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AGRICULTURAL EQUIPMENT DEVELOPMENT RESEARCH FOR TROPICAL RICE CULTIVATION

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Los Banos, Laguna, Philippines

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SEMIANNUAL PROGRESS REPORT NO. 15

JULY 1 TO DECEMBER 31, 1972

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CONTRACT NO. AID/csd-2541
Agricultural Equipment Development Research
for Tropical Rice Cultivation

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59

TABLE OF CONTENTS

Title	Page
Introduction	1
Progress Report	4
Design and Development	5
Field Machinery	
4-6 hp power tiller	5
8-14 hp power tiller	5
Non-selective herbicide applicator	6
Multicrop axial-flow thresher	7
PTO thresher	8
Stripper harvester	9
Drying and Processing	
Heated-sand drying and parboiling equipment	11
Rice hull furnaces	11
Centrifugal milling studies	12
Steel huller-mill improvements	13
Test and Evaluation	14
4-6 hp power tiller	14
Low-lift bellows pump	14
Hand-operated rice transplanter	15
Japanese transplanter	16
Cotabato paddy thresher trials	16
Batch type drier	18
Economics of Mechanization	19
Survey of large tractor contract operations	19
Grain loss study	20
Economic studies of rice processing systems	22
CB:IBRD loan assessment program	23
Small-scale industry study	26
Subcontract, Development, Extension and Training Activities	27
Work Plan	29
Personnel List	33
Tables	
Figures	

INTRODUCTION AND SUMMARY

The contents of this report, the 15th in a series, describes activities carried out under IRRI/AID Contract No. csd-2541 for the period July 1st through December 31, 1972. The major objectives of the contract continue to be the design, development, testing and extension of agricultural machinery for use by small- and medium-scale rice producers and processors in the tropics.

Response from manufacturers now producing and those contemplating production of the 4-6 hp power tiller has been encouraging. Two manufacturers are now building a total of 200 power tillers a month in the Philippines. Evaluation of various machine concepts for the application of non-selective herbicides in rice and upland crops was initiated. The design of the axial-flow thresher neared completion. High output, multicrop use, simplicity in design, and ease of local manufacture should make it widely acceptable in most Asian countries. The second prototype of the PTO thresher is approaching completion. Following final testing and evaluation, it will be released to manufacturers for production. Simple lifting-finger mechanisms for harvesting lodged crops were installed on the stripper harvester. Field trials with the stripper harvester indicate that grain losses with the field machine have been reduced to 6 percent. Additional modifications should further reduce these losses.

Two companies initiated production of the one-ton batch type drier in the Philippines. A production unit was received from one manufacturer and evaluated. Two different rice hull furnace designs which are compatible with the IRRI batch type drier were developed. The heated-sand drying and parboiling equipment has been improved to increase its thermal efficiency by utilizing heat from the exhaust port for preheating the ingoing high-moisture grain. The design of this machine is expected to be finalized in the next few months. Research activities to develop new methods of milling and processing paddy for village and farm level operations were continued.

The design of a larger 8-14 hp power tiller was completed and work on fabricating the first prototype unit was started. We expect to release this machine for commercial production in the next few months. Design and development work on power tillers has attracted unusual interest from manufacturers in Asia and work on the design of a four-wheel riding tractor utilizing readily available automotive components was started.

Two companies initiated production of the bellows pump. Evaluation of the initial production units from each company was completed. Evaluation of a locally manufactured manually operated rice transplanter and an engine-powered Japanese model was completed. Two locally manufactured double-drum type threshers were evaluated for their potential in comparison to the axial-flow thresher.

Two field surveys to gather information on the extent of field losses and the use of four-wheel tractors for contract operations were completed during the reporting period. A final document on the impact of credit programs on the growth and patterns of mechanization in Philippine agriculture was completed. Background research on the economics of conventional rice milling technologies has been completed and a field survey to empirically measure the technical and economic characteristics of operational processing units will be undertaken during the coming six months. Planning a study of small- and medium-scale metal fabricating firms continued during the reporting period.

Subcontract test and evaluation activities were expanded during the past six months. An agreement was signed with the Browns Group Industries Ltd. to conduct field testing of IRRI designs in Sri Lanka. The project has nine such agreements in effect in the Asian region.

Papers and publications

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Khan, A. U. 1972. New agricultural equipment from The International Rice Research Institute. Agricultural Mechanization in Asia 3(2):118-120.

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Manalo, A., J. Arboleda and A. U. Khan. Drying and processing research at IRRI. Saturday seminar paper, IRRI, August 12, 1972.

Khan, A. U. and J. Policarpio. Mechanization technology for small tropical farms. Saturday seminar paper, IRRI, September 2, 1972.

Orcino, N. Economic aspects of hand tractor ownership and operation. Paper prepared for presentation at the Seminar on Farm Mechanization, Penang, Malaysia, November 27-December 1, 1972.

Padolina, C. L. and F. Nichols. Methods of seeding and transplanting of rice. Saturday seminar paper, IRRI, August 19, 1972.

PROGRESS REPORT NO, 15
JULY 1 TO DECEMBER 31, 1972

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5. Axial-flow multicrop thresher	A. Khan, E. del Rosario
6. Stripper harvester	A. Khan, J. Policarpio

Drying and processing:

7. Heated-sand drying and parboiling equipment	A. Khan, J. Arboleda
8. Rice hull furnaces	A. Manalo, A. Khan
9. Centrifugal milling studies	J. Arboleda, A. Khan
10. Steel huller rice mill improvements	J. Arboleda, A. Manalo

Test and Evaluation

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14. Power tiller	C. Padolina
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18. Economics of processing systems	I. Estioko, B. Duff
19. Credit programs for mechanization	I. Estioko
20. Small-scale industry study	B. Duff

DESIGN AND DEVELOPMENT

Field machinery

4-6 hp power tiller

Two manufacturers began regular production of the tiller in the Manila area. One, Marsteel Corporation, is a large company which handles a well known Japanese brand of agricultural machinery. This company has excellent production facilities and is currently building 180 tillers per month. Oberly & Co., Inc., a relatively smaller firm which produces rice processing and industrial equipment, and also makes the IRRI table thresher, recently began production of 20 power tillers per month. Figure 1(a) and (b) illustrates the commercially produced units. Both manufacturers offer the machine with a 5-7 hp aircooled engine.

It is premature to estimate the market response; however, both manufacturers have conducted their own market studies and are confident that there exists a large market for this machine in the Philippines. The tillers, complete with engine, cage wheel, comb harrow, and a moldboard plow, are sold for approximately US$500. Both manufacturers offer a trailer and rubber tires as optional attachments.

During the past six months, some design modifications and improvements were suggested to the manufacturers as a result of trials conducted by the test group on commercially manufactured machines. Drawings have been released to two additional manufacturers in the Manila area and they are fabricating their prototype units. Interest in the machine remains high and drawings have been sent to many countries in the region.

8-14 hp power tiller

The encouraging response of the manufacturers to the 4-6 hp power tiller prompted us to look into the possibilities of developing a slightly larger unit equipped with steering clutches and some additional features. Semiannual report No. 14 includes the statistics for the sale of power tillers during the past two years in the Philippines. These figures show that the farmers are purchasing a large number of imported power tillers in the 8 to 14 hp range. These double-axle power tillers (Type III) with 8-14 hp diesel engines and separate rotary tillers are well suited to heavy clay soil conditions and can perform more work than the smaller single-axle type power tiller. In addition, they are equipped with steering clutches which permit easier operation in spite of their large size.

The initial design of an 8-14 hp power tiller (fig. 2) was recently completed. The machine uses a small standard automotive three-speed gearbox as a primary transmission and an enclosed oil-bath chain drive as a secondary reduction transmission. The primary transmission is installed using a bracket which accepts any make of automotive transmission without major changes in the basic tiller design. This feature facilitates production of

the design in various countries of the region where a wide variety of transmissions are available.

The secondary transmission consists of a two-step reduction system using two No. 60 and No. 80 chains. Two dog-type steering clutches are located on the primary reduction shaft and are spring-loaded in the engaged position. The low torque on the primary shaft permits easy engagement and disengagement during operation. Power from the engine is transmitted through two B-section V-belts controlled by an idler clutch. The design configuration of the larger tiller will be similar to the smaller 4-6 hp unit, giving the two IRRI tillers a harmonious look. Fabrication of the secondary chain transmission is approaching completion. The engine and other components for the prototype unit have been purchased. It is expected that the tiller would be ready for testing sometime during January 1973.

Non-selective herbicide applicator

Non-selective herbicides are noted for their effectiveness in controlling all kinds of weeds. Their use in crop production, however, is constrained by a lack of suitable applicators. Application of such a powerful herbicide by high-pressure spraying is limited to non-agricultural uses because of the danger of damage to the crop. Attempts have been made to apply these chemicals in row crops with the help of drift shields. These shields provide only partial protection from the drift because very fine spray droplets are blown on the plants. Another approach is to use gravity-flow or low-pressure sprayers to maintain larger droplet size to minimize the drift problem. With these methods, however, more chemical is used and the drift hazards are still not completely eliminated.

The objective of this project is to explore non-spraying application techniques for non-selective herbicide and to devise a method that will effectively apply powerful herbicides in row crops without damaging the plants. Different machine concepts based on a contact approach for applying the liquid chemical were tried. The following is a summary of the results of the different concepts.

Figure 3(a). A rag mop or bristles with one end dipped in the solution. This approach provided insufficient capillary movement of the chemical. Also, dust accumulated on the rag mop and interfered with the flow of the chemical during operation.

Figure 3(b). A brush with a drip-feed mechanism. Two paint brushes with short nylon bristles were tested with a manually controlled drip-feed arrangement. Continuous dripping of the liquid helped to wash the dirt from the bristles; however, the soft bristles flexed, resulting in a low pressure contact with the weeds. Perhaps the use of extra-long and stiffer brushes may solve this problem. Because of the manual feed rate control, careful monitoring of the feed rate is a problem.

Figure 3(c). Urethane-foam ground roller with external drip-feed. A urethane-foam ground roller with a drip-feed mechanism was tested. The resiliency of the roller permitted good contact of the liquid herbicide with the weeds, even over rough ground. A steel wire scraper, attached to the roller, eliminated dirt accumulation problems. Urethane foam was preferred because of its resiliency and capacity to absorb and expel liquid. This material, however, seems to have a short service life. Absorbent linings of more durable material used in conjunction with urethane foam may increase durability. Again, an automatic feed mechanism is necessary to minimize human errors in application.

Figure 3(d). Urethane foam ground roller with automatic roller feed. A set of auxiliary feed rollers were attached to the ground roller to replace the drip-feed mechanism. The auxiliary feed rollers, which were made of steel, worked well for feeding herbicide to the ground roller. A uniform film of liquid was transferred to the ground roller with no need for a feed control. The major problem, however, was the accumulation of dirt between the auxiliary rollers which reduced herbicide transfer.

Figure 3(e). Urethane foam ground roller with automatic internal roller feed. To prevent accumulation of dirt on the feed roller, a hollow ground roller was made from perforated metal and equipped with an external surface layer of urethane foam. An auxiliary feed roller was installed inside the hollow ground roller. The auxiliary feed roller was partially submerged in a semicircular herbicide container. Uniform liquid transfer was obtained between the two rollers through the sheetmetal perforations. Further field tests are planned for this unit.

Evaluation of additional applicator concepts will continue until a satisfactory solution is found for the contact application of non-selective herbicides.

Multicrop axial-flow thresher

The design of the axial-flow thresher was described in report No. 14. A second prototype (fig. 4) incorporating several modifications based on tests with the first machine was fabricated. Emphasis was placed on improving the performance and appearance of the machine. A rotary screen was incorporated to remove the straw pieces that were not removed by air action. During tests, it was observed that grain separation loss was higher in the second prototype machine. The machine also clogged more often, particularly when threshing wet crop.

A series of tests were conducted with the second machine using varying clearances between the threshing drum and the lower concave (from 1/4 in. to 1-1/4 in.). Tests were also conducted to study the effect of 2 in., 4 in. and 6 in. pitch of the wire loops on machine performance. Figures 5(a) and (b) illustrate the results of the tests which were conducted using IR24 paddy at approximately 27 percent grain moisture level. The tests indicate that a 3/4-in. clearance between the threshing drum and the lower concave

and a 4-in. wire loop pitch provided optimum performance. This configuration resulted in improved grain separation and the straw clogging problem was eliminated.

Tests with the second prototype indicated a somewhat higher grain separation loss (about 4-5%) when compared to the first prototype machine. The major difference between the two machines is in the size of the screen perforations in the concave. Due to the unavailability of the 1/2-in. perforated sheetmetal used with the first prototype, a 7/16-in. perforated sheetmetal was utilized in the second machine. It was hypothesized that the 1/16-in. decrease in hole size was responsible for the increased separation loss in the second machine. To eliminate this problem, the lower concave of the second machine was fabricated with 3/16-in. round bars spaced 7/16 in. apart. Tests with this particular concave showed an improvement in performance with a loss of about 2 percent at an output of 1000 kg/hr.

In some tests, outputs of over 1000 kg/hr of paddy were obtained with two men feeding the machine. This output was obtained using a 6-1/2 hp aircooled engine which seems adequate for a two-man feeding operation. During regular operation, three men are needed, two to feed and one to collect and bag the grain. The machine uses rated engine power in an efficient manner with an output of 150 kg of threshed grain per horsepower-hour. This compares favorably with other machines such as 75 kg/hp-hr for the McCormick threshers, 99 kg/hp-hr for Japanese head threshing type threshers, and 100 kg/hp-hr for the IRRI table thresher. An average cleaning quality of 96 percent was obtained, which was quite satisfactory. The improved blower removes most of the lighter impurities. The larger, heavier impurities are separated by the rotary screen cleaner which also acts as an elevator for collection and bagging of the threshed grain.

Satisfactory performance has been obtained with both dry and freshly harvested paddy. There is considerable interest in the manufacture of this thresher because of its high output and low power and labor requirements. The second prototype machine is undergoing further tests and it is expected to be ready for release to manufacturers within the next two months.

PTO thresher

Design features of the PTO thresher are contained in previous reports. A second prototype model was fabricated (fig. 6). The major differences between the first and the second machines are in the basic frame, fan, feeding arrangement, PTO angle, inner rotary screen, and the belt drive of the rotary cleaning mechanism.

The frame and some other components of the second unit are designed with lighter structural steel sections. The second unit has an axial-flow fan instead of the radial fan used with the first prototype machine. The second machine is equipped with a flat belt feeding conveyor which permits

uniform feeding at a higher feed rate. These changes were necessary to reduce the weight of the machine for easier lifting by the tractor three-point linkage and to increase output.

Another improvement in the second unit is the PTO drive shaft angle which has been reduced appreciably from that of the first prototype machine. The angle on the first prototype exceeded normal design limits and would have encountered service problems. Reduction in the angle was achieved by recessing part of the PTO shaft and the universal joint into the threshing cylinder. With this arrangement, it was not necessary to extend the length of linkage components to accommodate a longer PTO shaft. It is necessary to minimize the distance between the tractor and the thresher to reduce the load on the three-point linkage. The longer PTO shaft reduced the angle from 24 to 14° .

The 1/2-in. perforated sheetmetal used in the inner cylinder of the rotary separator screen could not be obtained locally. A 7/16-in. perforated screen was substituted in the fabrication of the second machine, resulting in reduced separation efficiency. Tests with the second thresher indicated a slightly higher grain loss in the straw than with the first prototype unit. A number of modifications to reduce this loss were attempted. Since perforated screens are imported in most Asian countries, attempts were made to minimize the use of perforated screen in this thresher design. A new cylinder screen of 3/16-in. round bars spaced 1/2 in. apart was fabricated and is now being tested. Threshing output of over 2 tons/hr has been obtained with both dry and freshly harvested crops with the second machine. This output is about 0.5 ton/hr greater than the first prototype unit's output.

The V-belt drive on the rotary screen separator in the first prototype machine encountered serious belt slippage problems. Perforated V-belts do not have sufficient strength to maintain uniform tension and require periodic adjustment. These V-belts were replaced with two 2-in. flat belts in the second machine. The flat belts are performing satisfactorily without any apparent slippage. This modification has further simplified manufacture because flat belts are readily available in most Asian countries.

It is expected that the PTO thresher will be ready for commercial production within a few months. A number of companies have already approached the Institute to obtain drawings and no problem is foreseen in its commercial introduction. As soon as the design is ready for release, local manufacturers will be asked to submit quotations. A few machines will be obtained for test and evaluation on rice and other crops in the Philippines and other Asian countries through our subcontracting agencies.

Stripper harvester

The details of the four-row, self-propelled stripper harvester are contained in semiannual report No. 14. The machine encountered some

problems in moving through wet fields. A half-track system was added to the front wheels to increase the ground contact area. The effective surface bearing area of the tracks is 0.194 sq m compared to 0.078 sq m when using wheels.

By incorporating the half-track, improved machine mobility was obtained in softer fields and in crossing levees. Further improvements, however, may be needed to negotiate extremely soft field conditions found in many tropical regions. Since the tracks are located on the sides of the harvesting header, the 25-cm paddy row spacing limits the width of the track assembly to a maximum of about 20 cm. This results in a long track to maintain the low ground pressures required. Future prototype units may have the four wheels located at the rear of the stripper header. A configuration of this type is possible with a wider six- or eight-row machine which will look similar to regular cutterbar type grain harvesting combines.

Another problem encountered with the machine was in harvesting lodged crops. Some plants, especially at the sides of the four-row swath, failed to enter the threshing mechanism. Japanese binders and combine harvesters have overcome this difficulty by using complex crop-lifting finger mechanisms which have many moving parts and high sliding friction in the finger-deflecting mechanism. A simple crop-lifting chain mechanism was developed to lift the lodged plant and feed it to the gathering bars. The mechanism consists of fixed fingers installed at regular intervals on a chain and which are inclined at 45° from the axis of the chain sprocket shaft. The sprockets are also inclined at 45° with respect to the direction of machine travel. When lifting lodged crops, the fingers are perpendicular to the direction of travel and are along the direction of travel when moving downwards. A shield over the downward-moving fingers acts as a crop divider for the machine.

Initial tests with the fingers indicate good lifting action, although some straw-cutting was observed which was attributed to the high speeds as the fingers turned over the small drive sprockets. Different relative finger-ground velocities were tested and a final horizontal finger velocity of one and one-half times the ground speed was selected for use with the machine. Using a 30° chain angle with the ground, a chain speed of 0.386 m/sec is required at a ground speed of 0.223 m/sec.

The 7.5 hp power tiller used as the prime mover on the harvester seems to have insufficient power to handle a four-row swath, especially when equipped with the crop-lifting fingers. At this juncture, however, it is difficult to change the prime mover because it would involve a major design change. Present plans are to continue experimenting with the four-row machine until all problems are eliminated from the harvesting mechanism. When the design of the harvesting mechanism is finalized, a larger engine with a new transmission will be installed to drive the harvester.

Field tests at Bay, Laguna with the stripper harvester (fig. 7) indicate a total grain loss of about 6 percent. The loss is comprised equally

of scattered and unthreshed losses. Most of the panicles left unthreshed were on short plants. Further trials and improvements are underway. This is a complex project and will require fabrication of a larger six- or eight-row harvester before its release for commercial production.

Drying and processing

Heated-sand drying and parboiling equipment

The design for the experimental rotary heated-sand drying and parboiling equipment has been described in previous reports. Semiannual report No. 14 indicated that attempts would be made to increase the heat utilization efficiency by utilizing exhaust heat from the machine to preheat the incoming high-moisture paddy or for further drying of the hot grain after it emerges from the machine.

A rotary tumbling conveyor was added above the drying unit to preheat the incoming grain. Hot exhaust gases from the area of the drying chamber are channeled through the rotary conveyor which tumbles the wet grain. Grain from the hopper passes through the tumbling conveyor and is exposed to the hot gases before reaching the drying chamber. Figure 8 shows the details of this modification. The modified unit has just been completed and is undergoing preliminary tests. The machine, prior to this modification, indicated a 55 percent thermal efficiency within the drying chamber and a 65 percent thermal efficiency when the moisture removed during grain cooling was included. It is expected that the thermal efficiency will be substantially increased with the addition of the preheating mechanism.

Rice hull furnaces

Two different rice hull furnace designs were described in semiannual report No. 14. One furnace is made of fire bricks enclosed in a steel frame and the other was made from steel plates. Several problems encountered with both designs were solved by a number of modifications. The modified furnaces are shown in fig. 9(a) and (b). An eccentric idler pulley was placed on the fan belt to drive a vibratory automatic hull-feeding and ash-removing system. This arrangement has worked satisfactorily and requires minimum manual attention.

The two furnaces have been tested in conjunction with the axial-flow blower that is being manufactured for the IRRI batch type drier. During tests, both furnaces had a hull consumption of 3-4 kg/hr which produced a drying air temperature of 43°C (starting from 29°C) at an airflow rate of 45 cu m/min against a static pressure of 1.9 cm of water. A maximum drying air temperature of 60°C was obtained when hull consumption was raised to 8 kg/hr at the same air flow rates. More complete hull combustion, however, was obtained at the lower feeding rate.

Centrifugal milling studies

As part of a series of studies on our centrifugal huller-polisher, a commercially available Japanese centrifugal huller equipped with a steel cylinder type polisher was obtained. This machine uses a special urethane lining as the impact surface for grain during hulling. The lining is expensive and must be imported in most Asian countries.

Tests were run using this machine equipped with both the original urethane lining and a standard rubber belting which is readily available at low cost in all Asian countries. Separate tests were run to study the performance of the huller and then the huller-polisher combination with the two linings. Three different settings, one as recommended by the manufacturer, one below, and one above, were tried on the polisher outlet. Other adjustments were set according to the manufacturer's recommendation. IR24 paddy with 12 percent initial moisture content dry basis and 97.23 percent purity was used in the test. About 22 kg of paddy was used for each test which were run at an average feeding rate of 950 kg/hr.

The huller performance with the two linings is as follows:

	Original lining Ave. of 9 runs, %	Flat belt lining Ave. of 6 runs, %
Head rice	49.11	43.22
Paddy	3.44	6.52

The data indicate that the flat belt reduces the hulling by about 3 percentage points. The cost of the original lining, however, is considerably more than that of standard rubber belting. The combined huller-polisher performance with the two linings were as follows:

Polisher setting	Centrifugal huller: Original lining, Total recovery (%)	Original lining, Head rice (%)	Flat belt lining, Total recovery (%)	Flat belt lining, Head rice (%)
1	67.85	43.13	67.92	38.98
2 (Manufacturer's recommendation)	64.89	34.40	63.85	27.01
3	61.00	25.11	62.26	26.82

This indicates that the cheaper rubber belt lining produces a slightly higher percentage of broken grains, but the difference is reduced at the higher polisher setting. The control sample milled in a McGill miller produced a total recovery of 68.57 percent, head recovery of 48.48 percent, and bran removal of 7.56 percent.

It was noted that very fine broken grains were thrown out of the centrifugal huller along with the hull which was separated from the grain by a blower. At the higher polisher adjustments, the 9 hp engine did not have adequate power for the combined hulling-polishing operation. The degree of wear on the impact lining at different housing positions is shown in fig. 10.

Further study and tests on the commercial centrifugal huller-polisher machine will be conducted to gain additional insight and information for the design of a new rice mill.

Steel huller-mill improvements

The Engleberg huller-polisher is the most popular mill used for small operations in all parts of Asia. The machine produces low milling yield and a high proportion of broken grains. There is a dearth of knowledge on the design of these steel huller machines. Since most of the original development was done by commercial organizations, very little published information is available describing the reasons for various features found in the design of this machine.

In discussions with local manufacturers, it was found that no one was clearly aware of the functions of the various design features found on their own machines. It became apparent, from these discussions, that certain features of the steel huller cylinder are critical in obtaining proper milling performance. Everyone indicated his preference for a specific rib design but no one was able to provide a specific reason for this preference.

Attempts are now underway to improve the steel huller mill. A popular size unit with a capacity of 175-265 kg paddy per hour was obtained from a local manufacturer. This machine was set up in the laboratory to study its performance, first in its original condition and later with some modifications on the steel cylinder and the concave screens.

In the steel huller rice mill, the amount of grain retained between the cylinder and the concave and consequently the pressure developed on the grain is controlled by an adjustable gate. Experience is necessary to obtain good milling performance and errors can be easily made by inexperienced persons with this arrangement. Attempts are now being made to develop an adjustable weight-loaded gate which will control the pressure at the discharge point. This will permit the development of uniform pressure in the machine and, hopefully, minimize grain breakage. A similar approach is used in some Japanese milling machines. If the experiment proves successful, then a weight-loaded gate can be developed for existing steel huller mills. The pitch of the rib screw on the cylinder also varies in different machines and seems to affect the milling efficiency. This is another aspect which will be evaluated in an effort to improve the machine.

TEST AND EVALUATION

4-6 hp power tiller

Field performance evaluation of our second prototype and one manufacturer's initial production prototype were reported previously (report No. 14). Tests were completed on the second manufacturer's initial production unit this period. A full report of our findings was submitted to the manufacturer.

The following components required repair during the test:

(1) Engine mount and counterweight support bracket failed.
(2) Hitch pin hole wore badly.

These items were repaired and the unit has been extensively used in our field operations. Performance has been satisfactory with no problems to report in over 200 hours of operation.

Tests are currently being conducted to determine effective field capacity, fuel consumption, operating speed and ease of operation for the different field tasks performed. For each test, soil penetrometer readings at 5 cm intervals to a 20 cm depth are taken, height of weeds and stubble are measured and general field conditions recorded. Data and information derived from these tests will be incorporated into the operator's manual.

Low-lift bellows pump

Two manufacturers submitted their initial production prototypes for evaluation. To facilitate test of these units, a test fixture was constructed to permit continuous pumping against a 1-m head. A 1/2 hp electric motor was used to drive the pump.

The bolt fastening the hinge shaft to the base plate failed in both units after less than 5 hours of operation. The outer canvas of one bellows failed along the width of the metal reinforcing plate in one unit at 7 hours and 37.5 hours in the second. This failure was caused by stitching too close to the metal reinforcement. A similar failure occurred in the second bellows of each unit after an additional 30 hours operation. Testing was continued on one unit until the inner rubberized canvas was punctured. This failure occurred at 165 hours of operation.

A complete report of the tests was submitted to the manufacturers. We recommended that the stitching around the metal reinforcing plates be removed if a good waterproof adhesive is used to glue the inner and outer fabric together. All stitching should be of a high-quality, waterproof thread such as nylon or a similar synthetic.

Hand-operated rice transplanter

Evaluation of a locally manufactured hand-operated rice transplanter was conducted to determine field performance, design characteristics, soundness of construction, ease of handling, and to check the specifications and other data furnished by the manufacturer. The transplanter is a five-row machine with a 20 cm row spacing. The manufacturer recommends 20 to 25-day-old wetbed seedlings for transplanting.

Field performance of the machine was evaluated on the basis of the following criteria:

1. Effective field capacity
2. Number of hills per square meter
3. Number of tillers per hill
4. Missed hills per square meter
5. Depth of planting
6. Distance between hills.

Three field trials were conducted, using 20-, 25-, and 30-day-old seedlings. The test results are shown in table 1.

On the first trial, the problems encountered were: (1) frequently the picking fingers did not pick any seedlings and (2) the seedling tray did not move back and forth uniformly or consistently. These problems are interrelated and are the primary cause for a high number of missed hills. If the operator repeated the transplanting cycle, this resulted in an excessive number of seedlings in some hills and a considerable reduction in field capacity.

The manufacturer was informed of these problems and prior to the second trial, replaced the picking fingers with a new assembly made of high carbon steel and adjusted the planting depth to a minimum. The results show (trial No. 2) an increase in field capacity with a significant reduction in the number of seedlings per hill. Planting depth control was not effective in these tests.

Increased field capacity with fewer missed hills was obtained in the third trial. However, the number of seedlings per hill was again too high. This appeared to be caused by greater root entanglement when using older seedlings. The increased field capacity observed may be partially due to increasing operator proficiency.

The distance between hills in all trials is too wide. Between hill spacing is controlled by the operator visually and judgment. Spacing is thus highly variable, and the effect of missing hills is more pronounced at the larger spacing.

A copy of the test results was provided the manufacturer, with recommendations for further improvement of the machine.

Japanese transplanter

Performance evaluation of a Japanese transplanter was conducted to determine its suitability for local conditions. The machine is a two-row, single-wheel, gasoline engine driven unit. Row spacing is 28 cm. Seedlings must be grown in 28 cm x 58 cm x 3 cm wood trays. Specifications state that 15, 20, and 25-day-old seedlings may be used.

Initial plans were to conduct field trials with each of the different age seedlings. However, after approximately 20 days of growth, all seedlings died. We were unable to solve the biological problem of raising beyond 20 days of age. Tests were conducted using 10, 15, and 20-day-old seedlings. The machine was adjusted according to the manufacturer's recommendations for the test. Results of the first trial are shown in table 2.

The effective field capacity was 10.5 hr/ha. Maintaining straight rows is difficult as movement of the seedling carrier from side to side tends to unbalance the machine. Considerable care must be exercised in raising the seedlings for proper transplanter operation. Our inexperience in raising seedlings and correctly operating the unit contributed to the high number of missing hills. Producing seedlings of the desired size and vigor is a difficult problem under local soil conditions. Experiments on the feasibility of using dapog seedlings are now being conducted.

Cotabato paddy thresher trials

Two double-drum type threshers produced in Cotabato were evaluated at the Institute. Test objectives were to determine the capacity, output per labor-hour, threshing, separating and cleaning efficiency, and the optimum drum speed for least grain damage at high output and efficiency. The two threshers differed in drum diameter and recommended drum speed. One was equipped with an oscillating straw rack (fig. 11a).

IR20 with approximately 20 percent grain moisture and 60 percent straw moisture was used in the tests. The material was hand-harvested with an average length of 70 cm.

Thresher A (fig. 11b) has a drum diameter of 38 cm and a tooth height of 7.6 cm. It was first tested at the manufacturer's recommended drum speed of 900 rpm on the first drum. At this speed the second drum rotates at 1450 rpm. During the tests, two men were feeding and a third removed straw from the straw outlet. Output under these conditions was approximately 420 kg/hr. Threshing efficiency was satisfactory but some visible grain damage was evident. Machine performance is shown in table 3.

Thresher B has a first drum diameter of 30 cm and a second drum diameter of 25 cm with a 7.6 cm tooth height on both drums. The manufacturer's drive design has both drums operating at the same speed. Two men were feeding and a third removed the straw from the straw rack.

This thresher was first tried at a drum speed of 600 rpm. At this rpm, the threshing and cleaning efficiency were satisfactory with no visible grain damage. However, separating efficiency was very low (70%) and straw ejection from the second drum was slow. Oscillation of the straw rack was too slow to move the straw off the rack. The capacity ranged from 265 to 350 kg/hr. The blower inlet was partially closed in an attempt to reduce separation losses. This greatly reduced separation losses but also reduced cleaning efficiency (table 4).

It was decided to run further tests with the blower inlet partially closed. Increasing drum speed would also increase blower speed. At 800 rpm drum speed, capacity was not increased. Threshing and separating efficiency were not improved although there was some improvement in cleaning efficiency. Straw rack oscillation was still too low for effective straw removal. Some visible grain damage was evident.

At 1000 rpm drum speed, capacity increased to 440 kg/hr. Threshing efficiency was good but there was no decrease in separation losses. Cleaning efficiency was increased and the straw rack was partially effective in moving straw out of the thresher. Considerable grain damage was evident at this rpm. Frequent clogging occurred at the first drum which stalled the engine. The first drum would accept material at a higher rate than the capacity of the second drum which caused the clogging. At 1200 rpm drum speed, seed damage was severe and high separation loss was experienced. Machine vibration was excessive and it was unsafe to operate the machine.

Thresher A is a double-drum thresher but there is no axial movement of the material in passing from one drum to another. The material moves radially from one drum to the other. Drum speeds are set to ensure continuous flow through the machine. This permitted continuous testing and gave overall better performance than thresher B. However, the recommended 9 hp diesel engine did not provide sufficient power to obtain the higher output claimed by the manufacturer. The air control was ineffective and thus cleaning efficiency was affected by the condition of the input material.

Threhser B follows more closely the double-drum principle of operation. However, the drum speeds are apparently incorrectly set for proper thresher operation. Clogging occurred frequently and the overall performance was poor. The straw rack oscillation was inadequate and the straw rack was ineffective in separating and moving the material out of the machine. Blower rpm was too high and no air control provided. Power requirements were excessive and we never obtained the output claimed by the manufacturer.

Brief tests were conducted on sorghum at approximately 14 percent moisture. Grain damage was severe, even at the lowest drum speed, and the test was discontinued.

A field trip to Cotabato was made to evaluate similar machines' performance under field conditions. It was not possible to locate any

machines produced by the manufacturers of the two threshers tested at IRRI. However, two other double-drum type threshers were tested during this visit. These threshers used wire loop threshing teeth while the ones tested at IRRI were solid steel. There were no major differences in the operating characteristics of these machines. Considerable labor was used which reduced output per man-hour. Total output per hour was higher than we obtained at IRRI. Threshing efficiency was good and cleaning efficiency excelelent, but separation losses were comparable to the machines tested at IRRI. Table 5 shows the results of the tests in Cotabato.

Batch type drier

One manufacturer's initial production prototype of the batch type drier was received and evaluated. Six trials were conducted using paddy with an initial moisture content of 19.04 to 25.82 percent (wet basis). Continuous temperature readings were taken of the top and bottom grain layers at several points in the bin with a thermocouple recorder. A dial thermometer was installed in the air plenum chamber to record drying air temperature. Drying air temperature was maintained at 110°F± 2°. Grain samples of the top and bottom grain layers were obtained every hour to determine grain moisture reduction per hour. The 3 hp engine was set at 3200 rpm giving a fan speed of 2200 rpm. This provided a static pressure of 2 cm of water or an airflow rate of 35 cfm/cu ft of grain. Drying bin capacity is 1 ton at a 30-cm grain depth.

Results of the tests (table 6, trials 1 to 5) show an average moisture reduction per hour in the top and bottom layers of 1.08 and 1.98 percentage points, respectively, for continuous drying. Gasoline consumption of the engine was 0.72 liter/hr and kerosene consumption of the burner was 2.14 liter/hr.

Drying with intermittent tempering was also evaluated (trial 6). Moisture reductions per hour in the top and bottom layers were 1.51 and 2.33 percentage points, respectively. The results show that tempering had no effect on the final moisture content difference between the top and bottom grain layers.

The safety control valve of the burner was tested. The air vane activating the fuel valve did not function effectively. Complete fuel shut-off was not obtained and the burner flame was not extinguished in the desired 30 seconds or less. The longer than necessary fuel line between the shut-off valve and the burner contributed to this problem.

We recommended that the manufacturer install an effective shut-off valve with a minimum length fuel line between burner and shut-off valve. A secondary fuel control valve, marked to correspond with desired drying temperatures, is also recommended. We suggest that the fuel container for the burner be clamped to the drying bin to prevent accidental spillage.

ECONOMICS OF MECHANIZATION

Survey of large tractor contract operations[1/]

A prevalent feature of rice farming in Central Luzon is the extensive use of standard four-wheel tractors and large stationary threshers for contract work. The tractors are used principally for land preparation and operate under conditions for which they were not designed. The adverse conditions encountered in lowland paddy operations present some crucial technical and economic limitations to the effective use of these machines. In order to gain more insight on these problems, a cooperative field study was undertaken in conjunction with a private firm in the agricultural equipment industry.

The study was premised upon a number of objectives which empirically support the design and development activities at IRRI. Specifically, it was designed to analyze the experiences and impressions of four-wheel tractor owners and operators regarding the suitability of their machines to wetland rice requirements. Information on tractor use patterns, costs, desirable and undesirable design features, technical efficiency and profitability was gathered in a field survey conducted in October, November and December of 1972.

A total of 134 respondents randomly chosen from a population of approximately 500 tractor owners in Nueva Ecija province were selected for personal interviews. The relatively high tractor density and the predominant use of the tractors in rice were the overriding considerations in the selection of the study area.

There are two distinct types of tractor owners in the area: farmers and non-farmers. Of the 134 respondents, 115 (86%) are farmers and 79 percent of them also rent out their tractors after work on their own farms. Unlike owners of hand tractors in Laguna province (a majority of whom are tenants and lessees), these farmer-contractors are primarily owner-operators cultivating an average of 19 hectares of irrigated two-crop land (table 7). Most of the non-farmers rely solely on contract work as a source of income and travel a maximum distance of 500 km to find work for their machines. Their tractors are seldom idle as they move from one area to another following the agronomic cycle in the region.

All the tractors are powered by diesel engines averaging 63.8 hp (table 8). There is also a discernible trend towards larger, more powerful machines. Average horsepower, for example, has increased by 10 hp over the past seven years. Viewed in relation to current farm size and use characteristics, the trend towards larger tractors seems to be partially a result

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[1/]The field survey upon which this report is based has only recently been completed and the data are presently being tabulated. The results presented here should be interpreted cautiously and as preliminary.

of dealer sales efforts rather than farmer needs. Interviews with tractor owners indicate that there are no clearly defined criteria for the choice of tractor size. Choice is often a combination of what the farmer thinks he needs and what machinery and equipment a dealer has available. This is further substantiated by the fact that most tractor owners have pieces of equipment which they seldom, if ever, use. Table 9 shows that they invariably have a disc plow. In practice, however, this implement is seldom used since the rotavator is more effective for tillage under wetland conditions. While tractor harrows are found in the equipment inventory of many tractor owners, it is surprising that 78 percent of the farmers still feel the need to keep and maintain carabaos for final land preparation (harrowing) and other farm jobs. This adds to the costs of the farmer who pays for extra power and extra pieces of equipment he does not actually need.

The majority of the tractors (83%) were acquired through credit programs of which the CB:IBRD (see report No. 13) and dealer installment plans are the most important (table 10). These financing schemes invariably require a substantial amount of collateral as security for the loan. This could partially explain the divergent pattern of ownership for large vs small power units. In Laguna province, where power tillers predominate, average farm size is only 4.3 ha. But what is more important in the present context is that most farmers have only a minimal equity in the farm business and thus have a very low credit-carrying capacity. Owners of large tractors in Central Luzon, on the other hand, are predominantly owner-operators. Furthermore, they are cultivating farms four times the size of those of Laguna tractor owners. This underscores the selectivity of mechanization and indicates that the pattern of mechanization, even for the same crop, varies between regions and within regions as well. Credit has played a major role in determining emerging patterns of mechanization use and ownership in Philippine agriculture.[2/]

Grain loss study

An experimental trial was conducted during the 1972 dry season to quantify paddy loss characteristics which occur in the harvesting and threshing operations. The objectives of the study were: (1) to determine the magnitude and causes of field losses, (2) to determine the optimum time of harvest to obtain maximum grain yields (rough rice and head rice), and (3) to investigate alternative harvesting-threshing systems which will mimimize

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[2/] For a more comprehensive analysis of the impact of credit programs on mechanization in the Philippines, the interested reader is referred to R. Barker, W. Meyers, C. Crisostomo and B. Duff, "Employment and Technological Change in Philippine Agriculture," International Labour Review, August-September 1972, and I. Estioko, "CB:IBRD Farm Mechanization Credit Program: Philippines," presented at ADC Seminar on Farm Mechanization in Southeast Asia, Penang, Malaysia, November-December 1972.

losses and increase incomes. The results will provide the basis for formulating design parameters for improved equipment to be used in these operations.

The study made use of IR747[3/] and IR24, a shattering and a medium-shattering type, respectively. IR747 matures in 108 DS (days after seeding) and IR24 in 125 DS. The experiment had 10 treatments each representing a different harvest date beginning at 105 DS for IR747 and 113 DS for IR24 and continuing every third day for 30 days with three replications for each treatment. At the post-harvest stage, the samples from each treatment were divided and reduced to 14 percent moisture using solar (use of sunlight) and mechanical drying (use of hot-air drier). This procedure allowed examination of the effect of different drying methods on total and head yield recovery.

The rough rice yields of IR747 and IR24 are shown in tables 11 and 12, respectively. In general, the grain yield of IR747 increased gradually until a maximum point was reached at 111 DS (fig. 12). This gradual increase in grain yield apparently came from a decrease in unfilled grains. It was evident that at the first harvesting date (105 DS), some of the grains were still green and as the date of harvesting was delayed, the percentage of unfilled grains decreased. Consequently, up to 111 DS, the percentage of ripe grains rose and the moisture content decreased. Note also, that the weight of rough rice increased with a corresponding decrease in moisture content. Beyond 111 DS, a decrease in seed weight occurred up to 123 DS. This indicates that after 111 DS there is little or no accumulation of dry matter and grains begin to decrease in moisture. It is probable that the high grain losses incurred during the later harvests are due principally to a reduction in moisture content. As the moisture content decreases, the pedicel becomes brittle, resulting in increased shattering losses as the time of harvest is postponed. Postponing harvest may also cause cracking of the caryopsis with resulting decreases in milling recovery. The last three harvest dates showed slight increases in seed weights which can be partially explained by early rains which increased the moisture content of the grains.

The yield pattern of IR24 (table 12 and fig. 12) shows a different trend, gradually decreasing from the first to the last date of harvest. Another notable feature is the low grain yield. IR24 is a high-yielding variety and reputedly more resistant to shattering than IR747. These seemingly inconsistent results are largely attributable to climatic conditions at the time of harvest. IR24 was harvested under extremely adverse weather conditions while IR747 was cut during normal weather.

Comparing the milling quality of mechanically and sun-dried samples within varieties, we found that the former gives a higher head rice

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[3/] IR747 is not a named variety. Its complete designation is IR747B2-6-3.

percentage than the latter. This demonstrates the advantage of controlled drying (mechanical) over the sun-drying method. Mechanical drying of paddy reduces sun-checking in the grain and subsequent breakage during milling. Tables 11 and 12 show that for both varieties, head rice yields increased up to the approximate date of maturity and gradually decreased as harvesting was delayed. Treatments 1, 2, 3, 9 and 10 for IR747 sun-dried samples produced low head yields due to a slight rain (drizzle) that occurred during the drying experiment. It was found that the rewetting of dried grains resulting from rain or moisture condensation which occurs during cool, humid nights increases breakage during milling. Sharp changes of temperature during the drying operation also increase checking of the kernels, thereby decreasing milling recovery rates.

Comparing the milling quality of mechanical and sun-dried samples between varieties shows that IR747 mechanically dried and sun-dried samples have higher head rice recoveries than those of IR24. Again the effect of weather conditions at the time of harvest decreased both the milling recovery of IR24 and the comparability of data. The constant rains brought about by the typhoons might have resulted in saturation of the panicle and consequent chalkiness in the harvested grain. Yields also were influenced by climatic factors such as wind, temperature and atmospheric moisture during the grain maturation period.

Summarizing, a close correlation appears to exist between the date of harvest, yields and head rice recoveries. Both early and delayed harvesting resulted in increases in broken grains. The optimum harvest time is partially determined by the date at which the percentage of brokens is at a minimum level. In this study, it was ascertained that the optimum time is reached when the moisture content is between 19 and 24 percent (105-114 DS) and between 17 and 22 percent (116-122 DS) for IR747 and IR24, respectively.

Economic studies of rice processing systems

Research on alternative rice processing systems during the reporting period has been confined to a review of the rice processing industry in the Philippines. A field survey of existing rice processing technologies, to be implemented during the first half of 1973, will attempt to compare the economic and operational parameters of existing milling technologies in the Philippines with similar studies available from other countries in the region. The objective is to provide basic benchmark data for the design and development of improved milling equipment at IRRI.

Report No. 14 described the approximate relative recovery efficiencies for the three milling systems in the country. Substantial differences can be noted between systems as output increases and quality improves when the choice moves from the kiskisan (Engleberg huller) to the cono and to the rubber roller mills. Similarly, the investment requirement becomes higher as the level of technology becomes more sophisticated.

The major companies which produce and market rice mills were interviewed to determine production and sales patterns and general impressions regarding the current state of the local milling industry. Company price lists and descriptive brochures were obtained. This information for a capital budget is to be used to construct investment and operational budgets for alternative systems of milling. These will form part of the field survey of rice mills in the country.

Table 13 presents some typical machinery purchase prices for a range of Engleberg huller and cono installations. These values do not include the cost of land, buildings, transportation equipment and other miscellaneous items which make up a complete processing system. Local cost data for the rubber roller technology is not readily available. The Engleberg huller ranks lowest in terms of total investment requirements and investment cost per unit of rated capacity. There is also a discernible downward trend in the cost per unit of capacity for both the cono and Engleberg machines as capacity increases. The same is also true to a lesser degree for power requirements per cavan of capacity as size increases in both categories.

From table 14, it is possible to draw some conclusions regarding the concentration of milling capacity and mill numbers. Examination of the data for the cono installations indicates that both numbers and capacity are heavily concentrated in the Central Luzon and Southern Tagalog regions. This is in contrast to the kiskisan installations which are more evenly distributed throughout the country. The cono tends to be oriented towards milling activities involving the purchase of paddy and sale of milled rice to commercial centers while the kiskisan relies principally upon small-lot household milling. Consequently, when transportation facilities are lacking and markets are small and/or isolated, the kiskisan finds wide application. The recent growth of cono capacity and concentration seem to have exceeded paddy supplies in some areas.

The field survey which will be undertaken is designed to investigate the technical and economic characteristics of small- to medium-scale rice mills. The information gathered will be used to analyze the practices of the local milling industry with particular emphasis on the areas where development and innovation are most needed.

CB:IBRD loan assessment program[4/]

Report No. 13 contains a brief description of the CB:IBRD loan program. Through the IBRD, the Philippine Central Bank with the cooperation

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[4/] A complete report of this program is contained in I. Estioko, "CB:IBRD Farm Mechanization Credit Program: Philippines," paper presented at ADC Seminar on Farm Mechanization in Southeast Asia, Penang, Malaysia, November-December 1972.

of the Department of Rural Banks, administered two credit programs for farm mechanization. During the reporting period, a complete assessment of these programs was made to trace the nature and rate of loan utilization to identify the resulting patterns and types of mechanization in the Philippines.

The first program with $5 million from the IBRD was initiated in 1965 and was fully utilized by the first quarter of 1968; the second program with $12.5 million was implemented in June 1969 and will expire in March 1973.

Both programs were designed specifically to encourage mechanization on small farms defined as operational units of not less than 5 ha nor more than 50 ha in size. Credit facilities were made available to eligible farmer-borrowers on the basis of farm management plans and budgets developed jointly by the farmer, the CB and other government agricultural technicians. The size of a loan granted to an applicant-borrower depends upon the actual cost of the object to be financed, the needs of the borrower, the collateral offered, and the borrower's repayment capacity and credit worthiness. Funds were loaned out to finance purchases of four-wheel tractors, hand tractors; farm equipment for planting, harvesting, spraying and dusting; irrigation pumps and engines; equipment and materials for livestock, poultry raising and fish culture. The borrower is required to liquidate his account within (a) three years for farm implements, (b) four years for light machinery, (c) seven years for heavy machinery, (d) five years for irrigation pumps and engines, swine and poultry projects, and (e) ten years for investments in the complete development of an irrigation system or a fishpond culture.

A comparative summary of loan releases as shown in tables 15 and 16 indicates that roughly 88 percent of all loans granted under both credit programs were utilized for the purchase of farm equipment. The concentration of loans for the acquisition of four-wheel tractors and power tillers indicate that mechanization has primarily taken the form of machinery for land cultivation and seedbed preparation.

Out of the first credit fund ($5 million), $4.9 million was withdrawn by some 2,400 farmer-borrowers. Of this amount, 66.3 percent was spent for tractors and implements and 21.6 percent for power tillers and attachments (table 17). In 1967 alone, 560 tractors and 724 power tillers were purchased through the fund (table 15). During the first program, the sale of power tillers rose substantially as more loans were granted for power tillers than four-wheel tractors (table 18). However, of the total amount disbursed, the value of the larger tractors was greater than that of power tillers.

The rate of utilization of the second credit line has not been as rapid as the first. In 1969, the second line of $12.5 million was implemented shortly before devaluation of the Philippine peso (February 1970). In addition, the Central Bank as well as the rural banks found it difficult to fulfill the 10 percent counterpart peso requirement. A subsequent rise in

machinery prices and import restrictions discouraged purchases; loans for tractors and power tillers fell sharply and sales declined. The evidence is not completely clear as to the factors which affected the use of mechanization. The introduction of minimum wage legislation and a general increase in the price level during this period makes an assessment of causality extremely difficult.

As of March 1972, total resources extended under the second credit line to 132 participating rural banks and 1,240 farmer-borrowers amounted to ₱18.3 million with the size of loans ranging from ₱4,000 to ₱40,000 (table 19). Loans for the purchase of farm tractors and accessories totalled ₱15.1 million or 82.1 percent of total loan releases. About 9.5 percent or ₱1.7 million were utilized for livestock development while ₱0.8 million or 4.4 percent went for fisheries development. As a result, including technical service fees, only $2.9 million have been drawn from the second $12.5 million credit line which is to expire in March 1973.

Loan maturities under both programs range from three to ten years. During the first program, four-year and seven-year loans made up 88.6 percent of the total number of loans. These were usually for light and heavy machinery purchases as loans for power tillers may be liquidated in four years and tractors in seven years. Under the second credit program, loans with maturities of seven years amounting to ₱12.3 million represented more than 70 percent of total releases, indicating that the major portion went to purchases of larger tractors.

As of March 1972, 70.6 percent of rural bank gross releases under the first program remained as outstanding loans; 53.3 percent of these loans were past due (table 17). For the second credit line, $2.6 million of the total amount withdrawn from the IBRD are outstanding loans, 2.5 percent being past due.

The diffusion of loans granted through the CB:IBRD credit program is largely concentrated in the regions growing either rice or sugar. A majority of the loans are distributed among the provinces of Luzon, Western Visayas, and Western Mindanao.

While the CB:IBRD loan program may have been a strong single factor in the promotion of farm mechanization, loans have been granted selectively, resulting in limited participation by small farmers. Since all loans granted have been made on the basis of the collateral available rather than on the productivity of the investment, more than half of all loan applications are denied each year. The extension of medium- and long-term loans benefited mostly farmer-owners; more small farmers may be encouraged to avail of the credit when the regulations are relaxed. The operation of the second credit program has been retarded to some degree by the financial condition of the rural banking system. In 1971, according to the Central Bank records, only 125 rural banks out of a total of 539 drew funds from the CB: IBRD agricultural credit line.

Based on the requirements for reviving the second rural credit program and filling the normal agricultural machinery needs for the balance of the agricultural sector, it is estimated that more than 4,000 tractors and 5,000 irrigation units can be funded each year from the CB:IBRD project.

The government's program to promote the growth of mechanization has had mixed results. During the period of the first IBRD loan, tractor and power tiller sales increased significantly, in large part due to the availability of financial resources at reasonable rates. There is little or no indication that the initial CB:IBRD loan unduly discriminated against smaller farmers as shown by the large number of power tillers sold to small farmers. The bulk of the loan did, however, go to the purchase of larger four-wheel tractors. The second loan program shows a definite bias in favor of larger farmers resulting primarily from the tighter collateral requirements imposed on borrowers. These latter conditions, in combination with the devaluation of the peso in 1970, have resulted in a substantial decrease in the quantities of agricultural equipment sold. The increase in the domestic price of equipment and its consequential low rate of return, plus the non-availability of suitable machinery produced domestically, has seriously dampened the government's efforts to introduce mechanization.

Combined with considerations related to growth in output, equity, welfare, and the distribution of income, the issue of employment has caused more serious attention to be focused on the types and patterns of mechanization which are compatible with overall policy objectives.

More research is needed to provide precise measures of the impact of mechanization on these objectives. Additionally, there are strong and compelling reasons to believe that exclusive reliance on imported equipment is unnecessary. For production of certain types of equipment, countries such as the Philippines are well endowed with the knowhow and industrial capacity to produce their own requirements at a cost which is competitive with outside sources. Manufacturing programs of this type require capital and the government might consider use of resources available through agencies such as the IBRD for the design, development, and indigenous production of agricultural machinery.

Small-scale industry study

Work on the study of the small- and medium-scale metal manufacturing industry in the Philippines has been confined principally to establishing contact with relevant institutions pursuing work in the same field. A major problem has been the lack of adequate personnel to undertake this study on a regular basis. There has been considerable interest among local government planning agencies in assisting with the implementation of the study and there appears to be a reasonable chance that a well enumerated sampling frame will become available from which we may draw the sample for the field survey. With completion of the questionnaires, selection of a stratified sample and added personnel support, the project will be in the field during the first half of 1973.

SUBCONTRACT, DEVELOPMENT, EXTENSION AND TRAINING ACTIVITIES

A subcontract agreement was signed in December with the Browns Group Industries, Ltd. in Sri Lanka for the local testing of IRRI designs. This brings to nine the number of agreements which have been formalized with agencies and institutions within the region for the extension of agricultural equipment designs emanating from the project. A complete enumeration of the subcontracting agencies is as follows:

Country	Cooperating agency	Address
India	All-India Coordinated Rice Improvement Project (AICRIP) Dr. W. H. Freeman, Joint Coordinator	Rajendranagar, Hyderabad 30 A. P., India
Indonesia	Directorate of Agricultural Techniques Ir. Soedharso Rawidjo, Director	Pasar Minggu, Djakarta, Indonesia
Korea	Institute of Agricultural Engineering and Utilization Dr. Sung Kum Han, Director	Suwon, Korea
Malaysia	Malaysian Agricultural Development Institute (MARDI) Anuwar bin Mahmud, Director	Jalan Swettenham, Kuala Lumpur, Malaysia
Pakistan	The Ford Foundation Dr. Gordon W. McLean, Chief Advisor	2, Street 61st, Shalimar-7 Islamabad, Pakistan
Philippines	Nueva Ecija Land Reform Integrated Development Project Dr. B. de los Reyes, Director	Bitas, Cabanatuan City, Philippines
Sri Lanka	Browns Group Industries, Ltd. S. N. N. Perera, Manager, Landmaster Department	481, Darley Road, P.O. Box 200 Colombo-10, Sri Lanka
Taiwan	Joint Commission on Rural Reconstruction (JCRR) Dr. T. H. Shen, Chairman	37 Nan Hai Road, Taipei-107 Taiwan
Thailand	Engineering Division, Rice Department, Ministry of Agriculture Dr. Bhakdi Lusananda, Director-General	Bangkok-9, Thailand

Extension of designs in the Philippines has been considerably expanded in recent months. In addition to the small machinery test and evaluation program located in Central Luzon, tentative plans are being made to work with manufacturers located in other provincial centers. A working arrangement with the Board of Investments (BOI) to assist manufacturing associations in Mindanao appears to hold considerable promise as a vehicle for the transfer and diffusion of designs within the Philippines. The BOI has also offered to provide assistance to small firms facing technical and financial problems.

WORK PLAN

January 1 to December 31, 1972

DESIGN AND DEVELOPMENT

Axial-flow thresher

Additional field tests are scheduled with the second prototype using both low- and high-moisture paddy. Tests will also be conducted with crops such as sorghum, mongo, and soybeans. At the completion of this test series, a few machines will be purchased from local manufacturers for further field evaluation in the Philippines and other countries of the region.

Stripper harvester

There remain a number of problems in the grain conveying system and this will be improved. Continued investigations on various types of losses will be made to pinpoint and correct the design elements responsible. When losses are reduced to the 3 to 4 percent level, the current 7.5 hp tractor will be replaced with a larger gasoline engine and suitable power transmissions will be developed for the harvester. Extensive tests will then be conducted to determine the harvesting output and field losses under actual field conditions. Machine mobility will also receive continued attention. If a simple solution is not found, a wider machine will be fabricated using four wheels located at the rear of the stripping header.

8-14 hp power tiller

Field tests of the first prototype tiller will be undertaken. Any design modifications that are necessary will be incorporated. Field testing to study farmers' reactions and observe the machine's suitability for tilling as well as transport will also be included as a part of the program. As soon as the design reflects a satisfactory level of performance, it will be released to two or three local manufacturers and a few machines will be built for field testing in the Philippines and other countries of the region.

Rice hull furnace

The designs of two rice hull furnaces have been finalized. Tests indicate that both furnaces perform satisfactorily with the IRRI batch type drier. The two manufacturers who are currently manufacturing the drier will be invited to manufacture these furnaces. A limited number of hull furnaces will be purchased with the drier and tested at various locations in the Philippines to study their operational costs, suitability to local conditions, and farmers' reactions.

Oil burner for batch type drier

A kerosene burner and two rice hull furnaces have been developed for use with the IRRI batch type drier. A low-cost diesel oil burner for this unit will be designed.

Heated-sand drier

The improved unit will undergo further testing and evaluation at IRRI. If performance is satisfactory, a few units will be ordered from local manufacturers. These units will be shipped to countries where parboiling is commonly practiced for test and evaluation. In addition, the design will be modified to accept a rice hull furnace and other low-cost fuels. Attempts will be made to utilize the radiated heat from the drier for further drying of the hot grain discharged from the machine.

Rice milling

Tests will continue on various types of hullers and polishers that look promising for village and community level operation. Work to develop new concepts of milling rice will also continue to be explored including the possibilities of a centrifugal huller-polisher which can be fabricated in the less developed countries. There is considerable scope for improving the design of the common Engleberg mills found in all Asian countries. Various modifications to improve its performance will be tested.

Transplanter project

There is considerable interest in a low-cost transplanter for the tropical rice growing regions. Japanese machines are too costly for most Asian conditions and have not been widely accepted. Attempts to find new transplanting concepts permitting the design and manufacture of low-cost transplanters for tropical Asian farmers will be initiated.

Savonius rotor windmill

A Savonius rotor windmill will be designed and tested in conjunction with a Sakaia water-lifting wheel and other types of simple lowlift devices. The power generated by the windmill will be measured to estimate its suitability for other applications such as driving an electric generator.

Direct-flame drier

A direct-flame drier operated in conjunction with an air drier will be developed to reduce drying time. It will be designed for about 1/2 ton/hr drying capacity and will use husk or fossil fuels.

Multicrop seeder

Work will be continued on the development of a multicrop seeder for both upland and dryland work. An experimental unit has been fabricated and this machine will be tested. On the basis of field tests and farmers' reactions, the machine will be further modified. If the multicrop seeder concept is found to be unsatisfactory, a simple machine for seeding only upland crops will be developed.

Non-selective herbicide applicators

Further tests will be continued to evaluate various applicator concepts for non-selective herbicides. If a successful concept is developed, the design of a commercial machine will be undertaken.

PTO thresher

The PTO thresher will be released to local manufacturers for trial production as soon as the new inner cylinder screen of 3/16-in. round bars spaced 1/2 in. apart is completed. Trials using woven wire mesh of gauge 16 wire to replace the perforated screen will also be undertaken. When the design of thresher components is finalized, a few units will be ordered from interested manufacturers for further tests and evaluation in the Philippines.

ECONOMICS OF MECHANIZATION

Tractor contractor operations

The field survey phase of this study was completed during the current reporting period. Tabulation, analysis and interpretation of the survey data will be undertaken and the results prepared in report form within the next two months. Information from this study will be used in the evaluation of design features for future tractor development work.

Grain loss study

Plans are being made to continue field work during the 1973 dry season to determine field loss characteristics incurred in harvesting-threshing operations. Unlike the survey work undertaken during the wet season of 1972, there will be an attempt to incorporate a wider range of rice varieties into the sample and obtain a broader picture of the effect of varietal type on losses. The objectives of the study are to provide the design and development group with additional information on the point in the production sequence at which benefits may be maximized through the introduction of improved harvesting-threshing technologies.

Rice processing systems

A field survey of the technical and economic characteristics of existing milling technologies will be undertaken during the first half of

1973. Plans are to conduct interviews and sample milling at randomly selected cono and kiskisan mills to measure relative recovery rates, technical and economic efficiencies, and marketing characteristics of alternative systems. The results will be used in the establishment of design parameters for improved processing components of the systems.

Small-scale metal industry study

With the establishment of a satisfactory working relationship with a Philippine institution, finalization and pretesting of questionnaires and the enumeration of an adequate sampling frame, the economics group will embark upon a field survey of approximately 150 firms stratified by size and geographic dispersion. The initial results of the study should be available by July or August of 1973.

Rice production task studies

Work will be continued on the assembly and tabulation of data describing individual operations in the rice production sequence. The major objective of this study is to assess the conditions under which improved field production techniques will substantially alter the income opportunities of farmers. As an adjunct to this work, a computer programming model is being constructed to evaluate the interdependencies and impact of alternative technologies on income, employment and resource allocation.

PERSONNEL LIST

Personnel and their respective man-months engaged on the project during the past six months, July 1 to December 31, 1972, and projected requirements, January 1 to June 30, 1973:

Position	Name	Fr: 7- 1-72 To: 12-31-72	Fr: 1- 1-73 To: 6-30-73
Development Engineer & Project Leader	A. U. Khan[a]	4.5	4.5
Agricultural Economist	B. Duff	6	6
Evaluation Engineer	F. Nichols	6	6
Assistant Design Engineer (Machinery)	J. Policarpio	6	6
Assistant Design Engineer (Processing)	A. Manalo	6	6
Research Assistant (Engineering)	J. Arboleda	6	6
Research Assistant (Engineering)	E. del Rosario	6	6
Research Assistant (Engineering)	N. Navasero	6	6
Research Assistant (Economics)	N. Orcino	6	6
Research Assistant (Test & Evaluation)	C. Padolina	6	6
Research Aide (Economics)	I. Estioko	6	6
Research Aide (Economics)	B. Samson	6	6
Research Aide (Test & Evaluation)	B. Ramos	6	6
Draftsman	F. Cabrales	6	6
Draftsman	B. Buan	6	6
Secretary	V. Maraan	6	6
Secretary	C. Jizmundo	6	6
Shop Foreman	S. Gutierrez	6	6
Machinist	Z. Borja	6	6
Machinist	A. Dizon	6	6
Tinsmith	E. Dungo	6	6
Tinsmith	R. Santos	6	6
Welder	A. Barot	6	6
Shop Mechanic	R. Dignadice	6	6
Shop Mechanic	M. Macatangay	6	6
Shop Mechanic	P. de Mesa	6	6
Shop Mechanic	F. Flores	2	0
Laborer (Shop helper)	M. Castro	6	6
Laborer (Shop helper)	E. Macatangay	6	6
Laborer (Student assistant)	L. Lumang	6	6

[a] Three-fourths time charged to the Contract.

Table 1. Test and evaluation trials with manually operated rice transplanter, IRRI farm, 1972.

Trial No.	Age of seedlings (days)	Effective field capacity (h/ha)	No. of hills per sq m	Missed hills per sq m	Seedlings per hill	Depth of planting (cm)	Distance between hills (cm)
1	20	30	13.4	2.6	14.32	5.06	33.5
2	25	17.45	12.3	2.6	6.5	5.18	33.5
3	30	12.2	12.8	1.6	13.28	6.34	33.5

Table 2. Test and evaluation trials with power driven Japanese transplanter, IRRI farm, 1972.

Age of seedlings (days)	No. of hills per sq m	Missed hills per sq m	Seedlings per hill	Depth of planting (cm)	Distance between hills (cm)
10	13.6	3.4	3.4	3.6	18.1
15	14.4	4.4	3.6	4.0	17.2
20	15.6	3.8	3.3	3.7	17.2

Table 3. Thresher A (Figure 11) performance.

Date	July 24, 1972
Variety	IR20
Engine hp	9 (gasoline)
First drum rpm	900
Second drum rpm	1250
Blower rpm	1450
No. men feeding	2
No. men handling straw	1
Moisture content, %	20.5
Test duration, min	5.25
Output, kg/h	420
Labor output, kg/man-h	140
Purity of output, %	94.5
Straw loss, %	10.9

Table 4. Thresher B (Figure 11) performance at different drum speeds.

	Threshing drum rpm (no load)			
	600	800	1000	1200
Test duration, min	6	4	6.5	5
Output, kg/h	276	295	440	440
Straw loss, %	9	9.5	9.5	11.5
Grain M.C., %	19	19	19	19
Straw M.C., %	60	60	60	60
No. men feeding	2	2	2	2
No. men handling straw	1	1	1	1
Purity, %	90.5	93	95	95
Labor output, kg/man-h	98	99.8	146.6	146.6

Table 5. Double drum thresher test. (Threshers made in Bukidnon.) Variety used, IR20.

Date	July 12, 1972	July 13, 1972
Engine, hp	6.5 - 8 diesel	7.5 - 10 diesel
Paddy length, cm	approx. 50	30
First drum rpm	800	900
Second drum rpm	1050	1250
Blower rpm	1500	1450
No. men feeding	2	2
No. men bagging	2	2
No. men handling straw	3	2
Moisture content, %	23	20
Test duration, min	27	30
Output per test, kg	231	420
Output, kg/h	513.3	836
Labor output, kg/man-h	73	140
Purity of output, %	99.5	99.7
Straw loss, %	10 - 15	6
Recycle, %	30	15

Table 6. Results from test of batch type drier.

Trial	1	2	3	4	5	6
Variety	IR-1529	IR-24	C-4-137	C-4-137	C-4-137	IR-1529
Initial M.C. (w.b.), %	23.22	25.82	23.17	21.06	19.04	25.46
Final M.C. (w.b.), %						
Top	14.43	20.54	16.34	15.33	15.28	16.39
Bottom	12.92	10.83	9.94	11.01	13.33	11.44
Drying time, h	6	7	6	5	4	6
Fuel consumed						
Gasoline (engine), liter	4.72	5.57	4.10	3.93	3.16	4.82
Kerosene (burner), liter	9.0	18.0	14.50	11.20	8.70	12.00
Fuel consumption						
Gasoline, liter/h	0.49	0.79	0.68	0.78	0.79	0.80
Kerosene, liter/h	1.5	2.57	2.41	2.24	2.17	2.00

Table 7. Sample survey of tractor owner characteristics, Nueva Ecija, Philippines, 1972.

Occupation	Number	Percent
Farmer & custom service operator	91	68
Farmer	24	18
Custom service operator	19	14
Total	134	100
Farmer characteristics		
Owner-operator	113	98
Lessee	1	1
Tenant	1	1
Total	115	100

Table 8. Tractor characteristics, Nueva Ecija, Philippines, 1972.

Item	Age group (years)		
	< 3.1	3.1-5.0	5.1 & over
Number	56	52	26
Average age	2.7	4.5	10.0
Average hp	68.5	61.4	58.5

Table 9. Farm implements owned, 134 respondents, Nueva Ecija, Philippines, 1972.

Equipment	Number	Percent
Disc plow	84	63
Rotavator	75	56
Ara-wheel[a]	39	29
Disc harrow	26	19
Pegtooth harrow	16	12
Thresher	24	18

[a] The "Ara-wheel" is, in most respects, similar to a cage wheel. It is equipped with blades that till the soil as the tractor is driven through the field. Its continuous use in the field, however, promotes the gradual destruction of the hard pan and farmers are now discontinuing its use.

Table 10. Acquisition of tractors, Nueva Ecija, Philippines, 1972.

Terms	Number	Percent
Cash	24	17
Installment	112	83
Total	136[a]	100
Financing:		
CB:IBRD Program	88	78
Dealer installment plan	35	31
DBP	15	13
Other sources	3	2
PNB	1	[b]

[a] Some farmers own more than 1 tractor.

[b] Less than 1 percent.

Table 11. Rough rice yield and percent head and milled rice yields for mechanically and sun-dried IR747 samples harvested at 10 different dates, IRRI, 1972 wet season.

Days of harvest (DS)*	M.C. at harvest	Rough rice yield (kg/ha)	Mechanical			Sun-dried		
			Head rice %	Broken rice %	Total milled %	Head rice %	Broken rice %	Total milled %
105	23.8	5933	62.7	9.1	71.8	56.5	15.7	72.2
108	22.7	6200	64.4	7.6	72.0	54.2	18.0	72.2
111	20.4	6333	62.1	9.9	72.0	46.3	25.2	71.5
114	19.1	6233	63.7	8.7	72.4	59.2	13.5	72.7
117	18.8	5400	62.9	9.4	72.3	53.7	18.3	72.0
120	17.9	5267	58.4	14.3	72.7	54.5	19.0	73.5
123	17.2	5100	45.1	26.9	72.0	41.6	31.3	72.9
126	17.5	5400	44.2	27.8	72.0	38.2	34.7	72.9
129	19.2	4433	39.7	31.2	70.9	17.7	52.0	69.7
132	20.9	3133	34.0	36.7	70.7	13.9	55.3	69.2

*Days after seeding.

Table 12. Rough rice yield and percent head and milled rice yields for mechanically and sun-dried IR24 samples harvested on 10 different dates, IRRI, 1972 wet season.

Days of harvest (DS)*	M.C. at harvest	Rough rice yield (kg/ha)	Mechanical			Sun-dried		
			Head rice %	Broken rice %	Total milled %	Head rice %	Broken rice %	Total milled %
113	24.5	2333	44.3	23.8	68.1	31.5	37.2	68.7
116	21.7	2667	51.6	17.1	68.7	33.8	35.7	69.5
119	19.5	2200	54.5	14.6	69.1	46.8	22.2	69.0
122	17.4	1833	51.0	17.0	68.0	47.0	21.0	68.0
125	23.5	1567	35.8	30.7	66.5	19.3	47.0	66.3
128	16.2	933	44.5	20.5	65.0	40.8	25.0	65.8
131	18.0	900	-	-	-	26.6	38.3	64.9
134	19.6	200	-	-	-	-	-	-
137	-	-	-	-	-	-	-	-
140	-	-	-	-	-	-	-	-

*Days after seeding.

Table 13. Average investment costs for "kiskisan" and "cono" rice mills, by capacity.

Kiskisan[a]

Capacity per 12 hours (cavans)	Engine size BHP	Average price[d] (₱)	Power HP/cavan capacity	Investment cost[c] ₱/cavan capacity
30-100) with	5-12	1789.00	.167 - .12	113.19
120-180) polisher	16-20	2896.00	.133 - .11	72.13
30-100) without	5-12	897.50	.167 - .12	99.48
120-160) polisher	16-20	1545.00	.133 - .13	67.63
30-100) with	5-12	1574.00	.167 - .12	109.88
120-180) blower	16-20	2413.00	.133 - .11	68.91
40-100) without	5-12	967.00	.125 - .12	93.36
120-180) blower	16-20	1765.00	.133 - .11	64.59
30-100) with	5-12	2246.00	.167 - .12	120.22
120-180) polisher,) sifter	16-20	3417.00	.133 - .11	75.60
40-100) with	5-12	2011.00	.125 - .12	108.28
120-180) blower,) sifter	16-20	2971.00	.133 - .11	72.63

Cono[b]

50-100	15-24	16799.00	.300 - .24	375.37
150-250	25-30	36417.00	.167 - .12	286.08
250-350	32-45	47481.00	.128 - .13	260.65
350-450	45-55	56936.00	.128 - .12	219.13
450-700	60-80	83601.00	.133 - .11	193.14
700-1000	90-140	146027.00	.129 - .14	204.10

[a] Source: Survey of 6 major equipment suppliers by Ag. Eng. Dept., IRRI.

[b] Source: Survey of 7 major equipment suppliers by Ag. Eng. Dept., IRRI.

[c] Taken at midpoint of capacity range. Includes cost of prime movers.

[d] Prime movers (diesel engine) are priced separately:

5-12 BHP	= ₱ 5568.50	25-30 BHP	= ₱20800.00
16-20 "	= 7923.00	32-45 "	= 30715.00
15-24 "	= 11429.00	50-90 "	= 27455.00

Table 14. Rice milling capacity by mill type and region, Philippines, 1968.[a]

Region	Cono				Kiskisan				Total			
	Number	%	Capacity[b]	%	Number	%	Capacity	%	Number	%	Capacity	%
Ilocos	7	0.4	1325	0.5	1186	16.9	39377	12.3	1193	13.7	40702	6.8
Cagayan Valley	63	3.6	11685	4.2	526	7.5	25975	8.1	589	6.8	37660	6.3
Central Luzon	768	44.4	146595	52.5	960	13.7	61311	19.2	1728	19.8	207896	34.7
Southern Tagalog	291	16.8	33904	12.2	1222	17.5	55382	17.3	1513	17.4	89286	14.9
Bicol	116	6.7	17974	6.4	658	9.4	33474	10.5	774	8.9	51448	8.6
Western Visayas	114	6.6	24073	8.6	992	14.2	39639	12.4	1104	12.7	63712	10.6
Eastern Visayas	186	10.8	8917	3.2	468	6.7	20422	6.4	654	7.5	29339	4.9
Southern & Western Mindanao	97	5.6	19206	6.9	724	11.1	34359	10.7	871	9.9	53565	8.9
Northern & Eastern Mindanao	86	5.0	15269	5.5	205	2.9	10201	3.2	291	3.3	25470	4.3
Philippines	1728		278938		6991		320140		8719		599078	

[a] Source: Rice and Corn Administration, Quezon City.

[b] Capacity expressed in cavans per 12 hour operation.

Table 15. Number of CB:IBRD loan releases covering 1st and 2nd credit programs.

	1966		1967		1968		Aug/69-Dec/71	
	No.	%	No.	%	No.	%	No.	&
I. By category								
A. Farm development								
4-whl tractor	72	27.8	560	34.4	265	45.0	455	45.0
Power tiller	126	48.7	724	44.4	228	38.8	185	18.3
Irrig. pump	24	9.3	186	11.4	60	10.2	126	12.5
Spraying eqpt.	3	1.2	25	1.5	10	1.7	16	1.6
Storage & processing							41	4.1
Wells & dist. works							2	0.2
Cargo trucks & trailers								
B. Livestock development	34	13.0	134	8.2	25	4.3	123	12.1
Poultry							56	5.5
Swine							67	6.6
C. Fisheries development								
Fishing boats							5	0.5
Fishponds							59	5.8
TOTAL	259	100	1629	100	588	100	1012	100
II. By maturity								
3 years	18	7.0	48	2.9	7	1.2	16	1.6
4 "	87	33.6	743	45.6	256	43.5	210	20.8
5 "	73	28.2	242	14.9	56	9.5	266	26.3
6 "							6	0.6
7 "	72	27.8	560	34.4	265	45.1	458	45.3
10 "	5	1.9	31	1.9	11	1.9	56	5.5
Not included	4	1.5	5	0.3	17	1.2		
TOTAL	259	100	1629	100	588	100	1012	100
III. By region								
Luzon	170	65.6	1087	66.7	375	63.8	645	63.7
Visayas	59	22.8	302	18.5	91	15.3	212	21.0
Mindanao	30	11.6	240	14.8	122	20.8	155	15.3
TOTAL	259	100	1629	100	588	100	1012	100

Source: Department of Rural Banks, Central Bank of the Philippines.

Table 16. Amount of CB:IBRD loan releases covering 1st and 2nd credit programs (in thousand pesos).

	1966		1967		1968		Aug/69-Dec/71	
	Amount	%	Amount	%	Amount	%	Amount	%
I. By category								
A. Farm development								
4-wheel tractor	1,831.8	81.9	11,298.0	86.7	4,576.5	93.9	9,157.5	69.2
Power tiller							915.6	6.9
Irrigation pump	91.2	4.1	708.0	5.4	131.3	2.7	496.6	3.8
Eqpt. for spraying	12.1	0.6	169.1	1.3	54.3	1.1	175.9	1.3
Storage & processing							554.7	4.2
Wells & dist. works							26.5	0.2
Cargo trucks & trailers								
B. Livestock development	301.3	13.4	855.7	6.6	114.2	2.3		
Poultry							594.7	4.5
Swine farm							673.5	5.1
C. Fisheries development								
Fishing boats							59.1	0.4
Fishponds							574.3	4.3
TOTAL	2,236.4	100.0	13,030.8	100.0	4,876.3	100.0	13,228.4	100.0
II. By maturity								
3 years	33.7	1.5	169.4	1.3	4.0	0.1	96.2	0.7
4 "	331.7	14.8	2,958.0	22.7	794.8	16.3	1,108.3	8.4
5 "	700.4	31.3	1,277.0	9.8	117.1	2.4	2,052.2	15.5
6 "							56.0	0.4
7 "	1,086.1	48.6	8,300.6	63.7	3,823.0	78.4	9,346.6	70.7
10 "	61.0	2.7	273.6	2.1	73.2	1.5	569.1	4.3
Not indicated	23.5	1.1	52.2	0.4	63.4	1.3		
TOTAL	2,236.4	100.0	13,030.8	100.0	4,876.3	100.0	13,228.4	100.0
III. By region								
Luzon	1,599.7	71.5	8,719.8	66.9	2,893.4	59.3	8,875.2	67.1
Visayas	453.2	20.3	2,326.2	17.9	744.6	15.3	2,988.2	22.6
Mindanao	183.5	8.2	1,984.8	15.2	1,238.3	25.4	1,365.1	10.3
TOTAL	2,236.4	100.0	13,030.8	100.0	4,876.3	100.0	13,228.4	100.0

Source: Central Bank of the Philippines, Department of Rural Banks.

Table 17. Summary of the 1st CB:IBRD Credit Program (April 1, 1966 - May 31, 1968).

	Amount (₱)	Percent
Released for 4-wheel tractors and implements	12,949,202.68	66.3
Released for power tillers	4,218,744.76	21.6
Released for irrigation and livestock development	2,363,278.32	12.1
Total amount withdrawn from IBRD	19,531,225.76	100
Loans outstanding (March 31, 1972)	13,797,596.91	70.6
Loans past due (March 31, 1972)	4,866,114.98	35.3

Source: Department of Rural Banks, Progress Report on the CB:IBRD Farm Mechanization Program, March 1972. Central Bank of the Philippines, Manila.

Table 18. Annual sales of power units and number of mechanization loans released under CB:IBRD credit program.

Year	Total imports	Total sales	Inventory	Total sales	No. of loans released for	
	Tractors	Tractors		Power tillers	Tractors	Tillers
1960	297					
1961	102	813	(711)			
1962	262	994	(732)			
1963	918	863	55			
1964	859	950	(91)			
1965	769	607	162	1505*		
1966	518	664	(146)	1932	72	126
1967	2203	1531	672	3058	560	724
1968	1443	1630	(187)	1873	265	228
1969	1390	1358	32	910	54	34
1970	982	978	4	475	150	42
1971	1065	1086	21	258 (Jan-May)	251	109

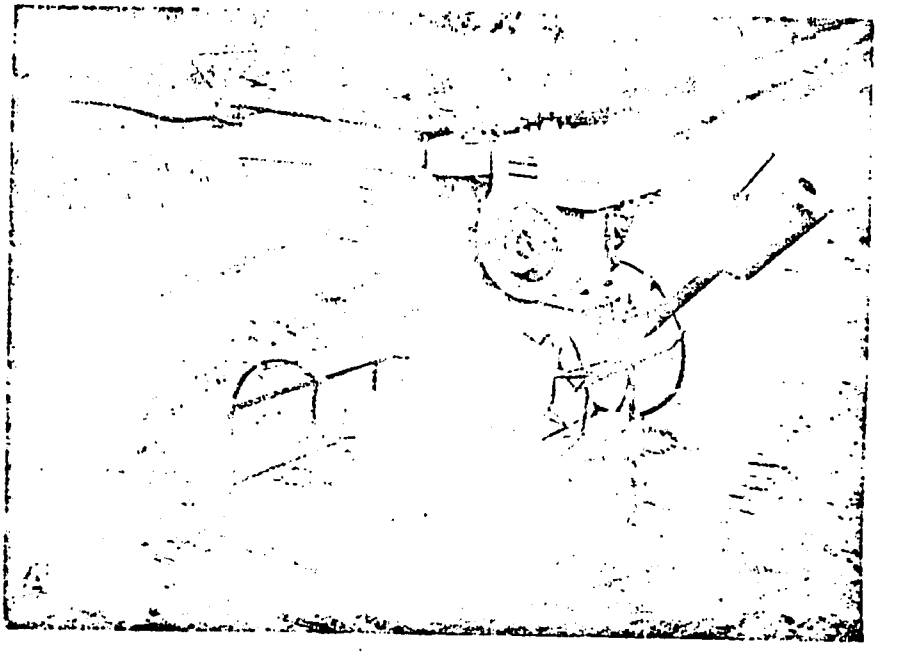
*Estimated cumulative total of power tillers sold between 1960-1965.

Source: Bureau of the Census and Statistics
Agricultural Machinery Dealers Association
Radiowealth, Inc.

Table 19. Withdrawals from IBRD loan account for quarter ended March 31, 1972 (in thousand pesos) (2nd CB:IBRD Credit Program).

	Farm development	Livestock development	Fisheries development	Technical services	Total
1. Total amount available	62,400.0	8,320.0	8,320.0	960.0	80,000.0
2. Total withdrawals at beginning of quarter	11,517.8	1,292.4	645.8	721.4	14,177.3
3. Withdrawals during quarter	3,534.4	451.8	167.6	-	4,153.8
4. Total withdrawals at end of quarter	15,052.2	1,744.2	813.4	721.4	18,331.1
5. Estimated balance available	47,347.8	6,575.8	7,506.6	238.6	61,668.9
6. Estimated commitments for next 12 months	22,000.0	3,000.0	2,000.0	-	27,000.0

Source: Central Bank of the Philippines, Department of Rural Banks.



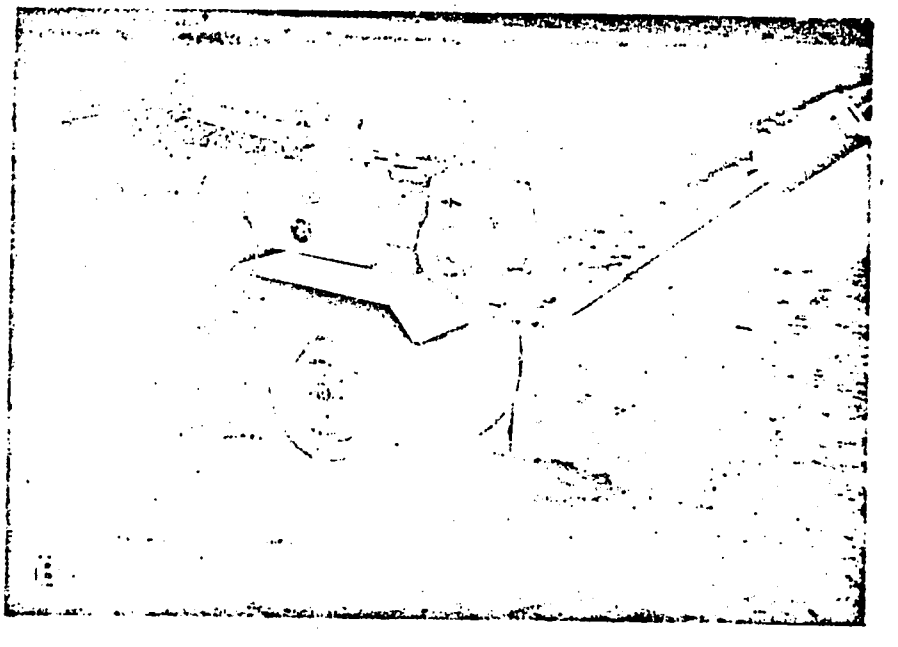


Fig. 1. Commercially produced 4-6 hp IRRI power tillers
a. Marsteel Corporation b. Oberly & Co.

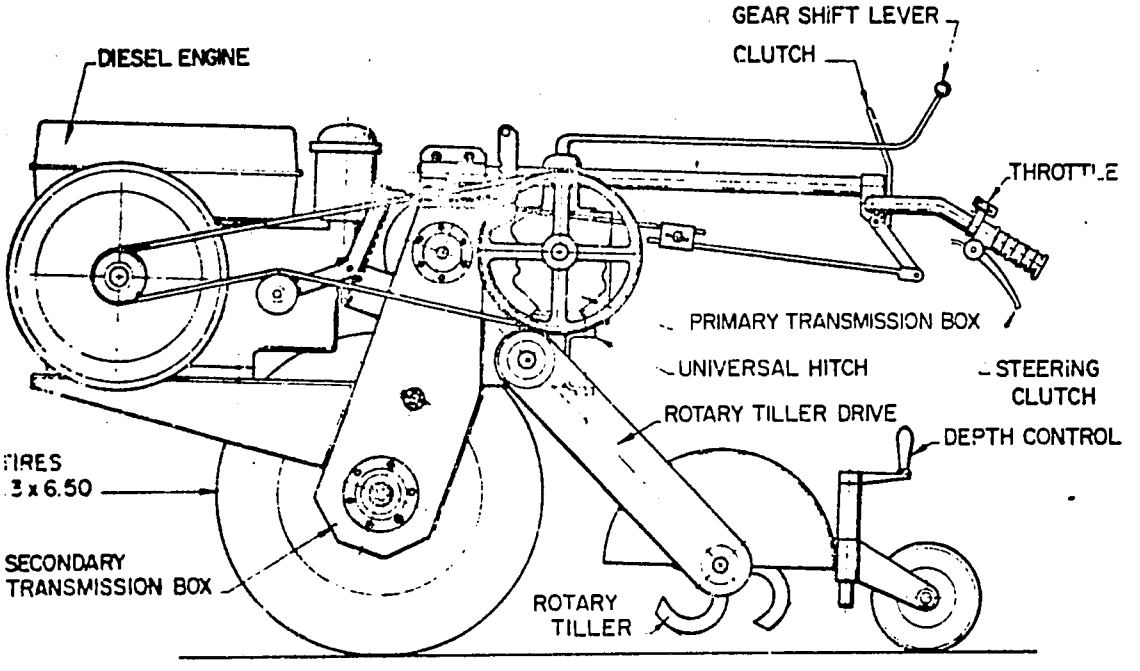


Fig. 2. Schematic drawing of 8-14 hp IRRI power tiller

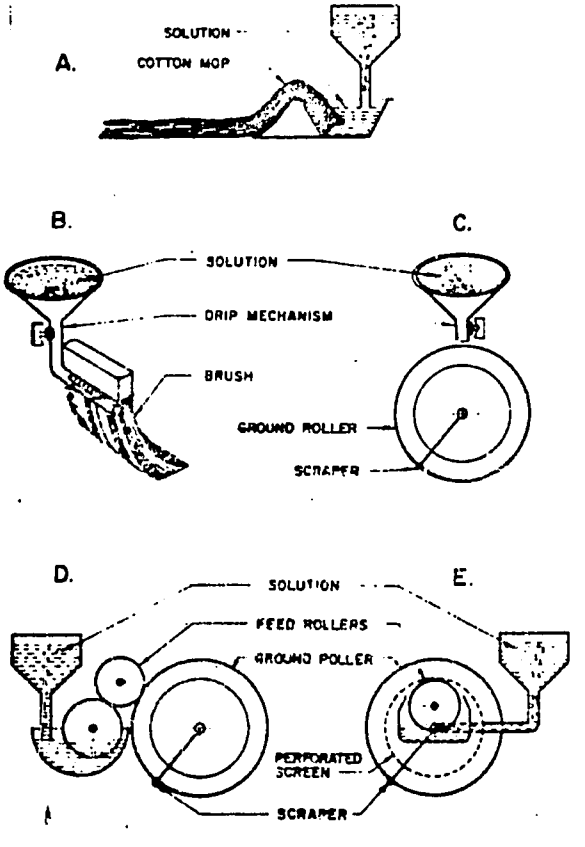


Fig. 3. Concepts for contact application of non-selective herbicides

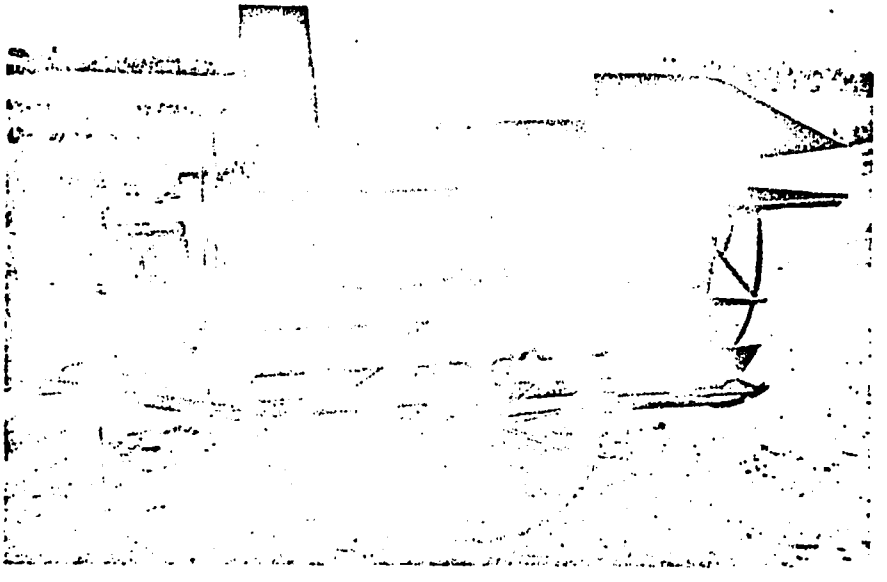


Fig. 4. Second prototype multicrop axial flow thresher

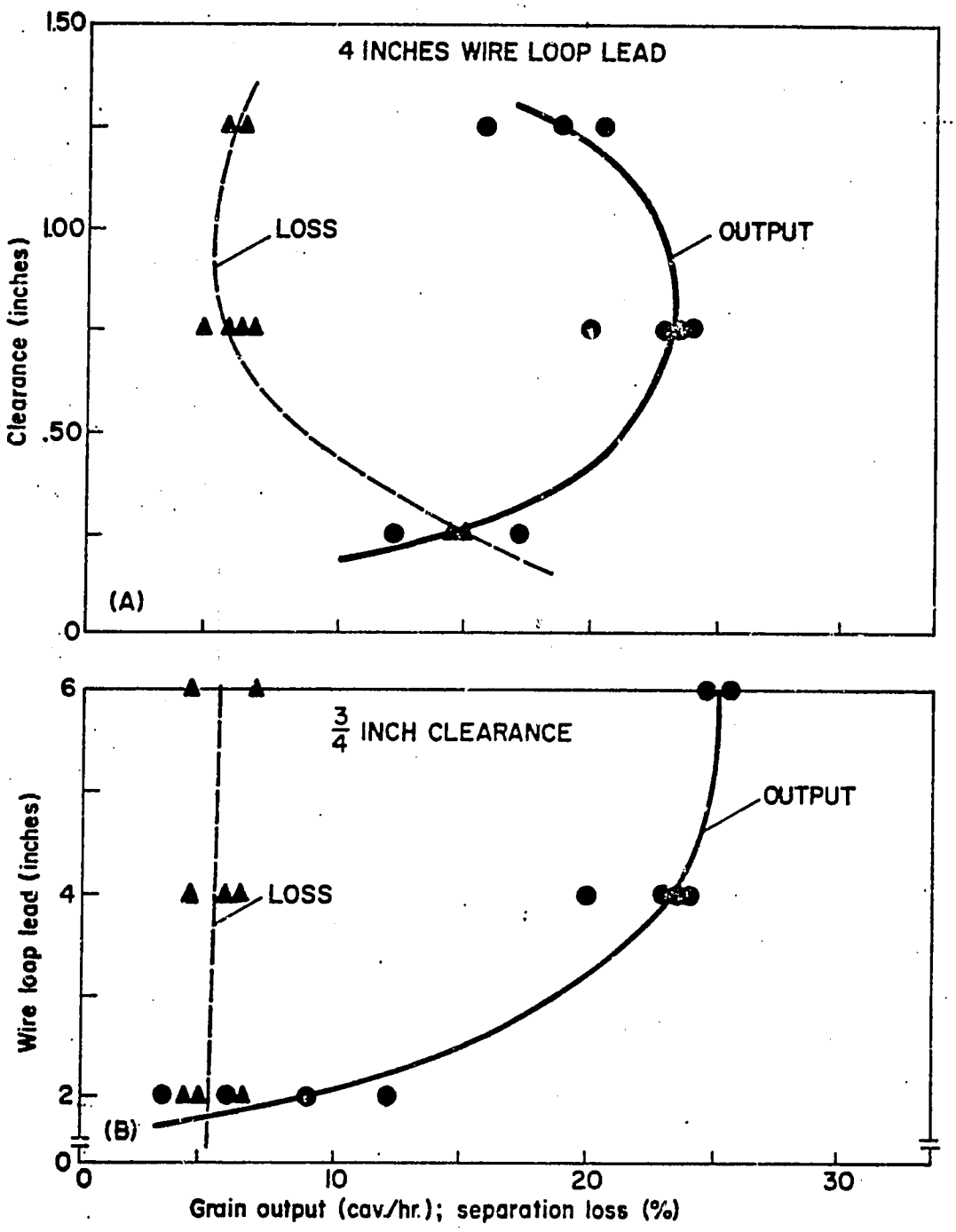


Fig. 5. a. Output and loss vs. clearance between thresher and concave
b. Output and loss vs. wire loop lead for 3/4 inch clearance

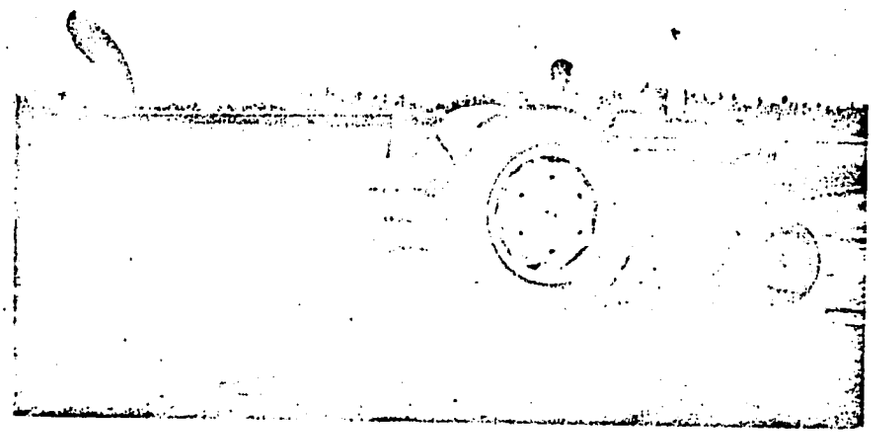


Fig. 6. Second prototype tractor PTO driven thresher

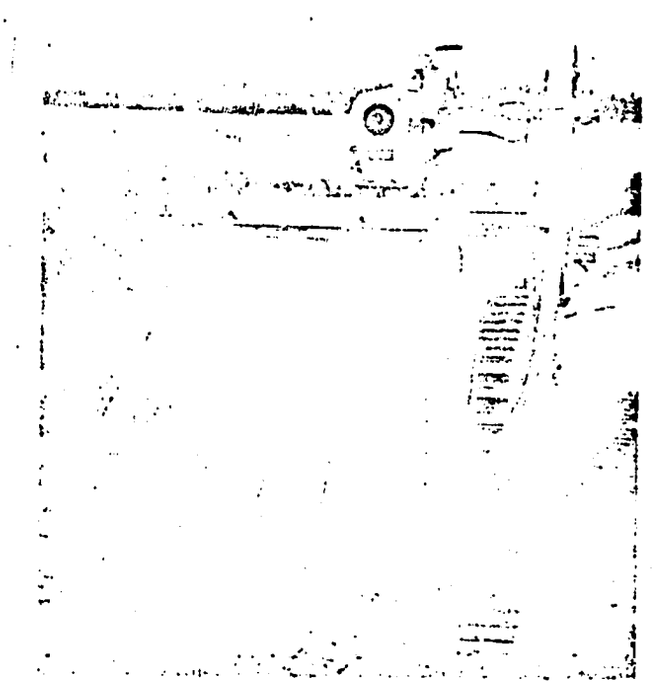


Fig. 7. Improved second prototype paddy stripper harvester

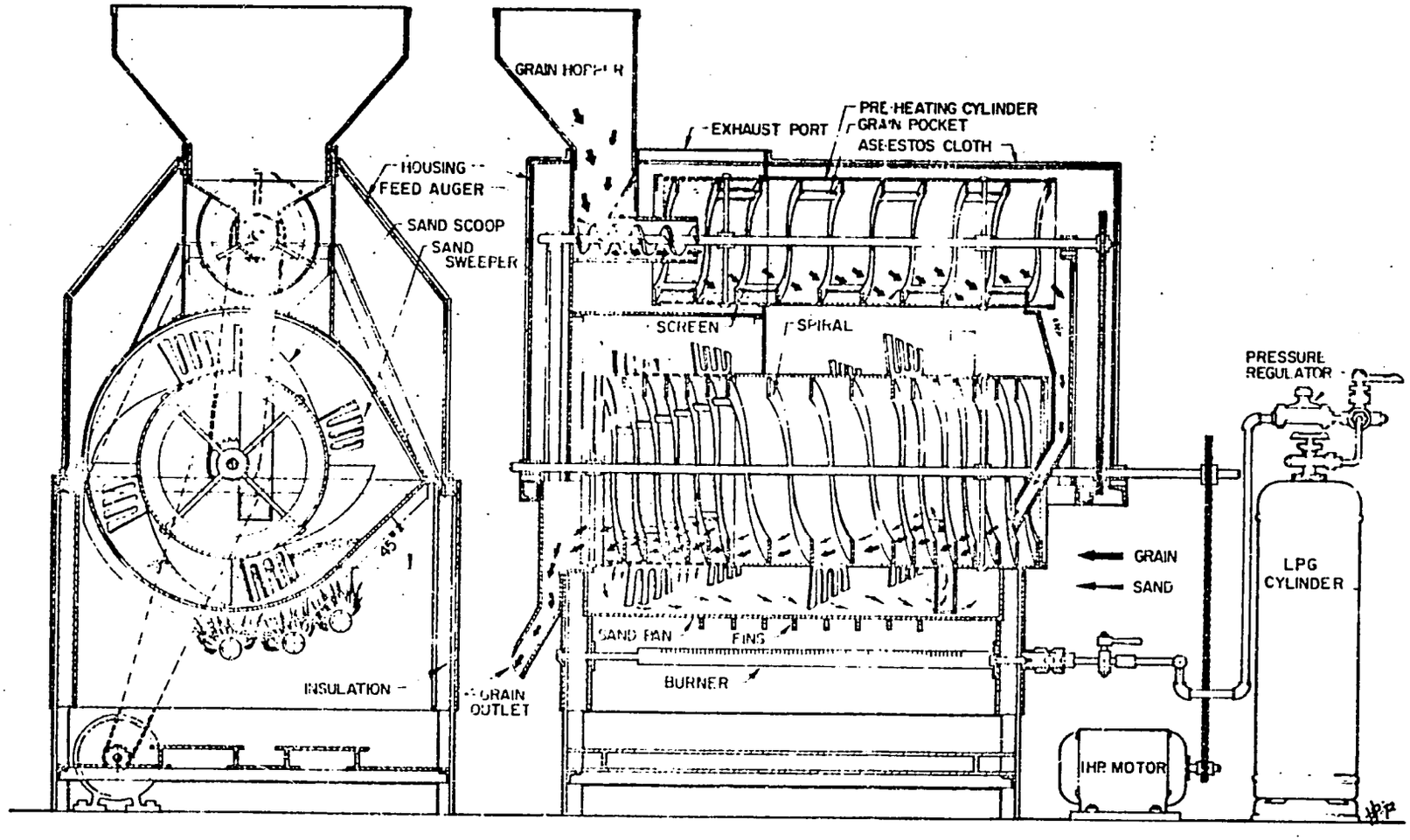
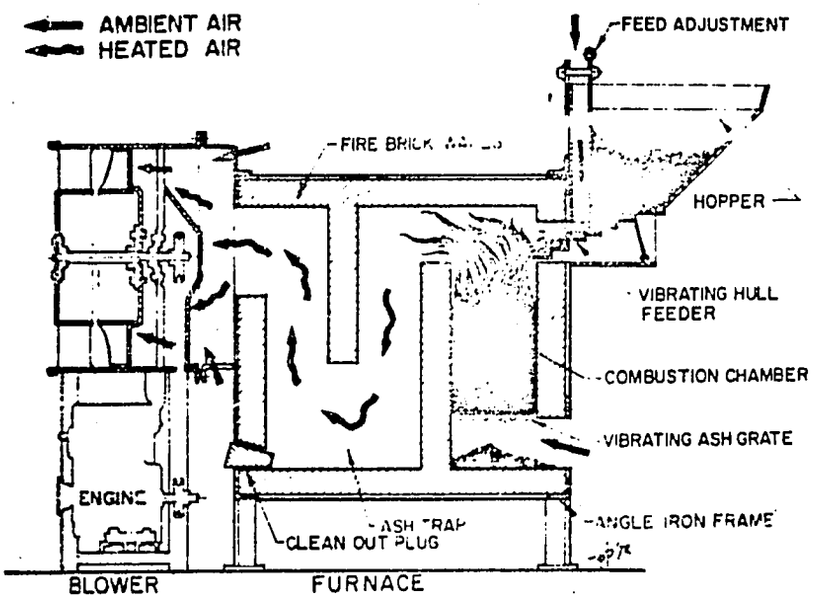
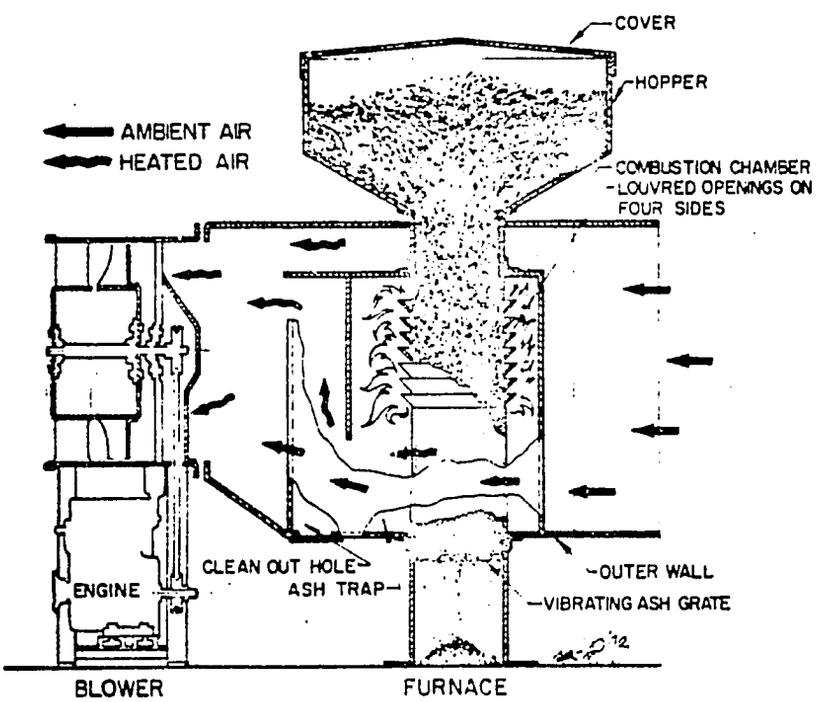


Fig. 8. Schematic drawing of the modified continuous flow heated-sand drying and parboiling machine



A



B

Fig. 9. Schematic drawings of modified rice hull furnace
a. Fire brick type b. Louvered columnar type

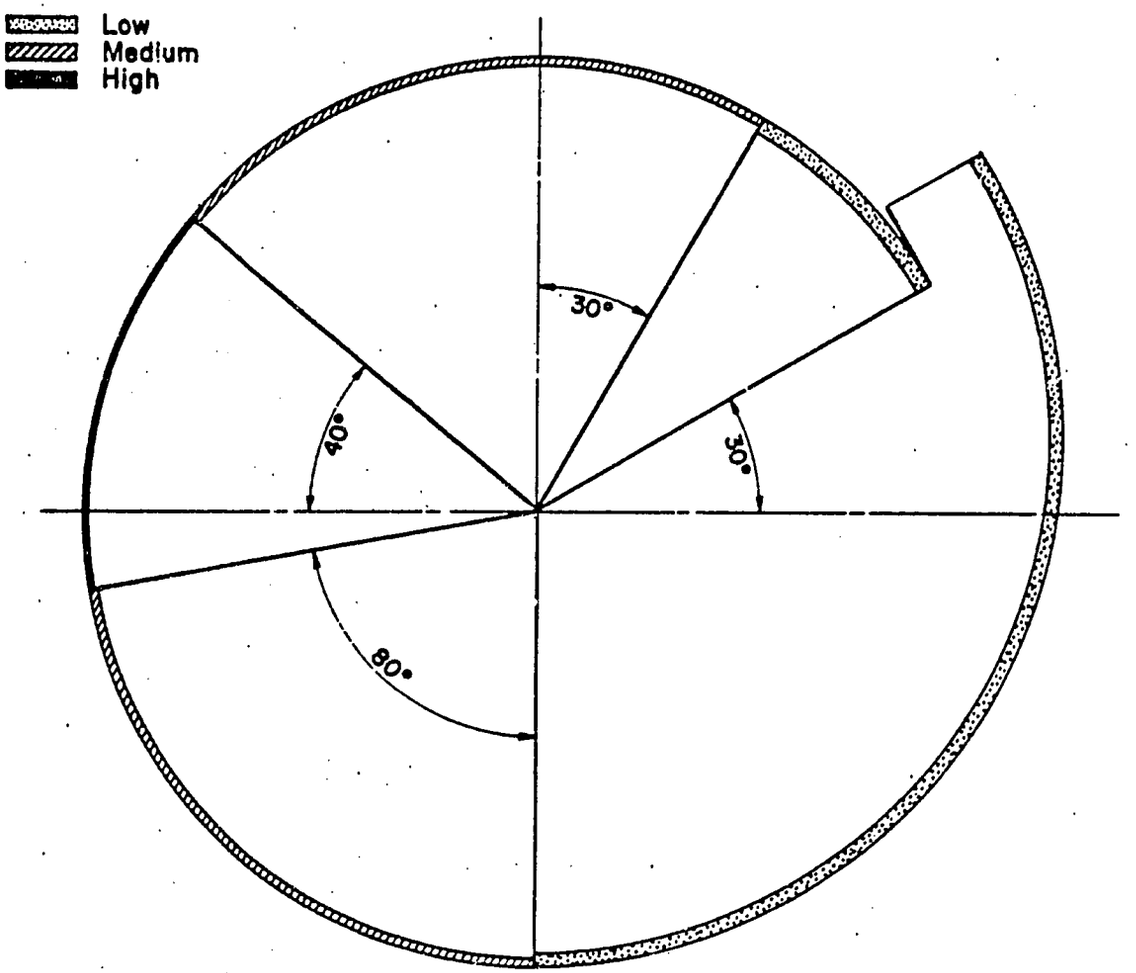


Fig. 10. Location and degree of impact lining wear on the centrifugal huller

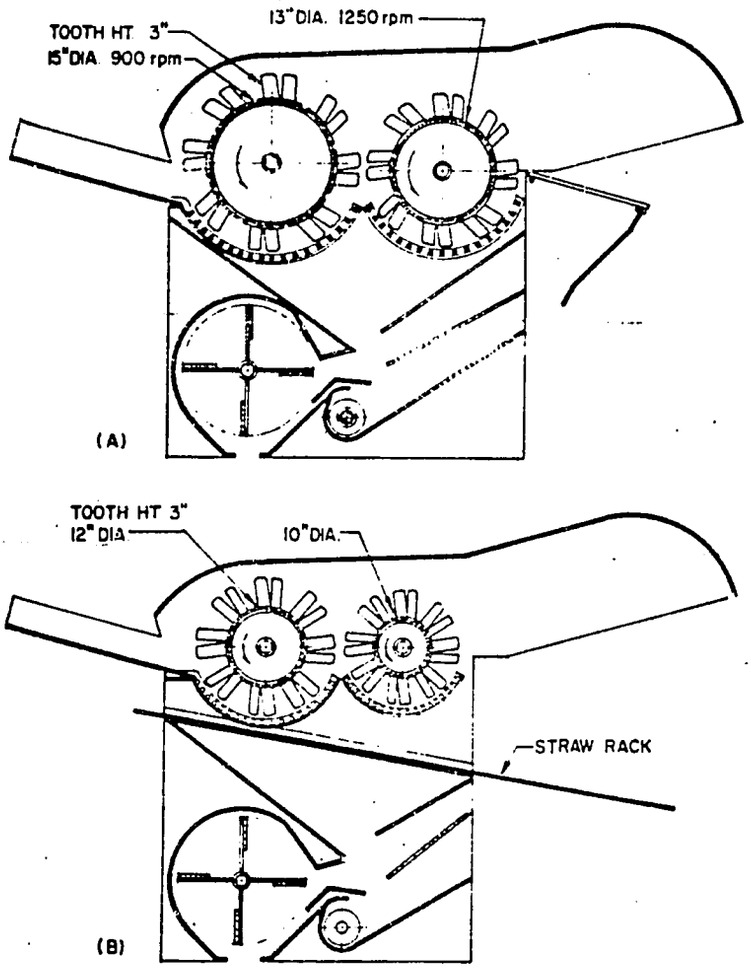


Fig. 11. Two types of Cotabato-made threshers

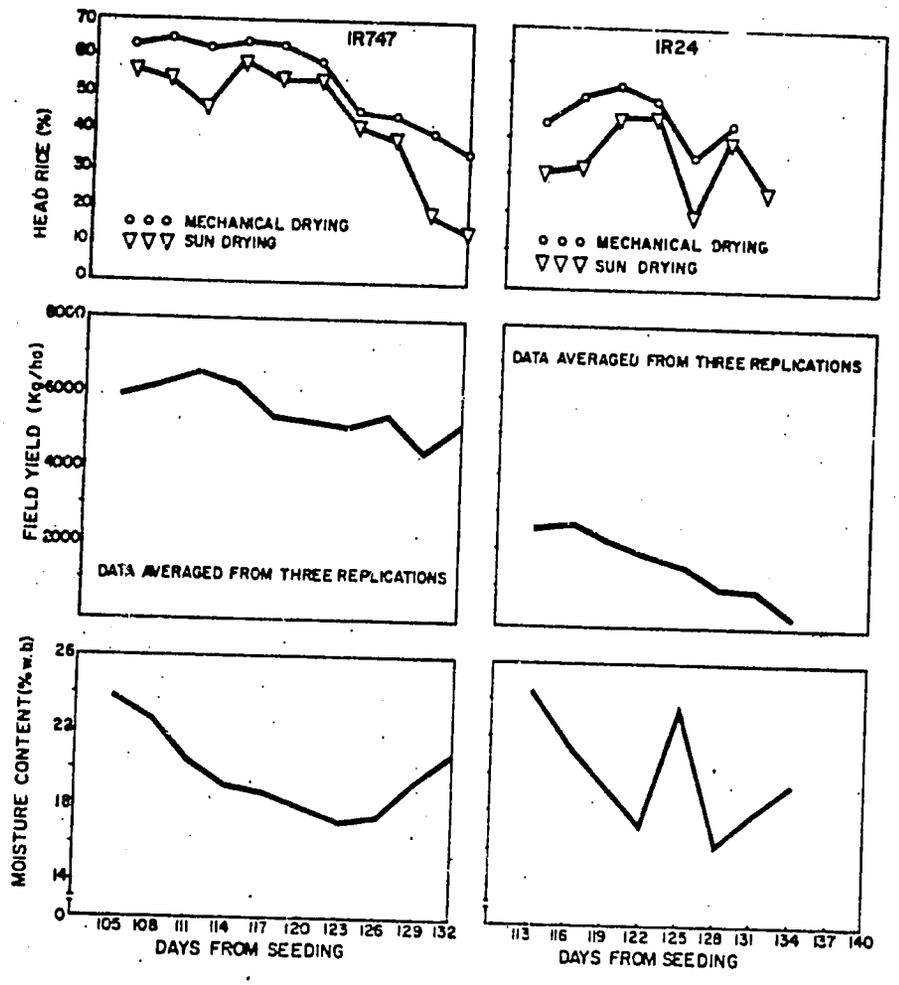


Fig. 12. Effect of date of harvest and method of drying on yield and milling quality