machine. It appeared, therefore, that the Type IV machine is one which combines high output per horsepower and per man-hour with minimum of losses.

The data relating to other aspects of use of these machines are being analyzed and will be reported later.

Modified rotary grain cleaner

A report from our subcontractor, the Taiwan Agricultural Research Institute (TARI), indicated an 8.3% higher output from the rotary grain cleaner when the auger type feed was replaced with a gravity flow system. The modification simplified the machine and eliminated many parts such as the auger, two bearings, step pulleys and V-belts. The report also stated that no grain damage occurred when the material was cleaned with the modified cleaner. To verify the TARI findings, a rotary grain cleaner with an auger type feed was converted into a gravity flow feed machine. This machine was tested with paddy that was threshed manually. The threshed paddy contained chaff and other impurities from 5 to 15 cm in length with an average purity of 3.25%.

During preliminary trials, it was observed that the inner screen could not adequately separate the grain from the impurities when the hopper opening was greater than 5 cm. This resulted in grain overflowing from the end of the rotary screen. The gravity feed had a tendency of non-uniform feeding whenever larger impurities were passing through the opening. This was unlike the auger conveyor where positive feeding was obtained and precise feed setting was possible through the step pulley auger drive.

Based on preliminary trials, the feed opening in the hopper was set at 5 cm to obtain maximum cleaning output. The average output obtained was 1.02 tons per hour (table 11) which was lower than the rated minimum capacity of 1.5 tons/hour of the original machine. Although the output was low, the modified machine had the advantage of less grain damage, ease of service, and greater safety in operation. The modification also resulted in less moving parts that would enable more economical fabrication for the machine.

Evaluation of commercially produced machinery

5-7 hp tiller

The popularity of the 5-7 hp tiller in the local market influenced a manufacturer of metal hinges to start manufacturing IRRI-designed machines. Although very new in the line of agricultural machines, the manufacturer's commercial model of the power tiller submitted for test and evaluation showed excellent workmanship. The machine was tested according to the standard procedure for endurance testing of prototype models. The tiller gave satisfactory performance throughout the test duration with no component broken. Minor complaints of the operator were the faster speed compared with the other tillers

previously tested and the loosening of the flange bolt at the left hand side of the main axle which had to be tightened frequently.

When the main housing of the tiller was disassembled for final inspection, it was found that the difference in speed was due to the deviation from the original IRRI design on the sprocket drive reduction. The sprocket drive on the second reduction had 14 teeth instead of 13 and the number of links was found to be 49 instead of 48. This resulted in higher rpm of the main axle.

A test report was sent to the manufacturer so they can incorporate in their subsequent units remedies for the defects noted.

Different types of huskers

A study was conducted to evaluate the performance of four rice hulling machines, representative of those used in many Asian countries. The four units studied were two of rubber roll type (fig. 27a), a centrifugal type (fig. 27b), and an under-runner disc type huller. Rice hullers are usually equipped with aspirators, pre-cleaners, paddy separators, etc. However, in this study only the performance of the hullers was covered.

In a rubber roll huller, the hull breaks and is stripped off by combined pressure and friction force exerted on the grain due to the small clearance and the differential speed between the rolls. The centrifugal huller utilizes centrifugal force to impel the grains against a resilient lining. The under-runner disc huller has two horizontally-mounted cast-iron discs coated with an abrasive layer. The clearance between the two discs can be adjusted by means of a handwheel connected to the lower rotating disc. When the paddy is fed in the center of the upper disc, the grains are forced outward and are hulled under pressure and friction.

Table 1 gives the specifications of the four hullers used for this study.

A procedure developed by Kuprits[1] was adopted for the evaluation, in which a huller's efficiency is determined by the amount of rice hulled and the proportion of whole kernels. These are expressed in terms of a coefficient of hulling, E_h, and a coefficient of wholeness of kernel, E_{wk}. The efficiency of a huller, μ_h, is then:

$$\mu_h = E_h \times E_{wk}$$

The paddy used was grouped into four samples with a moisture content range of 12 to 14 percent. The paddy in each group was thoroughly mixed, and cleaned to approximately 98% purity in all samples. Before conducting the main test runs, three to four trial runs with each sample group were carried out for setting up the machines and finding out the proper adjustments. The sample

---

[1] Technology of Grain Processing and Provender Milling, Israel Program for Scientific Translations, Ltd., Jerusalem, 1967. pp. 182-187.

size for each test run was determined on the basis of about two minutes running.

After each test run, one kilogram of subsample was taken to analyze the whole hulled kernels, broken kernels, unhulled kernels, and impurities. The coefficient of hulling and coefficient of wholeness of kernels were then computed.

Summary of results obtained is shown in table 13. The analysis of variance indicated that the difference in efficiency between hullers was highly significant. The rubber-roll huller with relatively low capacity showed the highest efficiency. The difference between the two rubber roll hullers may be attributed to constructional differences.

The centrifugal huller had the highest coefficient of hulling but the coefficient of wholeness of the kernels (E_{wk}) was the lowest among all machines. This indicates that although the hulling rate of the centrifugal huller is very high, it produces many broken grains. The coefficients of wholeness of kernels of both the rubber-roll hullers were high compared with those of other types of hullers.

Based on these results, it may be said that the rubber-roll hullers have higher efficiency than the other two types of hullers. Economic analysis of the different types of hullers will be made in further tests.

Different types of polishers

This study was made to evaluate and compare the performance of six commercial whitening machines. The usual auxiliary equipment such as bran aspirators, elevators, graders, etc., were not included in the tests.

The whitening machines used in the rice processing industry in Asia may be classified into five general types, viz: Type 1 -- horizontal friction; Type 2 -- horizontal friction-air jet; Type 3 -- horizontal friction-abrasive; Type 4 -- vertical abrasive cone; and Type 5 -- horizontal abrasive cylinder. In this study, two Type 1, two Type 2, one Type 3, and one Type 4 machines were only tested. These whitening machines are shown in fig. 28 and 29 and their specifications are listed in table 14.

A rubber-roll huller was used to obtain the brown rice samples. Three passes in the huller gave near 100% purity for the samples. Table 15 shows the information on the sample by group. Trial runs with each sample group were carried out to familiarize with the operation of the machines. The sample size for each test run was based on two to three minutes' running. Before each main test run, a trial run was also conducted to remove the remainder of the milled rice inside the whitening chamber and to fill the empty space with the same sample as the one to be tested.

After each test run, the weight and temperature of milled rice and weight of bran were recorded. During the test runs, representative samples of the products were taken and analyzed for head rice, broken grains, impurities,

and unhulled grain. The degree of whiteness of the milled rice was measured by the Kett whiteness meter. A statistical analysis of the total and head rice recovery was made.

The results show that the difference in the percentage of total milled rice recovery between the different types of whitening machines was not significant. However, the Type 2 (2) machine produced significantly low head rice compared with others except against the machine of the same class (table 16). The whitening machines equipped with abrasive roll (Type 3 and 4) in general showed a comparatively high head rice recovery. Type 2 machines had the highest hourly capacity per HP rating and Type 1 (2) had the lowest (table 17). However, the latter machine had a relatively higher head rice recovery than other whitening machines. Also, machines equipped with weight-loaded or spring-actuated discharge regulators were found to be very sensitive to the feed rate and to the load acting on the valve.

Further investigations for improvement of performance and economic analysis of these machines are planned.

Rice hull furnace

The rice hull furnace, reported earlier, is now being manufactured by two manufacturers in the Philippines. Interest in this furnace is gaining because of the increasing cost of petroleum fuels. The manufacturers have also made modifications on the basic IRRI design. Their furnaces are lighter with less fire brick linings, and have provision for easier initial firing.

During this reporting period, a prototype furnace from one manufacturer was evaluated in conjunction with the IRRI batch type dryer. Two hull feeding rate trials were conducted to determine consumption and drying air temperature generated. The drying bin was loaded with 15 cm depth of wet grain. The blower delivered 2400 CFM of air at an ambient temperature of 28.3°C. All noticeable defects of the furnace were recorded.

The trials indicated that the furnace can generate sufficient heat to dry one ton of paddy from 25 to 14% moisture content in 3.5 to 5.5 hours. This assumes 12,000 BTU/kg heating value of rice hull and 3080 BTU to vaporize a kilogram of water from the grain.

In the first trial where hull stoking was done every 3 minutes, the heated air temperatures ranged from 43.3° to 55.5°C at a hull consumption of 9 kg/h. However, the higher drying air temperature attained in such feeding is seldom used in a batch dryer. Defects listed below were observed in the furnace, especially when the hull stoking was done every 3 minutes.

1. The fire brick linings were reduced to the extent of directly exposing some sheet metal parts to the burning hull which were subsequently damaged.

2. The burning of the hull progressed into the neck of the hopper as it was located directly above the furnace. This was considered a fire hazard.

3. The ash grate was made of light-gauge steel material and buckling oc-

curred during the tests.

4. A large quantity of ash was sucked by the blower because of improper baffle arrangement inside the furnace.

Test results and recommendations for improvements were sent to the manufacturers. Subsequent design improvement was made by the manufacturer and the modified furnace is now in commercial production.

Evaluation of laboratory rice milling equipment

Laboratory rice mills are used to determine the milling recovery of samples from a batch of paddy for marketing, experimental work and performance evaluation of commercial mills. The performance of these mills and the proper determination of the corresponding milling recovery are of high economic importance. Milling recovery is evaluated by the quantity (total rice) and quality (head rice) recovered from the paddy sample. The laboratory mill must be able to perform reproduceable results without adversely affecting the quantity and quality of milled rice.

There are many machine variables that affect milling, namely: the principle involved, kind of milling surface, clearance, speed, feeding rate, grain residence time inside the machine, pressure developed inside the machine, and the method of by-product separation. The performance of various kinds of laboratory hullers and polishers available in the market varies depending upon these variables and the provisions made for their adjustment.

This study was initiated to determine the effect of operating characteristics and variable milling factors in laboratory hullers and polishers, to identify design parameters and to make recommendations on the proper selection and use of laboratory hullers and polishers.

Several types of laboratory machines are planned to be studied but only the following have been covered during this reporting period:

1. Rubber roller huller - two rubber rolls, rotating at different speeds in opposite direction, separate hulls by shearing action as the grains pass between the small clearance of the rolls.

2. Friction polisher separately used as husker and polisher

3. Emery polisher - an emery wheel enclosed in a metal housing with perforated screen at the periphery. Grain is fed at the center in batches.

For each machine used, the recommendations of the manufacturers on the proper operation, adjustments and sample size were followed. Pertinent information about the machines were recorded before the test. Several passes were made on the hullers until the paddy was totally hulled. Data were taken after each pass. Hulling efficiency, head and broken rice were determined. Polishing time was the main variable in the polisher. Total and head rice recovery were determined from the milled samples. Whiteness of the milled rice was obtained by using a Kett whiteness meter.

IR1561 paddy harvested from one of the IRRI plots, dried in batch dryer to 13.3% with a purity of 95%, was used in the study.

Preliminary tests carried out indicated the following:

1. The rubber roller huller had 91.12% husking efficiency with 7.56% broken grains in the first pass (fig. 30). Negligible amount of paddy was observed after the second pass. The head rice recovery was 70.65% and 7.72% broken grain. Negligible variations in the head, broken, and total recoveries and no bran removal were observed in the succeeding third and fourth passes.

2. Result on the friction polisher used as huller (Engleberg mill principle) showed that hulling was completed after 15 seconds (fig. 31). The brown rice (total rice) of 70.25% and head rice of 43.08% indicate that the process does not only remove the husk but also the bran. The low head rice recovery show the bad effects of friction husking on the grain.

3. Using the above friction polisher (Engleberg principle) to whiten the brown rice showed that polishing was effective in the first 30 seconds. Abrupt increase in grain breakage starts after one minute and a slight reduction in total recovery was observed (fig. 32). This indicate that friction polisher is effective within the first 30 seconds after which the grain just slides and breaks afterwards.

4. The performance of the emery disc polisher was affected by the polishing time, stone roughness and speed. Total and head rice recovery decreased with increased polishing speed and time. Rough stone surface scours the grain surface more, resulting in decreased total recovery, head rice recovery, and increased whiteness of the grain.

Further work is being conducted on other laboratory machines. Detailed report will be prepared on completion of performance tests of all other machines under this study.

Compacted soil pan studies in continuously cropped wetland rice

This project was initiated in 1973 to study the long-term effects on soil compaction when using large four-wheel tractors, power tillers and animals for land preparation under continuous cropping conditions. It is believed that many years of continued land preparation with animals increases the hardpan depth in rice paddies. Eventually the soil pan becomes so deep that tractors cannot be used in such fields for land preparation. A study was undertaken to establish the effects on hardpan depth due to use of different tillage equipment. One field with Maahas clay soil was selected at the IRRI farm and was divided into four sections. Soil compaction was initially recorded in this experimental field at two core penetrometer pressure settings of 2.46 and 4.92 kg/sq cm. Table 18 and fig. 33A indicate the variations in the depth of the soil pan layers at these two pressure settings. The difference is attributed to difference in previous land preparation.

Data have been kept on the soil pan depth at these two settings for the

last three cropping seasons. Significant increases in soil pan depth has been observed with all treatments on the first two cropping seasons after each land preparation. Figure 33B indicates that the deepening of the compacted soil layer for both penetrometer pressure readings was maximum with the large tractor and minimum when the small 5-7 hp tiller was used for land preparation. The depth of the compacted layers shows a stabilization tendency on the 5-7 hp and 10 hp power tillers, on the third cropping season. Stabilization rate within cropping season on 5-7 hp power tiller treatment is faster than with the 10 hp power tiller. The hardpan continues to deepen with the animal and large tractor treatment without any tendency to stabilize so far. The experiment is continuing and more detailed data will be reported in the future.

ECONOMICS OF MECHANIZATION

Economic and Technical Evaluation of Rice Processing Facilities in the Philippines

Detail of this study has been reported previously and the present report will briefly discuss some preliminary findings from two of the survey areas, Central Luzon and Camarines Sur

A. Survey of Post-Production Practices Among Rice Farmers in Central Luzon

The study is confined to the results obtained from an analysis of the farm level data. The specific objectives of this study are: (a) analyze the harvest and post-harvest practices of farmers and their effects on the timing of operations and the quality and quantity of milled rice; (b) examine the reasons behind a farmer's choice of a particular type of mill; and (c) analyze the demand patterns for alternative milling services.

Post-Harvest Practices

Low yields and output levels resulting from economic, technical or environmental causes may be further aggravated by antiquated, wasteful techniques of post-production grain handling, processing and marketing. These losses (both quantitative and qualitative) take place at various stages of the harvest and post-harvest operations which amounts to 25 percent [1] While this figure may represent an extreme case, the magnitude of post-production losses makes consideration of their causes, pattern and eventual control a matter of primary concern

The rice farmers surveyed in Central Luzon are still using traditional methods in their post-harvest operations Harvesting is commonly performed with the use of scythe or sickle Harvested stalks are either laid loosely on the ground, bundled or stacked in a variety of ways to facilitate drying. The length of drying depends on local weather conditions, the general practices in the area and the type of thresher to be used

The most common method of threshing is with the use of the McCormick type thresher or "tilyadora" (Table 19) Farmers using this type of thresher usually depend on the machine to clean their threshed paddy. Paddy threshed by hand or animal treading are usually cleaned with the use of winnowing basket or "bilao".

Solar drying is the only method practised by farmers studied in Central Luzon. There are two methods of sun-drying reported In the first, the paddy is harvested and left to dry for several days in the field in loose bundles,

[1] NGA Grains Service Centers. Proposal prepared by the Directorate for Technical Research and Services, National Grains Authority, Manila, Philippines, 1974.

shocks or "mandala". In the second method, the high moisture grain is spread under the sun immediately after threshing using several drying surfaces such as concrete pavement, mats, plastic sheets, canvas, etc.

Paddy for home consumption are either stored in sacks, large bamboo baskets, cans or drums, small granaries or bodegas or special rooms within the house where paddy is stored in bulk (Table 20). The paddy for sale are either stored in the farmer's house or bodega or the marketable surplus is immediately sold following harvest. Only 21 percent of the farmers studied utilized the warehouse of the mill for storage.

Laboratory Analysis of Paddy Samples

The post-harvest practices that have just been discussed tend to indicate that processing is but one component of a system of operations which incurs losses and one which cannot be isolated from the effects of other operations which precede it (harvesting, threshing, handling, drying and storage).

The results of our analysis of paddy samples taken from 111 rice mills located in three regional areas of the Philippines tend to support this hypothesis.[2] The results of this sample study indicate that a number of the factors causing losses occur in operations preceding the actual milling of paddy. The accompanying table of Figure 1 shows that the paddy samples contain a relatively high percentage of foreign matter, a factor which in the absence of adequate cleaning equipment at the milling plant would reduce milling recovery and cause further wear and maintenance problems to the equipment. A further analysis of the pure paddy reveals the presence of a high percentage of cracked, damaged, fermented and immature kernels, all of which result from poor harvesting, threshing, handling and drying practices. Poor seed selection or production management is also indicated by the presence of mixed varieties and red rice in the sample.

A more meaningful evidence regarding the quality of paddy is shown in figure 34. The sample is segregated into six grade classifications used by the Philippine Government to assess quality. Only one-third of the sample fell into the upper three classifications categorized as high quality. The bulk or three-fourths were graded as low quality and one-third fell into the lowest or substandard category

Preference for Alternative Milling Technologies

Alternative milling technologies in this study is limited to the two most common types of rice mills used in the country; the steel huller or engleberg mill locally known as "kiskisan" and the disc huller or "cono" type of mill.

---

[2]We would like to acknowledge the assistance provided by Mr. Harry van Ruiten of the UPLB/UNDP/FAO Grain Processing Training Center for the analysis of these samples and the subsequent interpretation of the results.

"Kiskisan" is the type of rice mill whereby the hull and the bran are removed in one operation in solid fluted cylinder rotating within a hollow cylinder, the upper half of which is made of cast steel and the lower half is made of perforated sheet metal. Milling process is accomplished by the shearing action of the cylinder ribs against a blade whose clearance from the ribs can be adjusted.

In contrast, the "cono" type of mill has a separate section for the removal of the hull and bran. The hulling unit consists essentially of two cylindrical discs coated with emery stones, with the upper disc stationary and the lower one rotating. Contact of the grain with the two stones removes the husk from the grain. The pealing or scouring section where bran is removed consists of an inverted cone coated with emery stone which rotates in a housing with rubber brakes and perforated screen. The machine removes the bran by a carefully controlled abrasive action on the brown rice which occurs between the emery stone and perforated screen while the milled rice passes out at the bottom.

Reasons for using "cono" or "kiskisan" mill. Both cono and kiskisan users ranked availability and accessibility of the mill to be their main criteria for choice (Table 21). However, a difference of opinion was observed as regards the second most important reason for choice; high milling recovery for cono users and type of product most demanded in the case of "kiskisan" users. This indicates clearly the farmer's pattern of expectations regarding the performance characteristics of the mill they use, i e., "cono" users expect better head rice recovery while "kiskisan" users seem resigned to accepting more brokens and less head rice but a higher output of bran, brewers' rice and ground hulls for their livestock.

Farmer's attitude in using alternative mills. Farmers who commonly use a "cono" for their milling services usually use a "kiskisan" as a substitute whenever the "cono" is out of order, busy, etc. (Table 22). Moreover, the farmer shifts to "kiskisan" whenever he needs more by-products, more nutritious rice or when he has only small quantities of paddy for milling. "Kiskisan" users, on the other hand, shift to a "cono" whenever the "kiskisan" mill they commonly use is busy, out of order, etc. Moreover, when the farmer needs better quality rice for sale or when his paddy is not well-dried, he turns to a "cono" mill as the alternative.

B. Utilization of Improved Rice Processing Facilities in Camarines Sur

Camarines Sur is a major rice producing province in the Bicol region. Although it is considered as a rice bowl, the majority of the farmers still use traditional practices in harvesting, threshing, drying, storage and warehousing.

This study aims to probe on the extent to which the farmers use improved processing technologies[3] through an assessment of the degree of utilization of such facilities.

Post-Harvest Practices of Farmers

Traditional practices are still used by the farmers in their post-harvest operations. Threshing is manually done with the use of threshing frame or "hampasan", flail or stick and feet treading (Table 23).

Paddy is cleaned with the use of a winnowing basket or "bilao". The chaff, dirt and other impurities are removed from the grain with the aid of natural wind. Some farmers supplement the natural breeze with the use of axial flow fans while others use mechanical blowers.

Solar drying is predominantly practised in the area whereby paddy is spread out under the sun using several types of drying surfaces such as concrete pavement, mats, plastic sheets and canvas (Table 23). Although there are some private millers owning mechanical dryers, these are used primarily for their own paddy.

Farmers seldom use the commercial storage facilities available in the area. They usually store their crop in their houses since their production is only sufficient for their own consumption. In case of surplus, paddy is sold immediately after harvest. The storage containers commonly used are sacks, wooden boxes and baskets.

The most common type of mill used by the farmers is the engleberg or "kiskisan" mills as reported by 52 percent of the respondents. This was followed by a combination of "cono" and "kiskisan" mills, 35 percent, and "cono" mills, 12 percent.

Disc cone hullers or "cono" type of mills are generally preferred by farmers if they have bigger volume of paddy for milling and the milled rice is to be sold commercially. The farmers turn to an engleberg or "kiskisan" mill when the paddy is intended for home consumption and the quantity involved is very small.

---

[3]Improved processing technology is defined in this study as those used and/or to be used by farmers and millers other than what have been traditionally used. These include mechanical threshers, mechanical dryers, warehouse and storage facilities and rice mills. Considered as traditional or conventional facilities are the use of "hampasan" or threshing frame, flail or stick, manual or animal treading in the threshing operation; the use of the farmer's house or farm sheds for storage and the use of concrete pavement, mats, plastic sheet, etc. for solar drying.

The Potential for Mechanical Threshers and Dryers

Mechanical threshers. Of the 193 farmers studied, only 35 percent are potential users of mechanical threshers (Table 24). Forty-one percent are not interested and the other 24 percent require additional information on the performance and cost of the machine before arriving at a decision.

The farmer's lack of interest in the use of mechanical thresher was attributed to several reasons such as presence of adequate labor for harvesting and threshing, the tie-up of harvesting and threshing labor with other farming operations, the limited size of farm and low production and the possible displacement of threshing labor with the introduction of mechanical thresher which arouses sympathy from the farmers.

Mechanical dryers. There was a greater demand for mechanical dryers than threshers as exhibited by 76 percent of the farmers signifying interest in its use (Table 25). The farmer's willingness to adopt improved drying technology seemed to be related to the sizeable volume of paddy lost due to bad weather which caused rotting and discoloration of grains during the last season. Even the stored seeds were affected by the long rainy season during crop year 1972-73.

Utilization of Warehouse and Rice Mill Facilities

Utilization of warehouses. Storage and warehouse facilities were found to be under-utilized. Large warehouses were utilized only at an average of 18 percent of their capacity, medium warehouses, 21 percent, and small warehouses, 40 percent (Table 26). Under-utilization was either due to lack of paddy to be stored in 1973 or the fact that farmers seldom use them. Moreover, it was observed that there was an excess in available storage space that even if the total production of the province (7.6 million cavans) were tripled, the existing storage capacity would have been sufficient.

Utilization of rice mills. The usual rated capacity[4] of the mill was found to be hardly attained by millers even if there was available paddy. The reduced efficiency can be related to several factors such as loose compression and low horsepower of the engine, improperly cleaned and dried paddy and defective milling apparatus.

By type of mill, "kiskisan" mill was utilized only at an average of 12 percent monthly and "cono" mills, 26 percent (Table 27). The higher utilization levels of "cono" mills could be partially explained by the fact that aside from custom milling, most of these mills perform trading.

In terms of total volume milled, "cono" mills get a bigger share than the "kiskisan". Of the estimated 2 million cavans of milled paddy, 0.8 million was from "kiskisan" and 1.2 million from "cono".

[4]Whereas rated milling capacity refers to the specification of the manufacturer expressed in number of cavans paddy milled per 12-hour operation, actual capacity refers to the actual maximum number of cavans paddy that could be milled in 12 hours.

WORK PLAN

JANUARY 1 TO DECEMBER 31, 1975

MACHINERY DESIGN AND DEVELOPMENT

Steering clutch, 5-7 hp tiller

An improved design of the external steering clutch will be developed and field-tested. Upon satisfactory results, the design will be released to manufacturers. An alternative split-axle design of the steering clutch will be explored.

8-14 hp tiller

Technical assistance and advice will be provided to the manufacturers who are planning to produce this tiller in the Philippines. Design improvements and other refinements will be made as the manufacturers' prototype machines are evaluated.

Small four-wheel tractor

Modifications on the small four-wheel "Economy Tractor" are continuing. A lightweight diesel engine will be mounted on this tractor and arrangements will be made to seal some of the components that are immersed in mud during operation.

Extensive field tests will be conducted to evaluate its performance and the basic requirements for a four-wheel tractor fow wetland cultivation will be established. After the completion of the tests with the existing machine, a new tractor will be designed with maximum use of locally available components and with greater attention to simplifying the fabrication process.

Deep-placement liquid injector

A final field test of the liquid injector is being conducted to compare its performance with manual broadcast against the deep-placement granular fertilizer applicator. A separate test will be conducted to determine the speed of application, ease of handling and operation. Smaller-diameter wheels and lighter gauge materials will be used to reduce the machine weight.

Deep-placement granule applicator

A prototype unit has been developed and is being evaluated in comparison with the deep-placement injector and manual broadcasting methods. Engineering drawings have been sent to four local manufacturers and tests will be conducted on the manufacturers' machines before release for regular production.

Jet pump attachment

Studies on the centrifugal-jet pump combination will be continued. This study is devoted to optimizing the design variables for the jet pump

attachment. Various physical proportioning of components will be tried to obtain maximum efficiency for a low-cost jet pump. Efforts will be made to encourage local production in the Philippines. The data obtained in the above study will be used in the preparation of a Ph.D. thesis.

Tubular pump

Different-sized tubular pumps will be designed and the diameters and lengths relationships between the delivery arm and the suction pipe will be established. Based on these relationships a pump will be designed for installation at the IRRI farm. This pump will be coupled to an optimized Savonius rotor type vertical-axis windmill.

Vertical-axis windmill

Different forms of Savonius rotors and the NRC rotors will be evaluated and some new concepts of vertical-axis rotors will be tried. On completion of the the evaluation and experimental phase, an optimum windmill design will be developed.

Mechanical scoop

Moving water over short distances and heads with a scooping mechanism will be evaluated. A small four-bar linkage mechanism will be made to determine correct four-bar linkage that would approximate the scooping movement. A small engine-driven prototype water scoop will be built.

Drilling rig

Studies on low-cost portable drilling equipment will be initiated. There is a need for a low-cost, portable, fast-drilling equipment for shallow levels for operation by two persons. After a review of present equipment, attempts will be made to either adapt existing designs for local production in Asia or develop new designs to meet the needs of Asian farmers.

PTO thresher

Additional experiments will be conducted to determine the neutral zone on the straw thrower housing. Pressure and velocity readings in the straw thrower along the vertical axis have already been taken and a neutral zone has been established. Further experiments will be performed to collect data along the horizontal axis and in the thrower outlet to determine the zones where the material can be conveniently introduced into the thrower without creating [illegible] back pressure. If the present cleaning of the spike and thrower cannot be improved, alternate grain cleaning approaches will be investigated.

Stripper harvester

Tires with self-cleaning lugs will be installed to improve traction. Simulated field testing will be continued after the extra openings through which grain is now being ejected are closed and some other improvements are completed.

Extensive field tests will be performed to evaluate the performance of the lifting fingers on lodged crops. The present lifting fingers are screwed on a roller chain to lift lodged crops and guide them into the gathering bars. Observations will be made to check if the guiding action contributes to unnecessary threshing. If so, the upper end of the lifting finger mechanism will be lowered to eliminate contact with panicles.

A possible alternative for the efficient utilization of the mechanism is to use the front finger to lift lodged crops and use the rear finger to feed the crop into the gathering bars. This concept will eliminate the continious link of fingers on a chain, prevent threshing between the two fingers, and save about 20 percent weight on the mechanism.

Oscillating grain cleaner

A second prototype grain cleaner to suit the cleaning needs of the threshing floor and local farms will be developed. This cleaner would be a lighter machine which could be carried by two men, with an output of about 1 ton/h. Field testing and demonstration will be undertaken to evaluate the design and to obtain farmer comments. Upon satisfactory result, the design will be released for manufacture.

Centrifugal huller

It has been observed that in the horizontal-shaft centrifugal hullers, only a quarter of the impact surface is utilized for hulling. In vertical-shaft centrifugal hullers, however, only a narrow strip of the impact surface is used for hulling. In both cases, the wear on the impact surface is not uniformly distributed. The centrifugal huller performance can be improved if the wear could be more evenly distributed on the impact lining. A project will be started to explore possibilities for maximizing centrifugal huller efficiencies. An experimental centrifugal huller will be designed to test the principal components such as impeller and impact lining using different materials and orientation angles with respect to the impeller. Dual impact lining moving at different relative speeds will also be tested for hulling performance.

Solar collector for IRRI grain dryer

Further testing of the plyboard solar heat collector will be continued. The development of additional flat-plate collectors using different low-cost materials such as cardboard will be undertaken.

TEST AND EVALUATION

Power tiller survey

Initial survey results from three areas of the country provided an insight on the power tiller problems, distribution, use, and manufacture. The survey will be continued in other areas of the country. Data obtained from the previous survey will be analyzed for additional information.

Thresher survey and performance test

Test and evaluation will be extended to other places representing the country. Data gathered will be further analyzed for additional information on the machine. Plans are also underway to evaluate bigger harvesting and threshing machines.

Engleberg mill

Work will continue to determine the best combination of the modified parts for optimum performance. Test will also be made on the experimental one-pass mill to determine its performance and effect of the variable milling factors. Field testing of modified parts will also be started.

Rice mill evaluation

Evaluation of laboratory rice mill and commercial hullers and polishers will be continued. Attempt will be made to determine the performance gap between the laboratory and commercial mills.

Test of IRRI machines

Tests will be conducted on production prototypes of IRRI machines which have been released to manufacturers. Test results will be forwarded to the manufacturers so that the recommended improvements can be incorporated in the commercial units.

ECONOMICS OF MECHANIZATION

Economics and Technical Evaluation of Rice Processing Facilities in the Philippines

Work will be continued on the tabulation, analysis and interpretation of the farm and mill level data. The third phase of the study will start in February. This will involve a detailed engineering appraisal of a sub-sample of rice mills surveyed in the first phase of the study. As an adjunct to the project, a study on marketable surplus will be done on a limited sample of rice farmers included in the second phase. The objective of this study is to identify the factors that influence the supply of paddy sold to the market with specific reference to those variables over which the farmer can exercise some degree of control.

The Potential of Mechanizing Upland Cropping Operations

The objective of this study will be to assess the extent of and the potential of mechanizing upland cropping operations. It aims to explore the possibilities of developing technically and economically suitable equipment that will selectively meet the requirements of the upland cropping systems.

The study will involve a survey of farmers in the upland areas of Batangas, Cavite and Laguna. Farmers will be asked questions regarding the crops they grow, the production and disposal, the amount of labor required for different farm operations, the tools, equipment and farm inputs used, the market outlets, the sources of credit, etc.

Stratified random sampling with provision for replacement will be used in the drawing of sample farmers. Farms will be stratified into three levels based on the size of the farm (HaC.): (a) 2.0 hectares and below; (b) 2.1-4.0 hectares; and (c) 4.1 hectares and over. The study will cover the wet and dry seasons of crop year 1973-74.

The survey will be made soon after the questionnaires and sample frame have been finalized.

Regional Mechanization Study

This study will attempt to gather and present information describing the present level and pattern of mechanization in twelve countries throughout the Asian region. It will include an analysis of the factors which have affected the use of mechanization in the area and the impact of these programs on the adoption of particular strategies.

The countries that will be included in the study are some of the developing countries in the region such as Korea, Thailand, Malaysia, Indonesia, Philippines, Taiwan, India, Sri Lanka, Vietnam, Burma, Laos, Pakistan and the Khmer Republic. Japan, being the most developed among the Asian countries, will be used as basis for comparison

The Production and Marketing of Hand Tillers in the Philippines

Data from a number of previous and on-going studies in the Department will be synthesized and consolidated to have an insight on the production and marketing aspects of hand tillers in the country. Specifically, the study aims to: (a) examine the physical characteristics of hand tillers and their degree of performance; (b) determine the economics of ownership and operation of this machine through an analysis of the costs involved (initial capital investment, fixed, variable and comparative costs), (c) know the field repair and maintenance problems incurred; (d) compare the technical and economic performance of bullocks, hand tractors and 4-wheel tractors, (e) look at the marketing profile by examining the sales pattern, regional distribution and prices; and (f) determine the manufacturing requirements of the machine.

PERSONNEL LIST

Personnel and their respective man-months engaged on the project during the past six months, July 1 to December 31, 1974:

Position	Name	Fr: 7- 1-74 To: 12-31-74
Agricultural Engineer & Project Leader	A. U. Khan[a/]	4.5
Assoc. Agricultural Economist	B. Duff	6
Visiting Assoc. Agricultural Engineer	C. C. Lee	6
Assistant Design Engineer (Design)	Open	0
Assistant Design Engineer (Processing)	Open	0
Senior Research Assistant (Design)	J. Arboleda	6
Senior Research Assistant (Design)	N. Navasero	6
Senior Research Assistant (Test & Evaluation)	C. Padolina	6
Research Assistant (Design)	G. Espiritu	6
Research Assistant (Design)	S. Gutierrez	6
Research Assistant (Design)	G. Salazar	6
Research Assistant (Test & Evaluation)	B. Ramos	6
Research Assistant (Economics)	Z. Toquero	6
Research Aide (Test & Evaluation)	L. Villamayor	2
Research Aide (Economics)	V. Cueno	6
Research Aide (Economics)	C. Maranan	6
Research Aide (Economics)	F. Juarez	6
Research Aide (Economics)	E. Escover	6
Research Aide (Economics)	L. Ebron	6
Draftsman	F. Cabrales	1
Draftsman	B. Buan	6
Draftsman	N. Rivera	2
Secretary	E. Manalo	6
Secretary	C. Jizmundo	6
Shop Foreman	E. Dungo	6
Machinist	A. Dizon	6
Machinist	Z. Borja	6
Tinsmith	R. Santos	6
Tinsmith	C. Flojo	6
Welder	A. Barot	6
Shop Mechanic	M. Macatangay	6
Shop Mechanic	R. Dignadice	6
Shop Mechanic	P. de Mesa	6
Shop Mechanic	A. Camacho	6
Laborer (Shop helper)	M. Castro	6
Laborer (Shop helper)	E. Macatangay	6
Laborer (Student assistant)	L. Villamayor	4
Laborer (Student assistant)	W. Soguilon	5
Laborer (Student assistant)	E. Casanova	4

a/ Three-fourths time charged to the Contract.

Table 1. Effect of insecticide application methods on insect population in IR26 crop. IRRI, 1974.a/

Carbofuran treatment	Whorl maggot damage b/ 30 DT	Deadheart incidence (%) 50 DT	Yield t/ha
Imbedded gelatine capsules 2.5 cm from base of plant	0.00	0.06	4.486
Imbedded paper capsules 2.5 cm from base of plant	0.00	0.17	4.202
Liquid injection (IRRI injector) 0-N + carbofuran	0.00	0.12	4.417
Liquid injection (IRRI injector) 50 N + carbofuran)	0.00	0.17	4.507
Broadcast	1.75	5.56	4.399
Control	4.75	4.50	3.446

a/Carbofuran granules applied at the rate of 2 kg a.i./ha for broadcast treatments. Formulated 3% carbofuran granules contained in gelatin capsules and paper capsules applied at the rate of 0.4119 grams per hill. Wettable carbofuran mixed with starch gel in a more viscous solution was injected by the "grease gun" injector at the rate of 2 kg/ha. Wettable powder with starch slurry band-injected by the slurry injector at the rate of 2 kg a.i./ha without N and with 50 N, respectively. Low insect population except for whorl maggot.

b/On a scale of 0 to 5. Lower number indicates low infestation.

Table 2. Test results on different modifications of the Engleberg mill.[a]

Test number[b]	Recovery Total (%)	Recovery Head (%)	Rate (kg/h)	Blade clearance In (mm)	Blade clearance Out (mm)	Temperature °C	Whiteness
I. Original	69.53	25.48	288	2.46	4.60	41.1	24.8
II. (a,b,c,d)	70.87	32.93	206	5.72	7.11	46.7	23.6
III. (a,d)	68.13	27.90	192	2.46	4.60	51.7	25.4
IV. (a,e)	70.30	30.80	255	2.46	4.60	41.7	25.4
V. (a,f)	68.13	28.53	193	2.46	4.60	48.9	26.9
VI. (a,g)	70.73	24.23	256	2.46	4.60	40.6	25.5
VII. (a,h)	60.07	29.91	212	2.16	4.83	45.0	26.7
VIII. (a,i)	68.73	31.05	167	2.16	5.82	50.6	27.6
IX. (a,j)	69.73	34.47	196	2.16	5.82	45.6	26.0
X. (a,k)	65.07	25.97	203	2.46	4.60	42.6	24.1
XI. (a,l)	68.27	23.06	243	2.46	4.60	45.6	24.2
XII. (a,m)	67.33	24.14	249	2.46	4.60	45.6	26.0
Lab. milling	73.24	55.68	-	-	-	-	27.4

a/Data represent average of three milling test runs using IR1561 with 95% purity and 13.3% moisture content.

b/Letters in parentheses represent modifications on test mills:

a = Rice outlet changed from slide to weight-loaded gate.
b = Cylinder with two ribs and continuous spiral screw.
c = Lining insert -- a thin metal sheet placed beneath the top cover with four ribs slanted 15°, a full-length straight rib opposite huller blade, and inlet restriction.
d = Two strips with full-length ribs mounted on perforated screen.
e = New top cover fitted with semicircular perforated screen.
f = New top cover fitted with perforated screen bent three sides.
g = New top cover fitted with perforated screen bent four sides.
h = Blade with 2.38-mm depth cut 23 cm long from discharge end.
i = Blade with 3.18 mm depth cut 23 cm long from discharge end.
j = Blade with 4.76 mm depth cut 23 cm long from discharge end.
k = Screen with 1.19 x 12.70 mm oblong perforation.
l = Sectionalized cylinder (report #17).
m = Sectionalized cylinder (report #17) with the cylinder at the milling section installed inverted.

Table 3. The different power tillers used by the farmers, 279 respondents, Camarines Sur, N. Cotabato, and Laguna, 1974.

Brand	Camarines Sur		N. Cotabato		Laguna	
	No.	%	No.	%	No.	%
Imported						
Mitsubishi	-	-	64	71.9	12	16.4
Iseki	-	-	15	16.8	14	19.2
Suzue	-	-	4	4.5	-	-
Kubota	7	5.9	5	5.7	10	13.7
Honda	5	4.3	1	1.1	11	15.0
Landmaster	22	18.9	-	-	23	31.6
Yanmar	4	3.5	-	-	3	4.1
Local						
Buffalo	2	1.7	-	-	-	-
Pimco	7	5.9	-	-	-	-
Ciron	2	1.7	-	-	-	-
Magico	34	29.1	-	-	-	-
TMW	1	0.8	-	-	-	-
SM	33	28.2	-	-	-	-
Total	117		89		73	

Table 4. Reasons for selecting power tiller brands, 1974. Laguna, 73; Camarines Sur, 117; North Cotabato, 89.

Reasons	Laguna		Camarines Sur		N. Cotabato	
	No.	%	No.	%	No.	%
First machine introduced	32	43.9	12	10.2	33	37.0
Presence of dealers or manufacturers	21	28.8	92	78.6	26	29.2
Purchase cost is low	15	20.5	2	1.8	-	-
Availability of parts	5	6.8	11	9.4	10	11.2
Others	-	-	-	-	20	22.4

Table 5. Average price of power tillers with implements, 209 respondents, Camarines and North Cotabato, 1974.

Source	Average price (P)*		Implements and accessories
	Small (4-7.5 RHP)	Big (7.6-14 RHP)	
Local-made	4,600	5,100	Plow (spiral or moldboard), comb harrow, and cagewheels
Imported	18,100	21,200	Rotavator, cagewheels, pneumatic tires

Table 6. Power tiller components requiring frequent replacement or failing on regular basis, 209 respondents, Camarines Sur and North Cotabato 1978.

Parts	No. of farmers reporting	Percentage
Engine	73	34.92
Transmission		
Gear	16	7.65
Chain	21	10.04
Sprocket	9	5.06
Bearing	42	20.09
Gasket	4	1.91
Crankshaft	3	1.43
Body		
Belt	79	37.80
Clutch	59	28.23
Cable	35	16.75
Axle	48	22.96
Oil seal	37	17.70
Idler	3	1.43
Shaft	14	6.69
Rotavator		
Chain	2	0.95
Bearing	3	1.43
Blade	14	6.69
Gear	1	0.47
Cagewheel		
Hub	15	7.17
Bolt	23	11.00
Blade	1	0.47
Handle	3	1.43
Light fixture	2	0.95

Table 7. Problems encountered in using power tillers, 209 respondents, Camarines Sur and North Cotabato, 1974.

Problems	Source of the power tillers			
	Local-made		Imported	
	Number	%	Number	%
Inefficient in deep muddy soil	2	0.95	55	26.32
Heavy	14	6.69	31	14.83
Not balanced when used for harrowing	3	1.43	1	0.47
Limited supply of spare parts	3	1.43	12	5.74
Oil leakage	1	0.47	1	0.47
High price of fuel & oil	3	1.43	3	1.43
Cannot be used for upland	1	0.47	-	-
High consumption of gas and oil	2	0.95	-	-
No problem	46	22.0	-	0.47
No response	9	4.3	22	10.52

Table 8. Systems of threshing in different provinces, 1974. (No. of respondents: Laguna - 73; Camarines Norte - 58; North Cotabato - 93.)

Province	Sharing System	Thresher Used Types*				Type of Farmer				Threshing Method				Total
						Hiring		Owner		Manual		Mechanical		
	%	1	2	3	4	No.	%	No.	%	No.	%	No.	%	
Laguna	6	-	-	-	-	73	100.00	-	-	73	100.00	-	-	73
Camarines Norte	4	56	-	-	-	10	17.25	48	82.75	2	3.47	56	96.53	58
Kabacan, North Cotabato	8	-	-	93	-	4	4.31	89	95.69	2	2.16	91	97.84	93

*Type 1 - Single drum, without blower nor separator
Type II - Double drum, with single blower, no separator
Type III - Double drum, with single blower, with separator
Type IV - Single drum, with single blower, with separator.

Table 9. Number and size of farms, 209 respondents, Camarines Sur and North Cotabato, 1974.*

Farm size	Number of farms		All farms
	Camarines Sur	North Cotabato	
0.1 - 3	50	40	90
3.1 - 6	35	22	57
6.1 - 9	12	8	20
9.1 - 12	2	3	5
12.1 - 15	-	2	2
15.1 - 18	1	1	2
18.1 - 21	-	1	1
21.1 - 24	-	1	1
Not classified**	20	11	31
Total	120	89	209

*Sample of farms

**No data given by respondents as to the size of their farms.

Table 10. Rice thresher test results (November, 1974).*

Items	Thresher type**			
	I	II	III	IV
Operating speed, rpm -				
Threshing drum 1	1200	900	900	520
" " 2	-	1200	1200	-
Blower	-	1400	1400	1000
Auger	-	1200	1200	270
Separator	-	250	250	17
Horsepower rating	3	8	11	7
Crop condition:				
Grain M.C., %	23	23	21.3	20
Material length, cm	35	35	35	38
Grain-straw ratio	0.65	0.49	0.53	0.53
Labor requirement	4	6	7	4
Men feeding	1	1	1	1
Men handling	3	5	6	3
Test duration, min		3.75	12.13	6.25
Output, kg/test (total)	44	60.58	68.52	97.53
kg/hr	704	249.65	1148.38	936.36
Labor output, kg/man-hr	176	49.9	164	234.09
Capacity, kg/hp-hr	234.6	27.24	104.40	105.19
Unthreshed loss, kg/test	7.49	.787	2.26	.195
" " , percent	17	1.3	3.3	0.2
Separation loss, kg/test	24.85	9.25	2.74	2.6
" " , percent	56	15.27	4.0	2.67
Blower loss, kg/test	-	13.93	26.03	1.5
" " , percent	-	23	38	1.54
Purity, percent	92.1	98.1	98.3	97.4

*Average of 3 tests.

**Threshers tested were all throw-in feeding.

Table 11. Performance of the modified grain cleaner.

Description	Trial number 1	2	3	4	5	Average
Trial duration, min	35	43	37	52	55	44.4
Hopper opening, cm	5	5	5	5	5	5
Grain M.C., % w.b.	11.8	11.6	11.6	11.8	12.7	11.9
Input purity, %	96.94	97.16	96.81	96.63	96.25	96.75
Output:*						
Kg/test	650	738	650	836	866	748
Kg/hr	1114	1029	1053	964	944	1020.8
Purity, %	98.23	98.42	98.02	97.15	97.97	97.95

*Based on 14% M.C. (w.b.)

Table 12. Specifications of four hulling machines.

Items	Hulling machine type: Rubber roll huller (1)	Rubber roll huller (2)	Centrifugal huller	Disc huller
Maker	Sin-Haeng	Satake	Sanriku	--
HP required	3-4	0.6 - 1	2	7.5
Capacity in paddy, kg/hr	970*	380*	980*	620*
Rotation, rpm	Main roller, 750 Sub roller, 578	Main roller, 1370 Sub roller, 938	1466	280
Transmission	Gear	V-belt	V-belt	Flat belt
Size of rubber roll, impeller, or disc, cm	15.9Lx22.0D	7.6Lx15.4D	60D	75D

*Estimated values.

Table 13. Efficiency of three types of hullers.*

Type of machine	Coef. of hulling E_h	Coef. of wholeness E_{wk}	Efficiency** μ_h
Under-runner disc huller	.599	.695	.417
Centrifugal huller	.936	.660	.593
Rubber roll huller (1)	.756	.921	.695
Rubber roll huller (2)	.932	.912	.850

*Average of samples

**Highly significant differences.

Table 14. Specifications of the whitening machines.

Item	Whitening machine type[1]					
	Type 1 (1)	Type 1 (2)	Type 2 (1)	Type 2 (2)	Type 3	Type 4
Maker	Sin-Haeng Co.	Oberly & Co.	Sin-Haeng Co.	Sanriku Co.	Dae-Won Co.	-
HP required	4	5-7	7	7	10	
Capacity in brown rice, kg/hr	93*	68*	360*	520*	422*	261*
Main shaft RPM	400	900	500-600	800	950	450
Type & size (L x D) of roll, cm	Cylindrical steel, with 2 ridges, 25.4 x 5.2	Cylindrical steel, with 3 ridges, 30.3 x 5.4	Cylindrical steel, with 2 ridges & 2 long openings, 32.2 x 11.2	Cylindrical steel, with 2 ridges & 2 long openings 34.7 x 4.8	Cylindrical abrasive, 31 x 20.1, & steel roll w/ 2 ridges 42.5 x 7	Cone-type abrasive steel 60 x
Screen insert	Cylindrical steel sheet	Cylindrical steel housing (top) & slotted screen (below)	Hexagonal slotted screen	Hexagonal slotted screen	Cylindrical slotted and hexagonal slotted screen	Wire screen with rubber brakes
Type of outlet valve	End valve w/ balance weight	Side valve w/ balance weight	End valve w/ balance weight	End valve w/ spring resistance	End valve w/ balance weight	

*Estimated values.

[1] Type 1 -- Horizontal friction type.
Type 2 -- Horizontal friction-air jet type.
Type 3 -- Horizontal friction-abrasive type.
Type 4 -- Vertical abrasive cone type.

Type 1 (2) -- Engleberg mill. It is a machine that removes hull and bran of the rice kernel in one operation. It was used in this study as a whitening machine.

Table 15. Information on the sample by group.

Items	Sample group		
	Group 1	Group 2	Group 3
Variety	IR26	Mixture of IR26 & other varieties	Mixture of a few varieties
Moisture content,* %	14.2	13.0-14.2	12.0-13.0
Percentage of hull**	24.30	24.27	24.32
Head rice, %	96.8	85.8	80.8
(Whole grains	(73.6	(67.8	(63.0
(Greenish grains	(18.2	(15.0	(14.0
(Damaged grains	(5.0	(3.0	(3.8
Broken grains, %	2.1	12.6	16.2
Paddy, %	0.8	1.4	2.3
Foreign matters, %	0.3	0.2	0.3

*Obtained by 105°C air oven drying method.

**By Satake rubber-roll laboratory huller.

Table 16. Percentages of total milled and head rice recovery of six whitening machines.

Whitening machine type[a]	Average of total milled rice (%)	Average of head rice in milled rice (%)
Type 2 (2)	62.62 {37.6 }[b]	61.80*
Type 2 (1)	63.54 {38.0 }	70.21
Type 1 (1)	64.50 {37.6 }	72.27
Type 3	64.82 {39.23}	75.80
Type 1 (2)	66.27 {36.83}	73.80
Type 4	66.65 {33.77}	75.17

[a]Refer to Table 14 for machine description.

[b]Figures in brackets represent degree of whiteness as measured by a Kett whiteness meter.

* Significant.

Table 17. Capacity/hr/hp of the different types of whitening machines.

Items	Whitening machine type[1]					
	Type 1 (2)	Type 1 (1)	Type 4	Type 3	Type 2 (1)	Type 2 (2)
Capacity in brown rice, kg/hr	68.1	92.6	261.3	421.9	359.5	520.0
HP required	5*	4	7*	10	7	7
Capacity, kg/hr/hp	13.6	23.2	37.3	42.2	51.4	74.3
Capacity index	18.4	31.3	50.2	56.8	69.2	100**
Total head rice, %	48.92	46.59	50.08	48.82	44.59	38.65
Temperature of the milled rice, °F	119.3	112.7	107	130.3	109.3	108.7
No. of pass	1	8 - 10	2	1	3	1

*Estimated values.

**The highest hourly capacity per horsepower was considered as 100 in computing the capacity index.

Table 18. Depth of compacted soil layer with four different power sources for land preparation on continuously cropped wetland during three successive cropping seasons.

Description	Treatment[1]							
	T1		T2		T3		T4	
Penetrometer pressure (kg/sq m)	2.46	4.92	2.46	4.92	2.46	4.92	2.46	4.92
	Pan depth in cm*							
Cropping season								
1973								
1st (wet) Before land preparation	7.3	10.9	9.0	14.1	12.5	18.4	9.1	13.6
1st (wet) After land preparation	11.1	14.9	11.9	16.2	19.9	23.6	20.7	23.1
2nd (dry) Before land preparation	10.5	14.1	12.8	17.0	18.7	23.1	19.7	22.3
2nd (dry) After land preparation	12.5	14.9	12.6	16.5	21.1	24.1	25.5	26.9
1974								
3rd (wet) Before land preparation	14.4	18.0	13.1	17.2	20.6	24.3	24.0	26.4
3rd (wet) After land preparation	15.4	29.0	14.1	18.6	23.4	25.3	31.7	33.9

* Mean of 13 readings taken at different locations within the plot.

[1] T1 -- water buffalo, 452 kg approximately.
T2 -- 5-7 hp single-axle tiller weighing 50 kg.
T3 -- 10-hp tiller with separate rotary tiller weighing 145 kg.
T4 -- large four-wheel tractor (67 hp) weighing 4400 kg.

Table 19. Method of threshing by season, 211 rice farmers, Central Luzon, 1973.

Threshing Method	Wet		Dry	
	number	percent	number	percent
Mechanized				
Large McCormic-type thresher ("tilyadora")[1/]	85	41	47	52
Medium thresher[2/]	20	10	8	9
Small thresher[3/]	14	7	1	1
Tractor/jeep treading	3	2	2	2
Sub-total	122	60	58	64
Manual/Animal				
Threshing frame ("hampasan")	50	24	19	21
Animal treading	19	9	6	7
Manual treading	2	1	-	-
Flail or stick	1	[4/]	-	-
Sub-total	72	34	25	28
Combination				
Threshing frame and McCormick-type thresher	7	4	4	5
McCormick-type thresher and jeep	3	2	3	3
Threshing frame and animal treading	1	[4/]	-	-
Tractor/jeep and animal treading	1	[4/]	-	-
Animal treading and McCormick-type thresher	1	[4/]	-	-
Sub-total	13	6	7	8
Total	207	100	90	100

[1/] Threshing capacity of 1.50 tons or more per hour.
[2/] Threshing capacity of 0.51 to 1.49 tons per hour.
[3/] Threshing capacity of 0.50 ton or less per hour.
[4/] Less than one percent.

Table 20. Storage practices, 211 rice farmers, Central Luzon, 1973.

Practice	Cono User		Kiskisan User		All Farms	
	number	per-cent	number	per-cent	number	per-cent
Storage of paddy for home consumption						
Sack	47	51	43	29	90	38
Box (made of wood or metal sheet)	18	20	53	36	71	30
Bamboo basket	20	22	40	27	60	25
Small granaries or bodegas ("camarin")	5	5	4	3	9	4
Cans/drums	-	-	6	4	6	2
Bulk (stored loose)	2	2	1	1	3	1
Total	92	100	147	100	239	100
Storage of paddy for sale						
Sack	45	80	65	71	110	74
Box (made of wood or galvanized iron)	6	11	12	13	18	12
Basket	4	7	11	12	15	10
Small granaries or bodegas ("camarin")	1	2	2	2	3	2
Cans/drums	-	-	1	1	1	1
Bulk (stored loose)	-	-	1	1	1	1
Total	56	100	92	100	148	100
Utilization of the mill house for storage						
Farmers not using mill house	55	65	111	87	166	79
Farmers using mill house	29	35	16	13	45	21
Total	84	100	127	100	211	100
Source of sacks used for storage						
Mill-owner/FACOMA	17	59	10	63	27	60
Farmers	12	41	5	31	17	88
Landowners	-	-	1	6	1	2
Total	29	100	16	100	45	100

Table 21. First and last priorities in the choice of mill by type.

Reason	Cono Users		Kiskisan Users		All Farms	
	first priority	last priority	first priority	last priority	first priority	last priority
			percent			
Technical/Economic:						
Accessibility/availability of mill	33	29	48	-	42	13
High milling recovery	27	29	6	-	14	13
Accepts small quantities for milling	4	-	6	25	5	13
Efficiency of mill	-	13	-	-	-	7
Source of credit/other privileges	3	-	1	-	1	-
Reasonable milling fee	1	-	-	12	1	7
FACOMA member	1	-	1	-	1	-
No other mill available in the area	-	-	2	-	1	-
Other reasons[1/]	1	-	-	-	1	-
Type of product most wanted:						
more rice	12	-	7	38	9	20
more bran	1	-	17	13	10	7
more rice and bran	5	-	3	-	4	-
Sub-total	88	71	91	88	89	80
Social:						
Close personal relations/attachment to mill	11	29	9	12	10	20
Honesty and good public relation of mill operator	1	-	-	-	1	-
Sub-total	12	29	9	12	11	20
Total	100	100	100	100	100	100

[1/] Reasons include: a) milled rice comes from deposited paddy.
b) safety of deposited paddy from floods, etc.
c) has two apparatus (cono and kiskisan).

Table 22. Farmers' reasons for using alternative milling technologies, 211 rice farmers, Central Luzon, 1973.

Item	Cono Users		Kiskisan Users	
	number	percent	number	percent
Number of farmers	84		127	
Farmers without an alternative mill	16	19	25	20
Farmers using cono mill as alternative	29	35	39	31
Farmers using kiskisan mill as alternative	37	44	59	46
Farmers using hand-pounding as alternative	-	-	1	1
Farmers using cono/kiskisan as alternatives	2	2	3	2

	number	percent
Reason for using cono alternative by a kiskisan user		
Usual mill is busy/out of order/etc.	14	33
More and better rice for sale	10	24
Can mill high moisture paddy	9	21
Others	6	22
Reason for using kiskisan alternative by a cono user		
Usual mill is busy/out of order/etc.	14	32
More and better bran	8	18
Small quantity of paddy to mill	6	14
More nutritious rice for home use	4	9
Others	5	27

Table 23. Type of thresher and dryer used by season, 193 rice farmers, Camarines Sur, 1973.

Item	Season			
	Wet		Dry	
	Number	Percent	Number	Percent
Type of thresher				
Hampasan	55	28	42	27
Treading	37	19	21	14
Flail or stick	23	12	16	10
Hampasan and feet treading	35	18	30	20
Stick and feet treading	28	15	35	22
Hampasan and stick	15	8	11	7
Total	193	100	155	100
Type of dryer				
Concrete	71	37	59	38
Mats, plastic or sawali	73	38	57	37
Combination of concrete and mats; plastic and sawali	49	25	39	25
Total	193	100	155[1/]	100

[1/] Excludes 38 farmers without dry season crop.

Table 24. Number of potential users and potential non-users of mechanical threshers, 193 rice farmers, Camarines Sur, 1973.

Farmer type	Number	Percent
Potential users of mechanical threshers	67	35
Potential non-users of mechanical threshers	79	41
No comment	47	24
Total	193	100

Table 25. Number of potential users and potential non-users of mechanical dryers, 193 rice farmers, Camarines Sur, 1973.

Farmer type	Number	Percent
Potential users of mechanical dryers	147	76
Potential non-users of mechanical dryers	45	23
No comment	1	1/
Total	193	100

1/ Less than one percent.

Table 26. Monthly utilization of warehouse, by capacity, 30 warehouses, Camarines Sur, 1973-74.

Item	Large warehouses		Medium warehouses		Small warehouses		All warehouses	
	Volume	Percent utilized	Volume	Percent utilized	Volume	Percent utilized	Volume	Percent utilized
May, 1973	8,469	29	-	-	-	-	2,541	29
June	5,311	18	1,730	16	1,433	41	2,078	24
July	4,588	16	1,219	11	933	16	1,537	17
August	2,306	8	428	4	328	9	645	7
September	3,131	11	577	5	500	14	910	10
October	2,395	8	1,570	14	1,195	34	1,451	16
November	3,902	13	3,281	30	1,608	46	2,280	26
December	5,444	19	3,665	33	1,906	54	2,779	31
January, 1974	6,087	21	3,239	29	1,551	44	2,559	29
February	6,751	23	3,106	28	1,321	38	2,477	28
March	6,266	22	3,519	32	1,886	53	2,861	32
April	6,708	23	3,395	31	2,693	76	3,429	39
Monthly average	5,113	18	2,339	21	1,396	40	2,135	24
Reported capacity	29,128		11,088		3,529		8,831	
Frequency turnover	2.1		2.5		4.7		2.9	

1/ Cavans of 50 kilograms palay including rice, corn and corn grits.

Table 27. Required capacity of rice mills, by type of mill, Camarines Sur, 1973.

Mill type	Number	Average volume milled	Estimated capacity utilized	Annual available capacity	Percent capacity utilized
I. Kiskisan mills					
K_1	265	2,092	554,380	4,874,717	11
K_2	34	3,138	106,692	944,695	11
K_3	13	8,804	114,452	557,061	20
Sub-total/Average	312	2,485.65	775,524	6,396,473	12
II. Cono mills					
C_1	40	7,444	297,758	1,211,779	25
C_2	14	10,896	152,544	767,783	20
C_3	23	32,935	757,504	2,582,295	29
Sub-total/Average	77	15,685.79	1,207,806	4,561,857	26
T o t a l	389	5,098.27	1,983,228	10,958,330	18

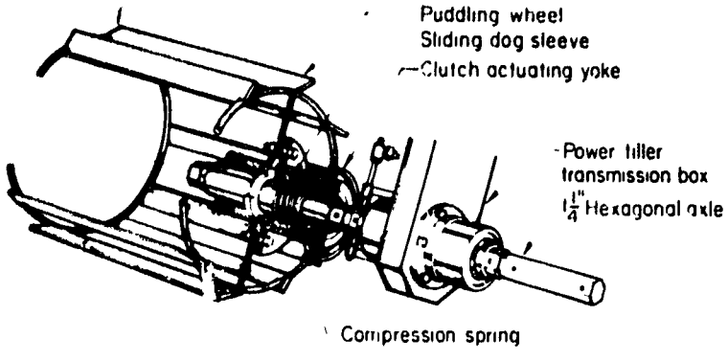

Fig. 1 Schematic drawing of externally mounted steering clutch on 5-7 hp IRRI power tiller.

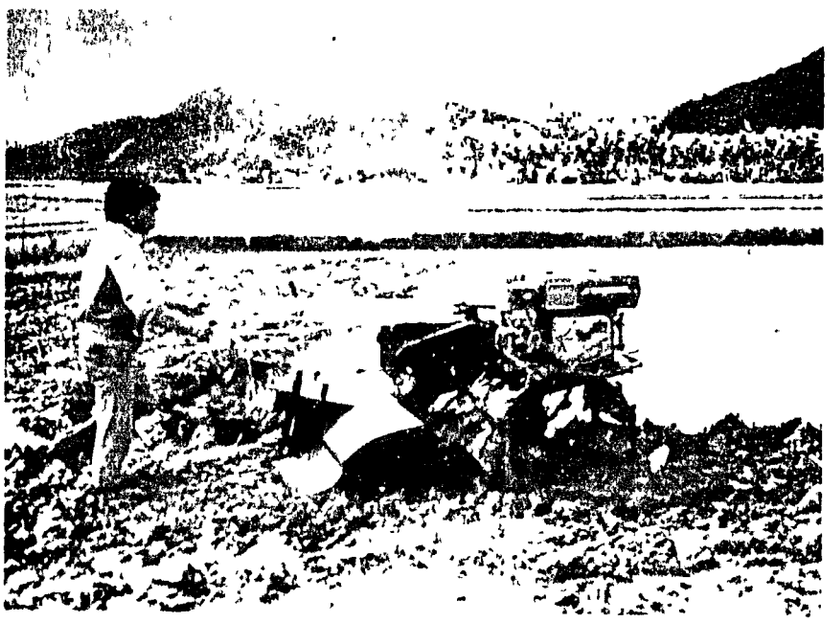

Fig. 2 Prototype unit of IRRI 8-14 hp tiller.

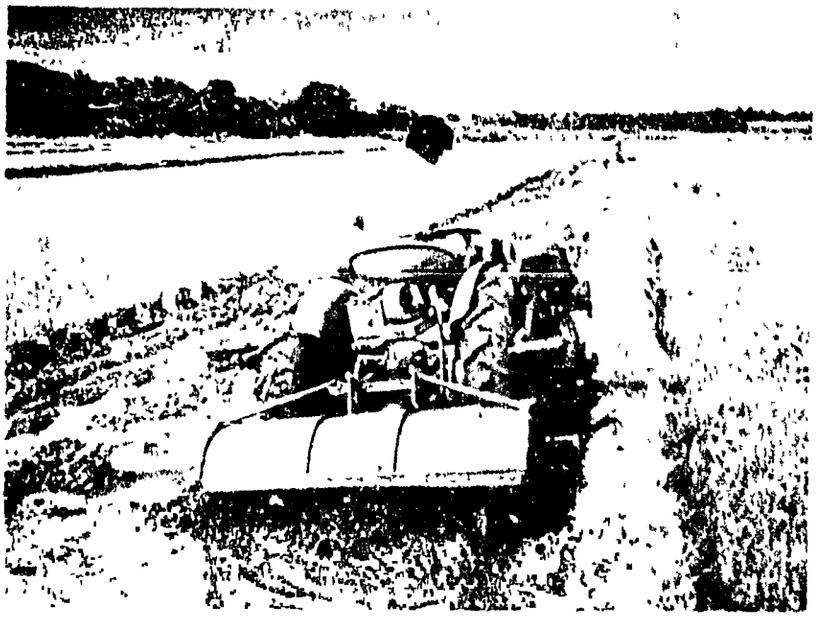

Fig. 3 U.S.-made Economy tractor with widened rotary tiller which permits tilling close to levees.

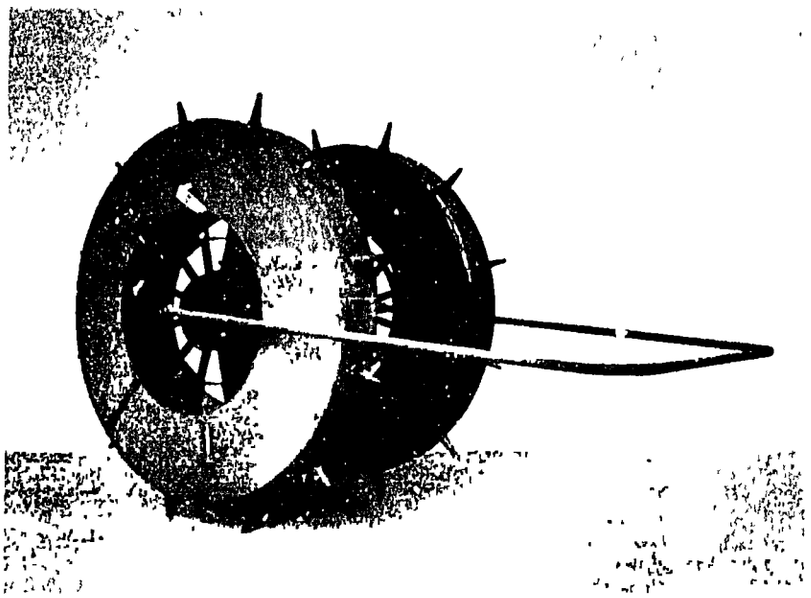

Fig. 4 Experimental deep-placement spot injector.

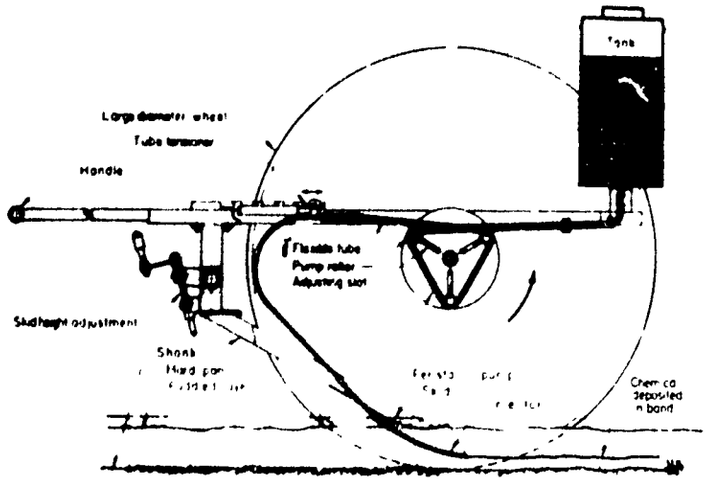

Fig. 5 Schematic drawing of a deep-placement injector with peristaltic pump.

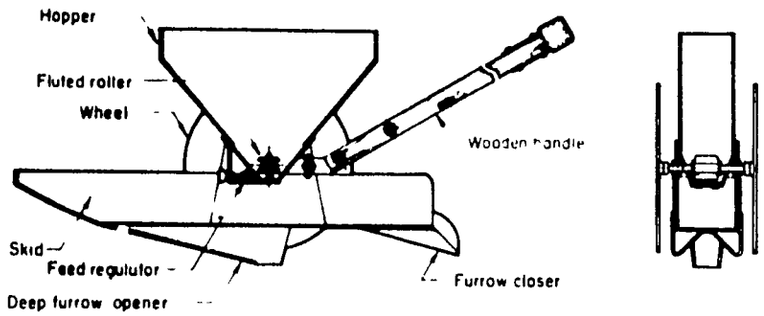

Fig. 6 Schematic drawing of push-type deep-placement granular fertilizer applicator.

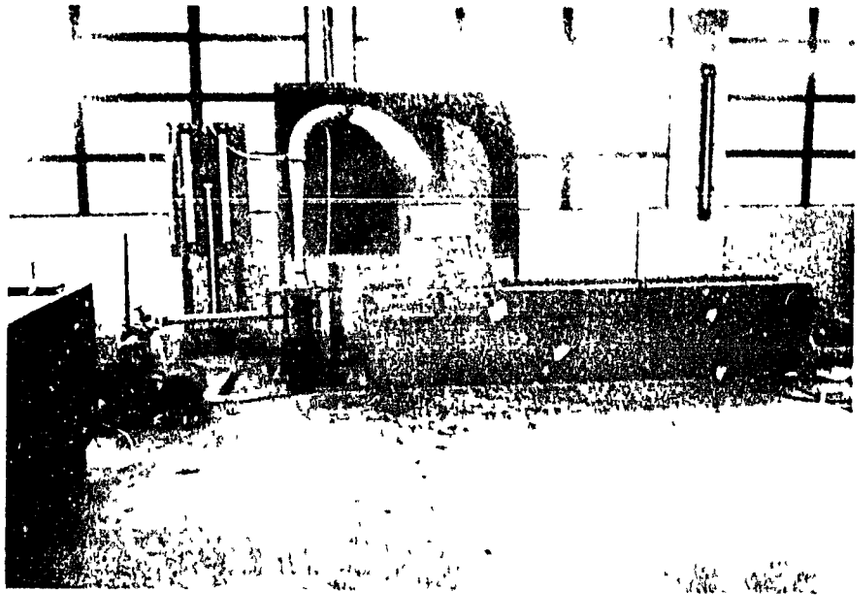

Fig. 7 Laboratory set-up of an experimental jet pump.

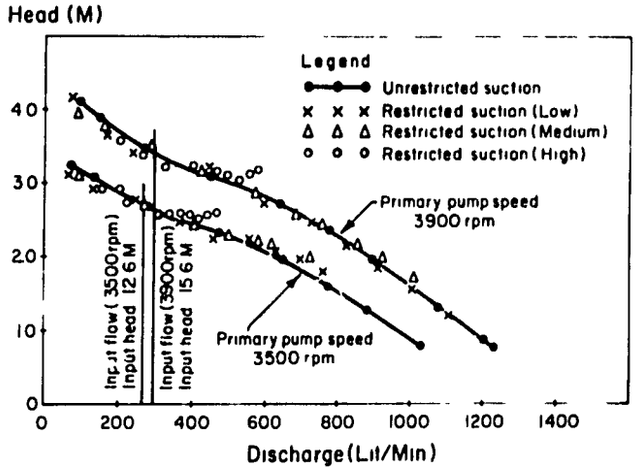

Fig. 8 Performance curve of the experimental jet pump at three head conditions.

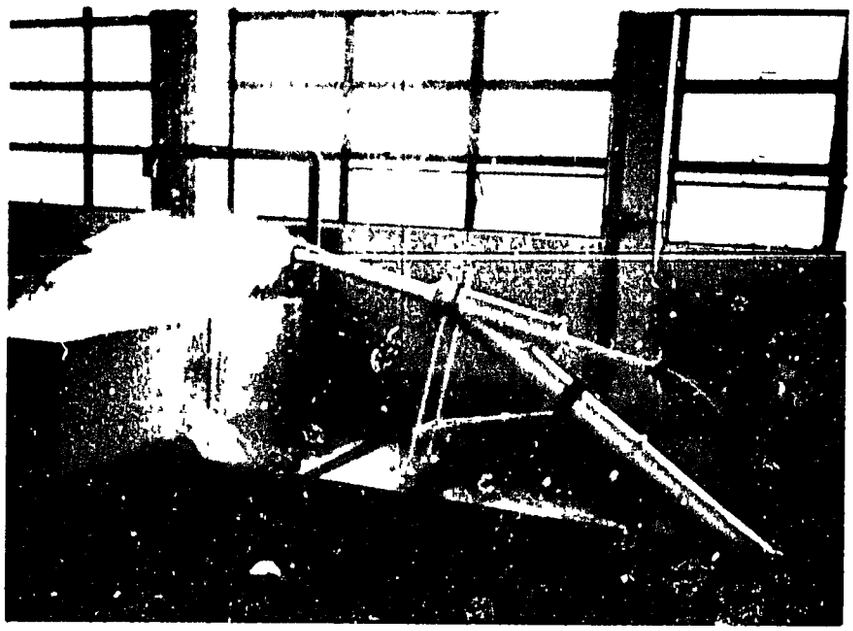

Fig. 9 A low-cost jet pump attachment for use with centrifugal pump for lowlift irrigation.

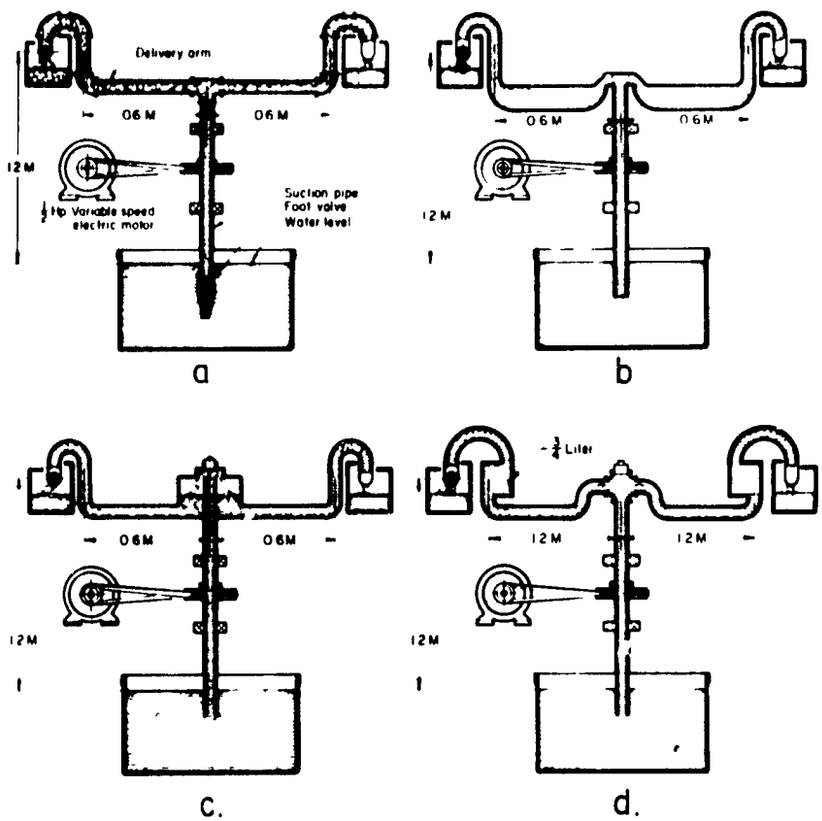

Fig. 10 Schematic drawing of four versions of the tubular pump.

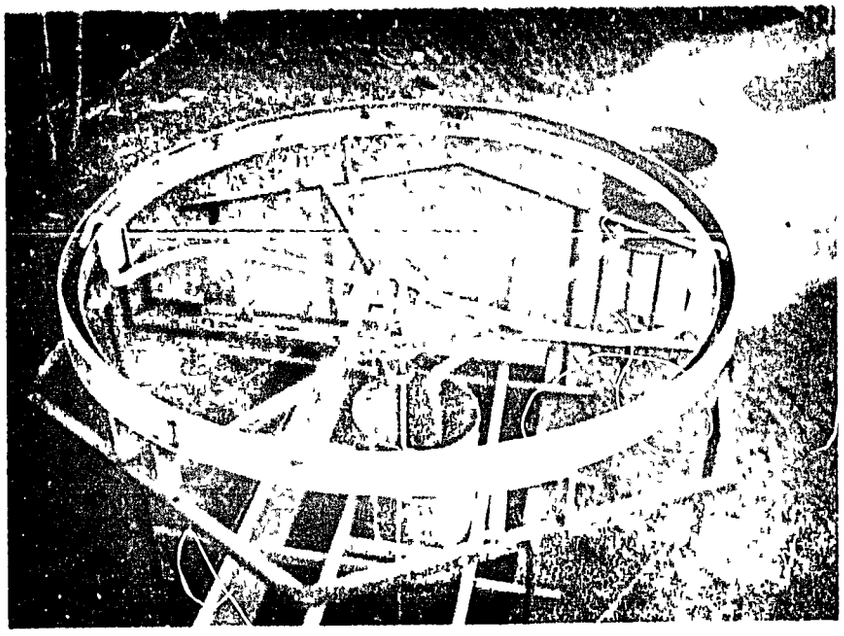

Fig. 11 A 1.4-m arm tubular pump mounted on a test stand.

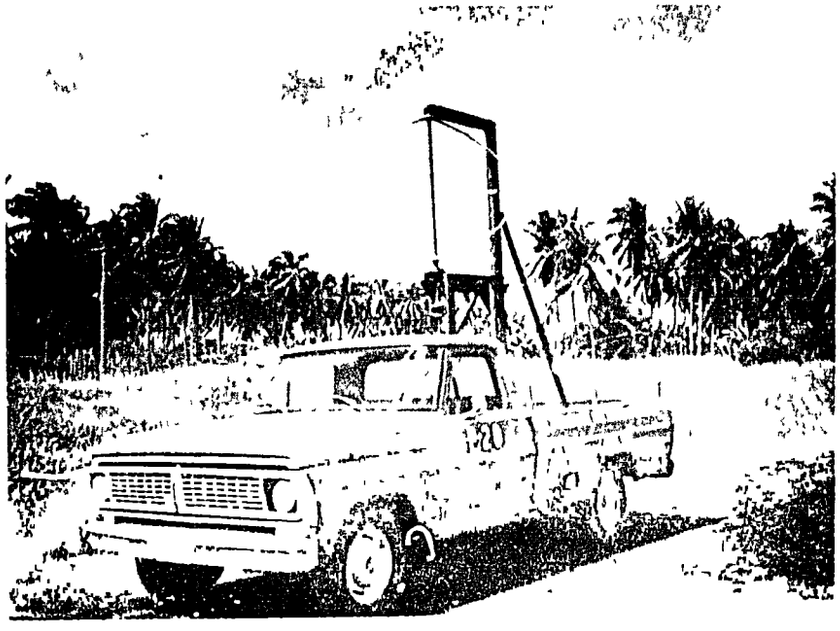

Fig. 12 NRC-type two-bladed rotor on truck-mounted test rig at IRRI.

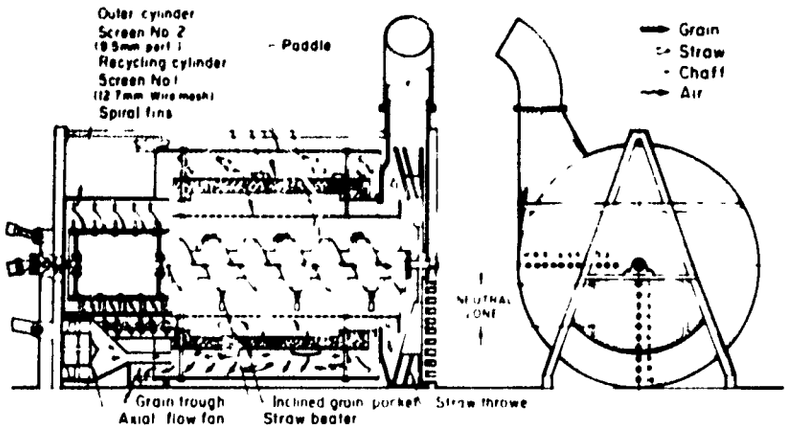

Fig. 13 Schematic drawing of the PTO thresher showing location of pressure tapping outlets on the straw thrower housing.

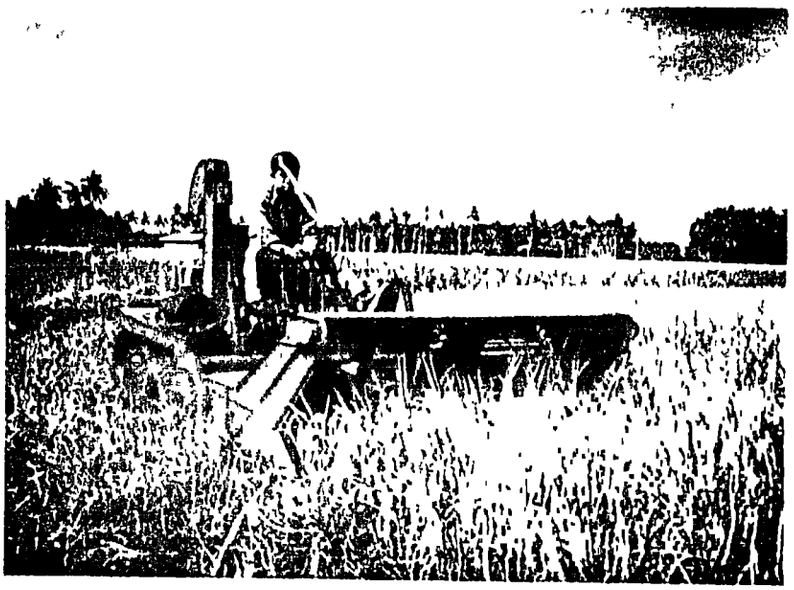

Fig. 14 Six-row experimental stripper harvester.

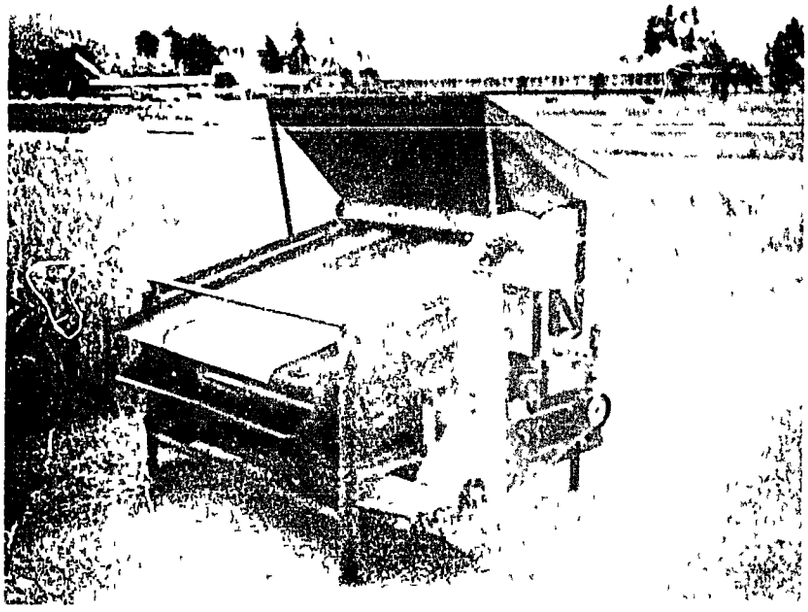

Fig. 15 Prototype of IPRI oscillating grain cleaner.

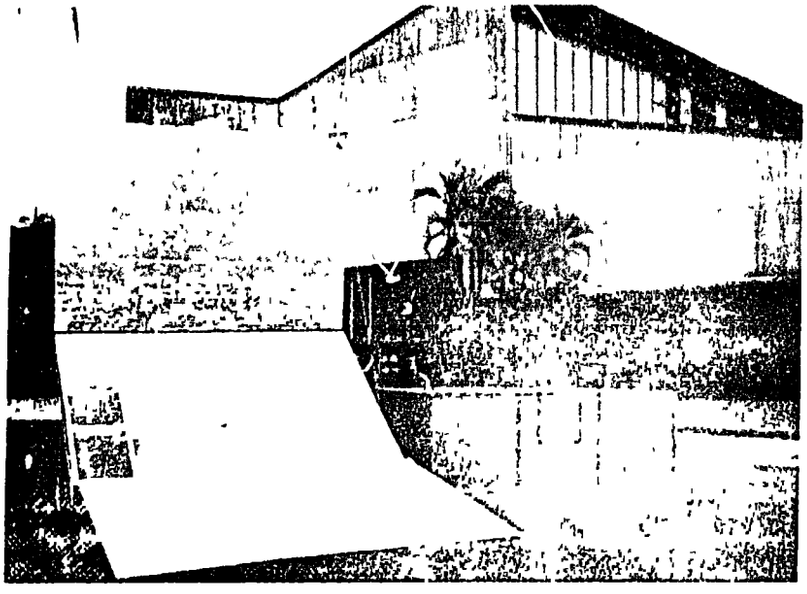

Fig. 16 Solar heat collector for the IPRI batch dryer.

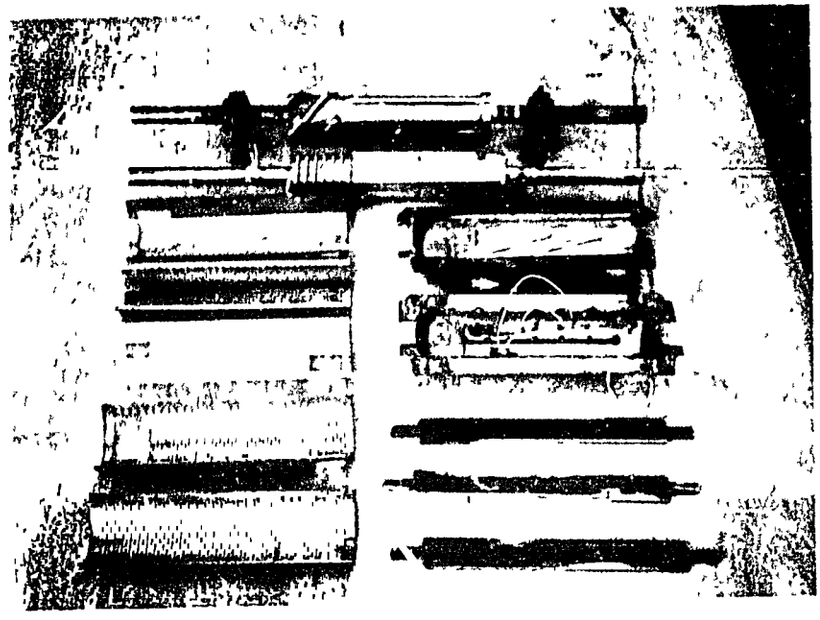

Fig. 17 Existing and modified parts used in Engleberg milling test.

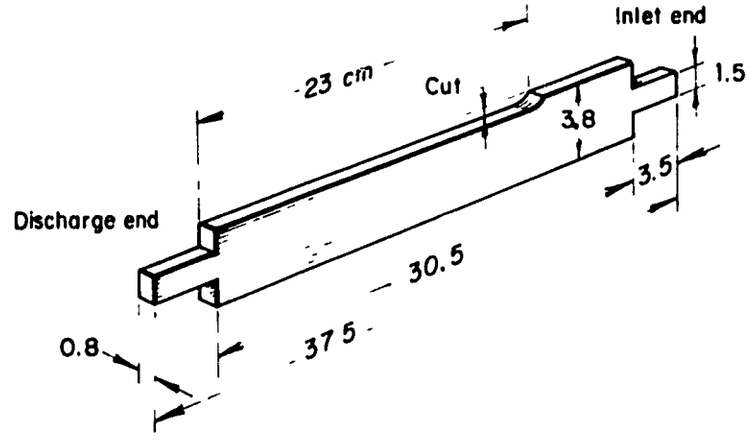

Fig. 18 Engleberg mill test blade.

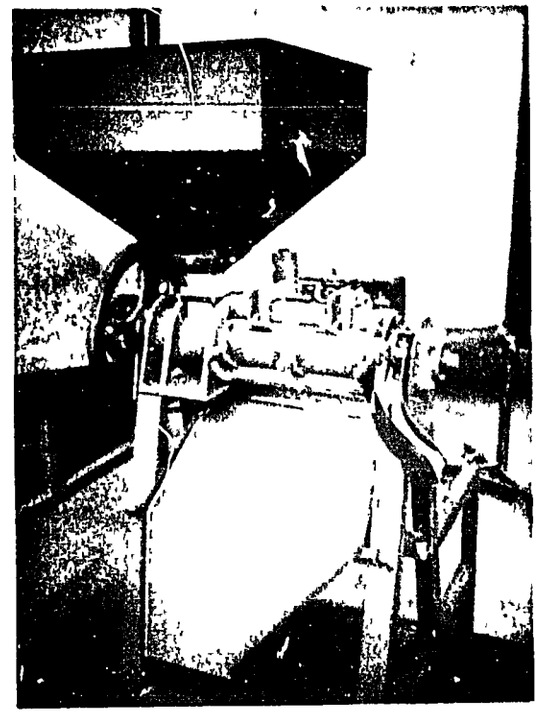

Fig. 19 Experimental single-pass rice mill.

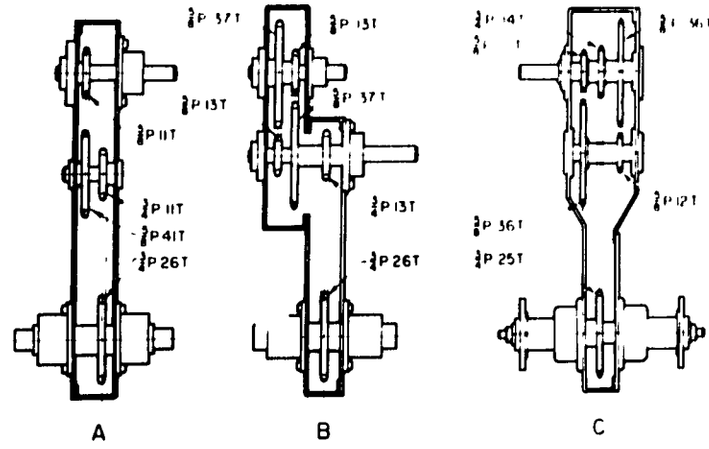

Fig. 20 Transmissions of locally manufactured power tillers.

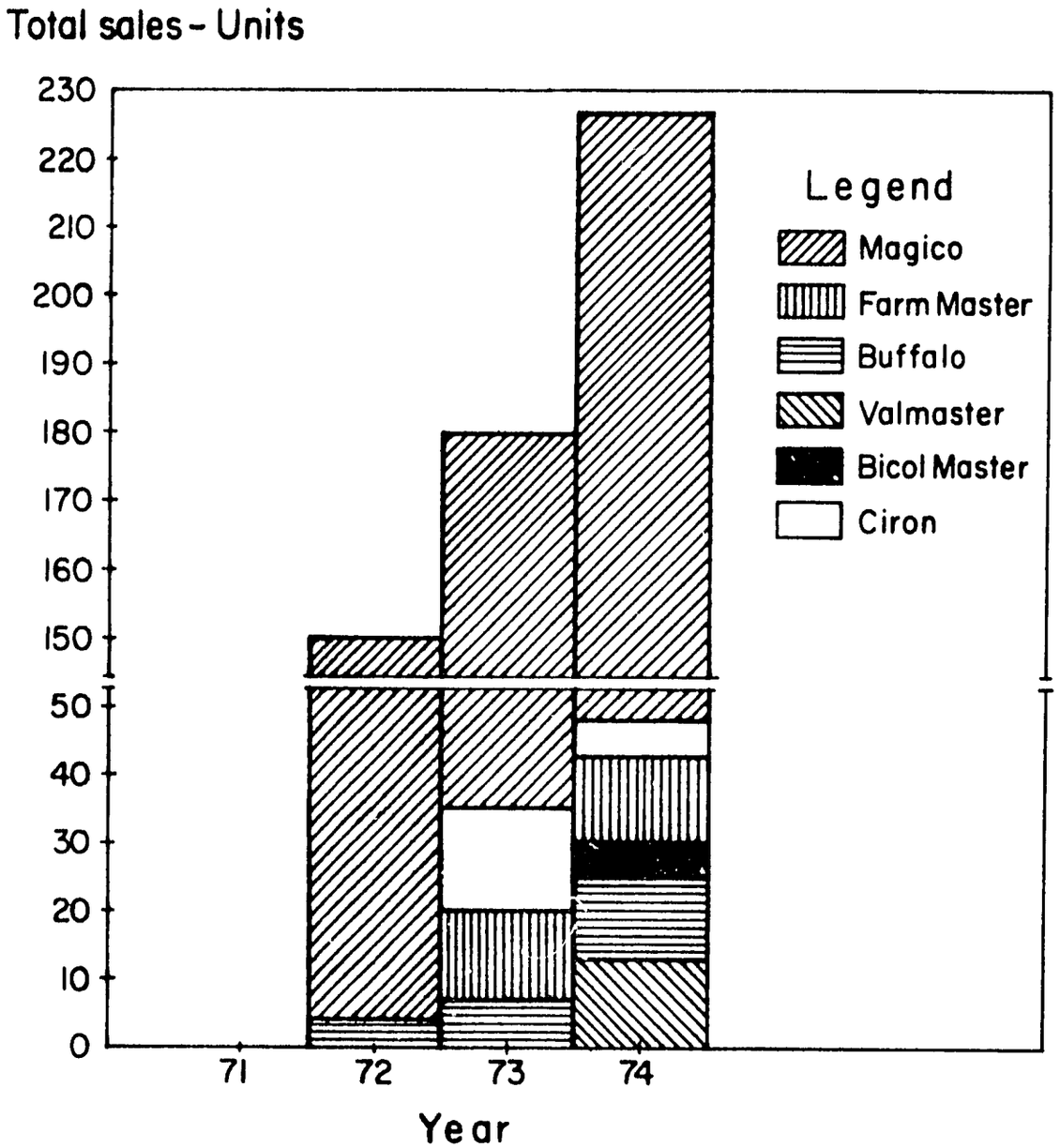

Fig. 21 Sales pattern of local power tiller manufacturers in Camarines Sur, Philippines, 1971-74.

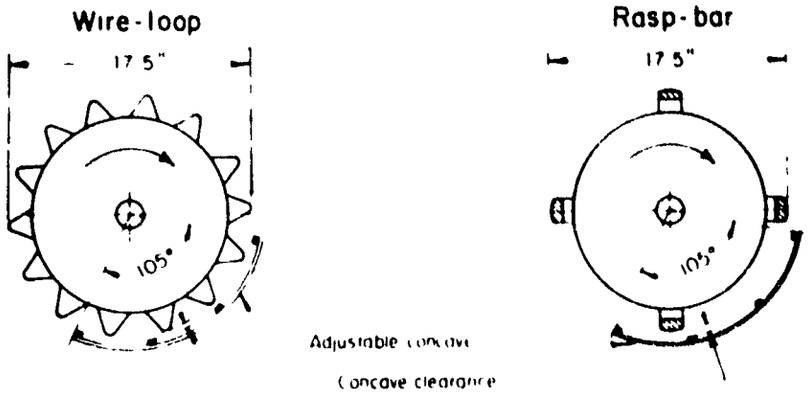

Fig. 22 Schematic drawing (end view) of threshing cylinders showing concave set-up.

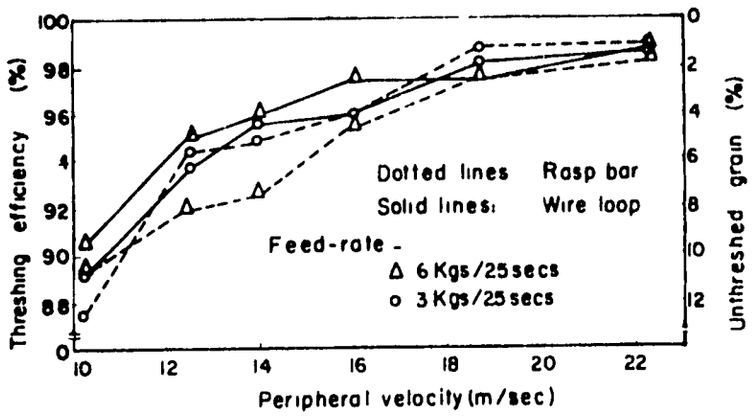

Fig. 23 Relationship of peripheral velocity to threshing efficiency and unthreshed grain at 1/8" concave clearance and 16% moisture content.

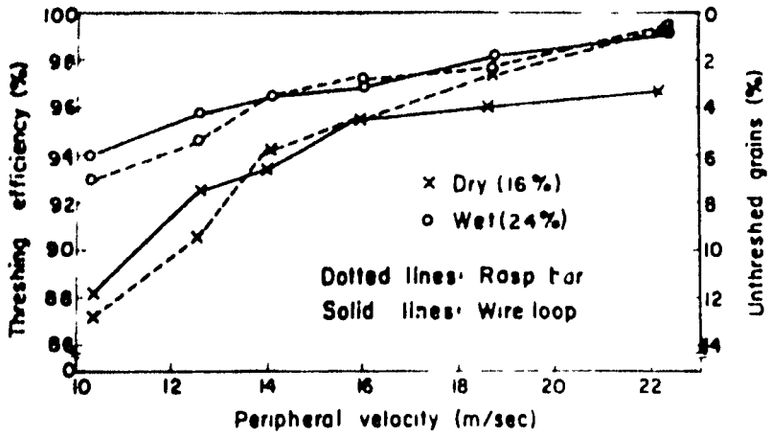

Fig. 24 Relationship of peripheral velocity to threshing efficiency and unthreshed grains at 1/4" concave clearance and 3 kg/25 sec.

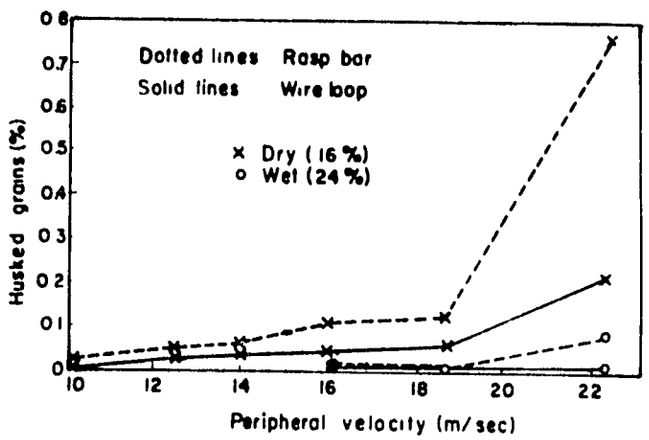

Fig. 25 Relationship of peripheral velocity with husked grains at 1/8" concave clearance.

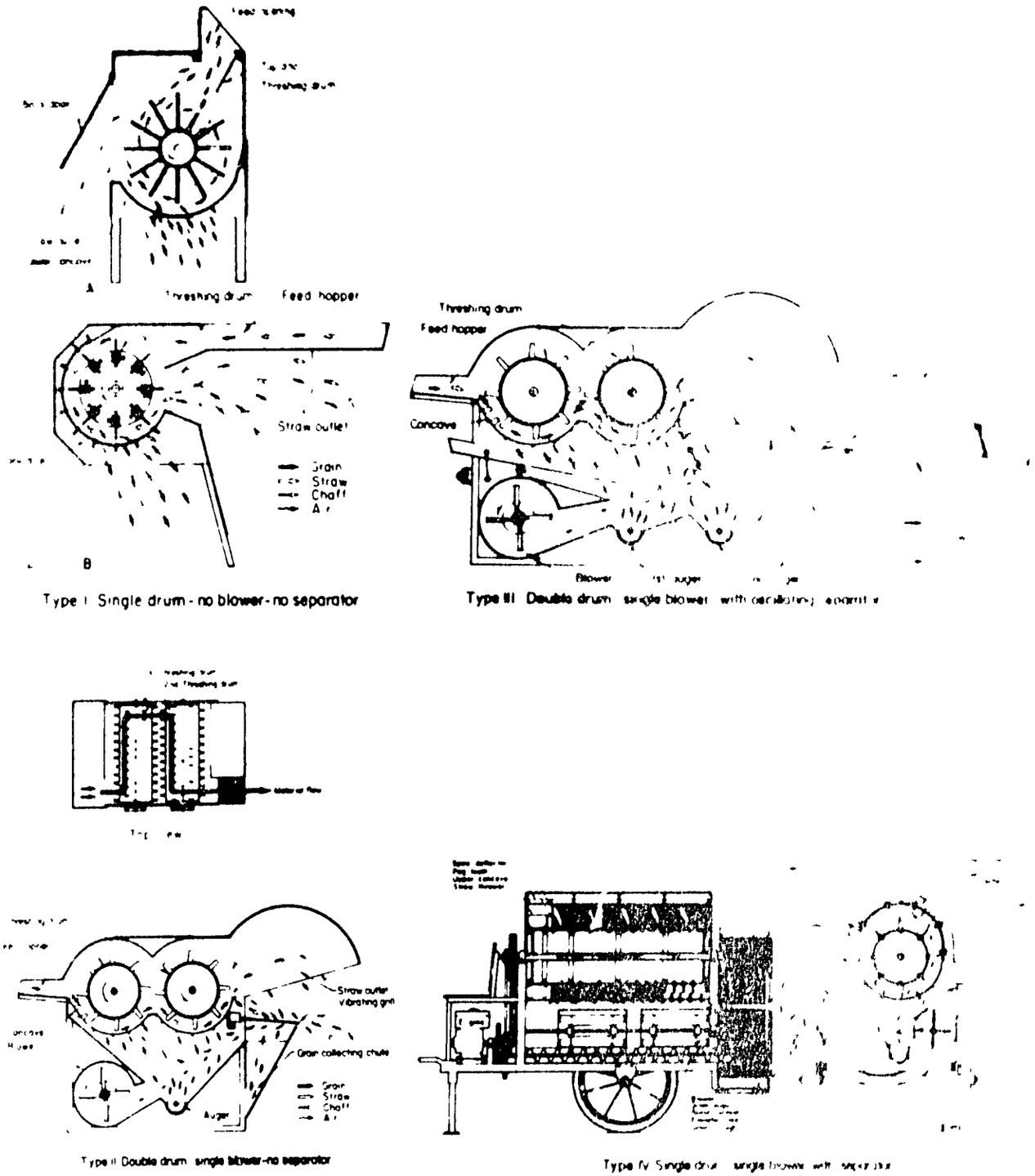

Fig. 26 Different types of small r[illegible] threshers.

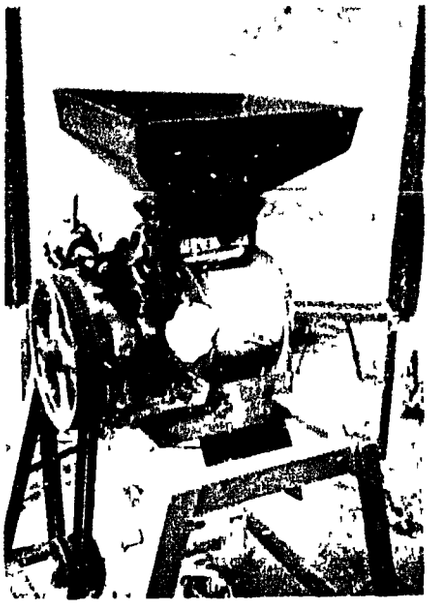

Fig. 27a Rubber roll huller.

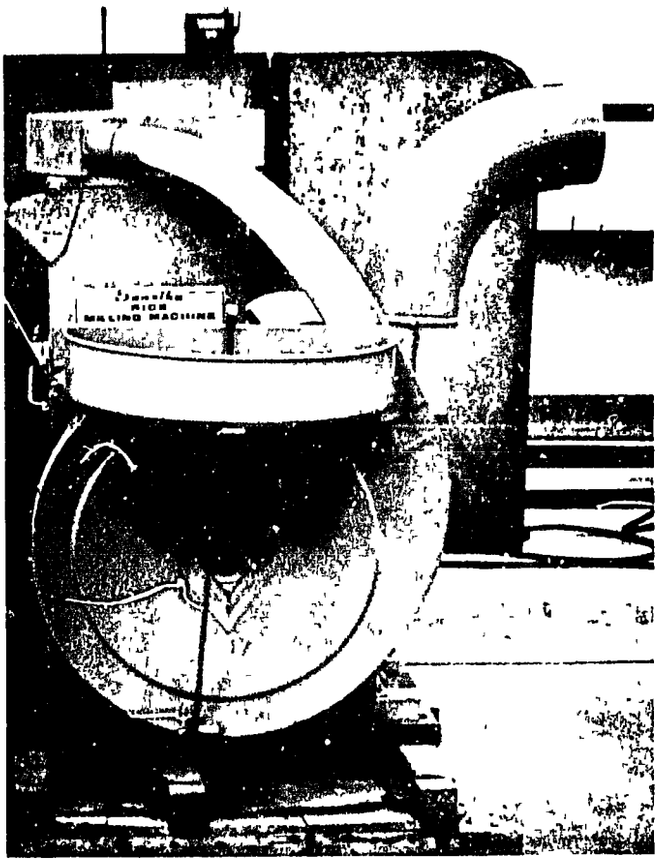

Fig. 27b Centrifugal huller.

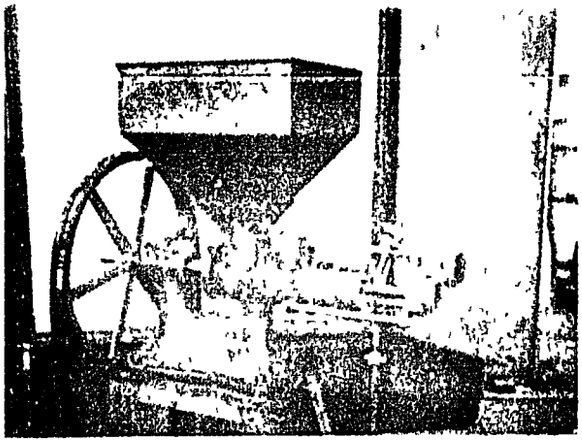

Fig. 28a Horizontal friction-type whitening machine.

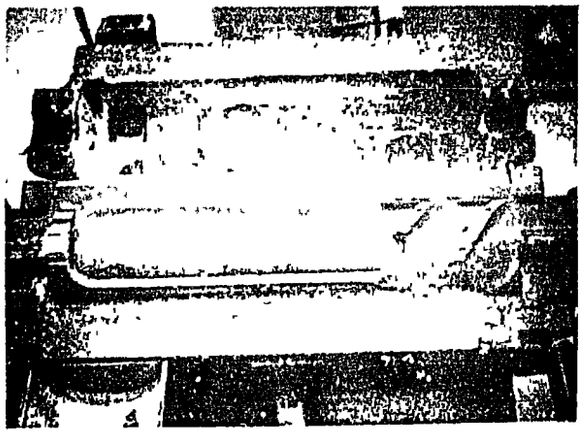

Fig. 28b Inside view of the "kis-kisan".

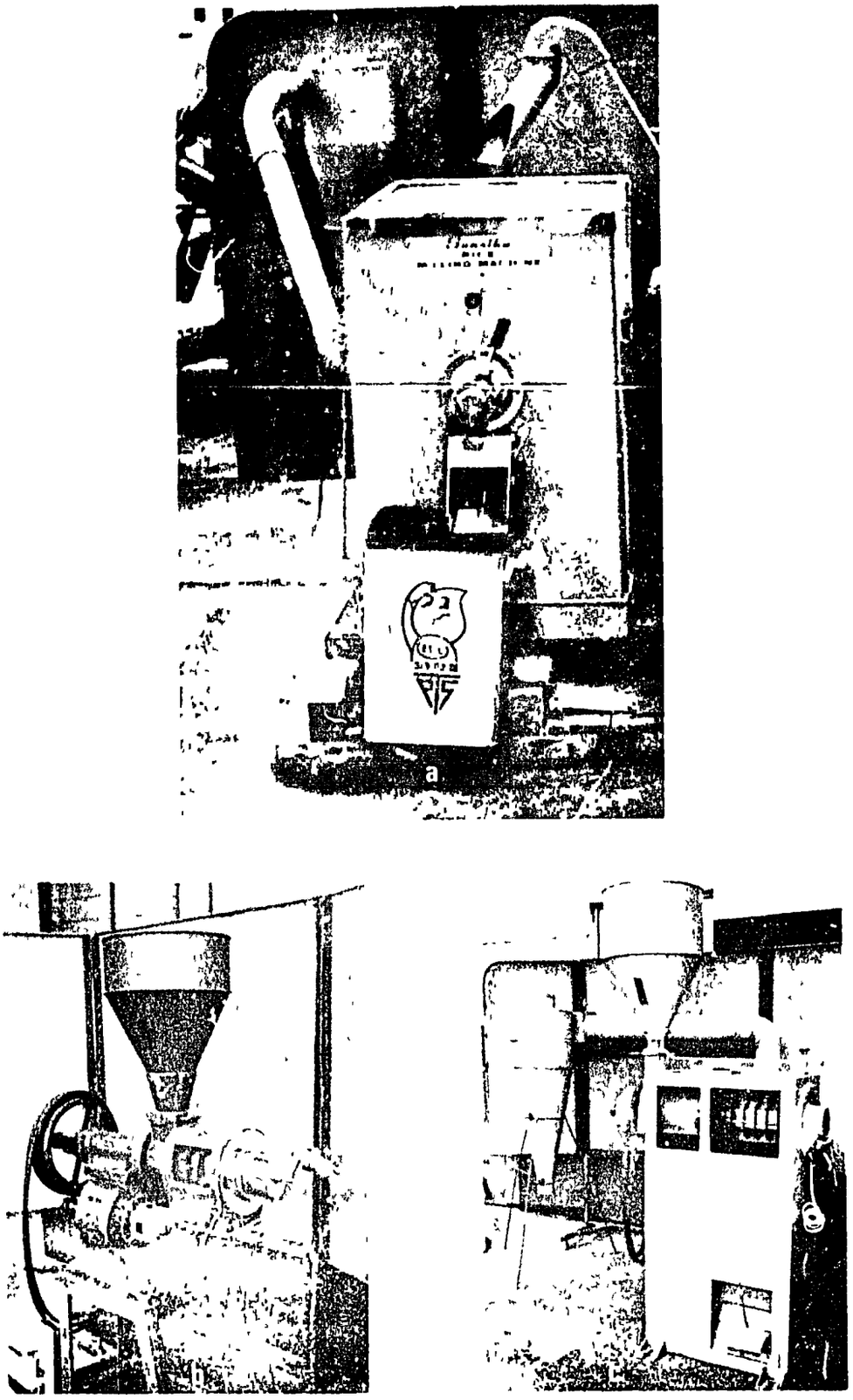

Fig. 29 Horizontal friction-air jet (a and b) and horizontal abrasive-friction (c) rice whitening machines.

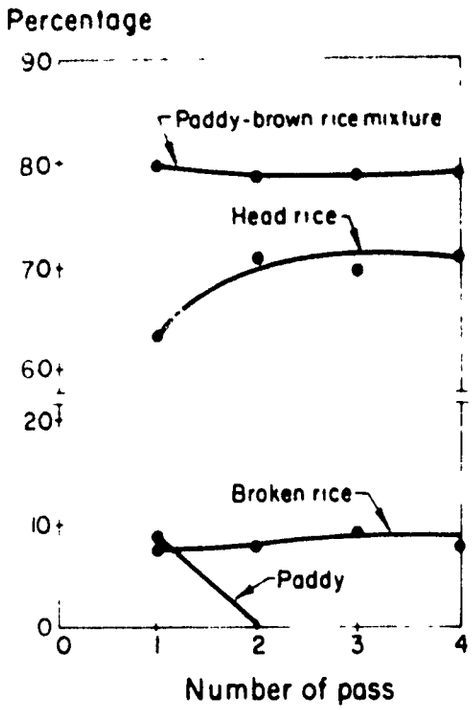

Fig. 30 Performance of laboratory [illegible] roller rice [illegible] [illegible] paddy at different [illegible] passes.

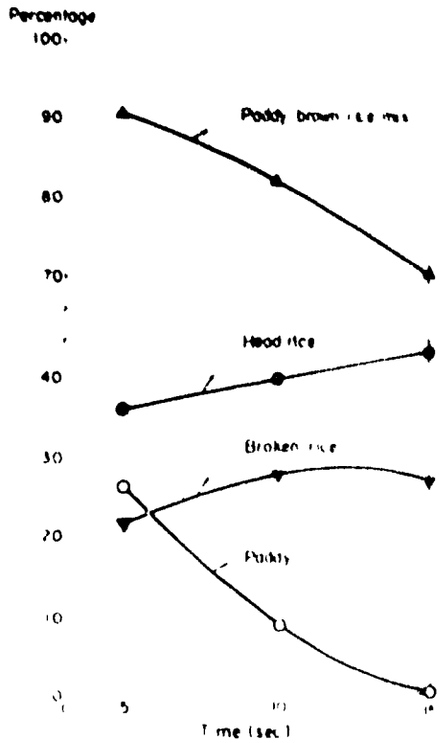

Fig. 31 Perf[illegible] friction-t[illegible] us[illegible]

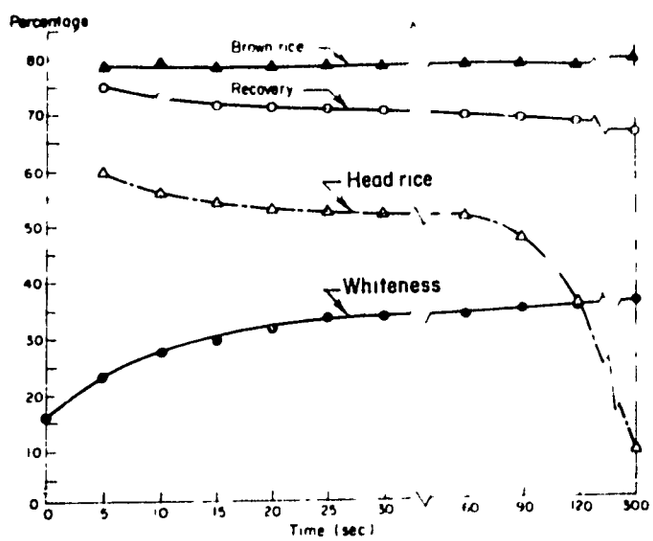

Fig. 32 Performance of laboratory friction-type rice mills as polisher

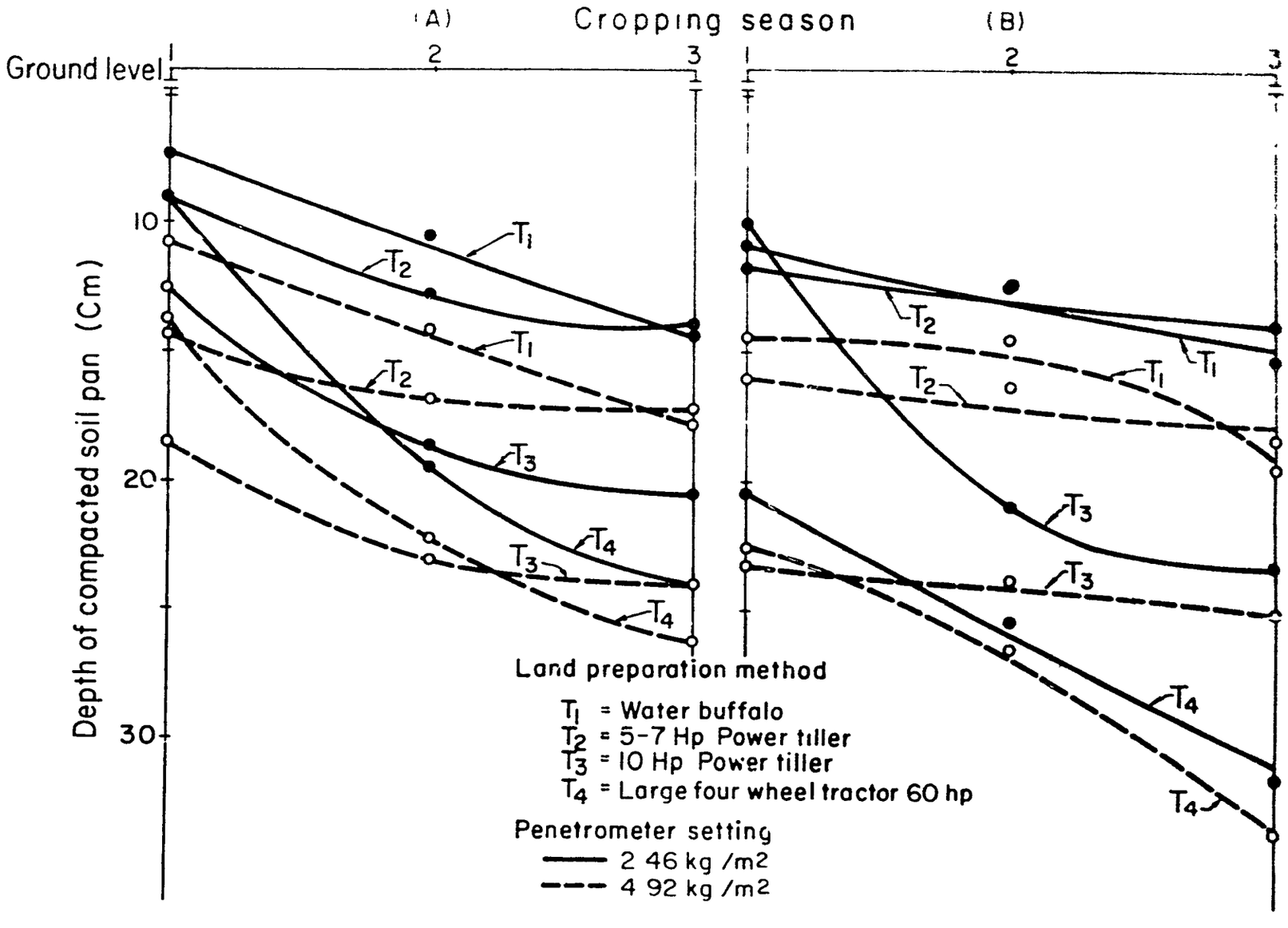

Fig. 33 Compacted soil pan depth at two penetrometer settings before (A) and after (B) land preparation using four different land preparation for two cropping seasons (1973-74)

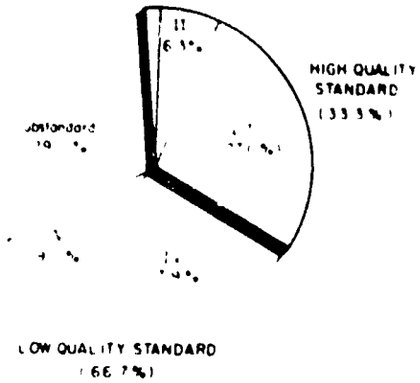

Fig. 34 Results of paddy sample analysis, 111 rice mills, Central Luzon, Southern Tagalog and Camarines Sur, 1973.