AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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BATCH #14

1. SUBJECT CLASSIFICATION

A. PRIMARY
Serials

Y-AN20-0000-GG50

B. SECONDARY
Agriculture--Farm equipment--Tropics

2. TITLE AND SUBTITLE
Research on farm and equipment power requirements for the production of rice; semi-annual substantive report no.8,Jan.1969 to June 30,1969

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

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1969	94p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
IRRI

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

9. ABSTRACT

10. CONTROL NUMBER
PN-RAA-742

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Agricultural machinery
Rice

13. PROJECT NUMBER

14. CONTRACT NUMBER
CSD-834 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

SEMI-ANNUAL SUBSTANTIVE REPORT NO. 8

(For the Period January 1, 1969 to June 30, 1969)

Contract No. AID/csd-834
For Research on Farm and Equipment Power
Requirements for the Production of Rice and Associated
Food Crops in the Far East and South Asia

By

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INTRODUCTION

This is the eighth Semi-Annual Substantive Report on Contract No. AID/csd-834. The Contract originally scheduled to terminate on June 27, 1968 was extended for one year. The activities under the Contract are broadly divided into two categories Agricultural Machinery Research and General Engineering and Economic Research.

Work on the Agricultural Machinery Research continued to make satisfactory progress during the period of this report. Assistance was provided to local manufacturers of the drum thresher in developing their manufacturing programs. Several drum threshers were sent to seven countries in South and South East Asia for test and evaluation. The fabrication of an experimental paddy stripper-harvester was completed and preliminary field tests were conducted. Promising results were obtained in the initial field trials and further development work is being continued.

In the past, projects on rice drying and processing were not included in the Contract Machinery Development program. Due to the complexity of the drying and processing problem and the lack of adequate research in the developing countries, attention is now being directed in this area. Projects are being initiated which may lead to the development of specially suited low-cost dryers and rice processing machinery.

The Agricultural Economist completed his two-year assignment on the Contract and departed on November 3, 1968. He returned for a brief period of six weeks in May and June 1969 to complete his terminal report. His report on past activities in the Economic and General Engineering Research part of the Contract has been submitted to USAID/WOH, Washington. In the absence of a senior economist, the economic research is now being conducted by a research assistant under the supervision of the Agricultural Engineer.

The services of Dr. William Chancellor, Professor, Agricultural Engineering Department, University of California, Davis were made available as a consultant for five weeks during June and July 1969. Dr. Chancellor made some useful suggestions on the various research projects and provided a critical evaluation of the program. The exposure of the Contract personnel to a senior professional scientist from an outside organization was a valuable experience. It is felt that such short-time consultations are beneficial to the program and should be availed of more frequently.

The Agricultural Engineer visited the Agricultural Implement Design and Testing Unit, Maha Illuppallama, Ceylon in April 1969 to demonstrate the drum thresher to representatives of the government and industry.

The Contract staff underwent some changes. The services of an Assistant Design Engineer, Mr. P. Cabanos, were secured to fill the vacancy created by the departure of Mr. M. Hoki, Visiting Assistant Design Engineer. The Project Leader spent two months, May and June, in the United States on a home leave and took this opportunity to visit the USAID/WOH office in Washington for discussions with the Project Monitor and other officials.

The projects handled by the Contract engineering staff during the period of this report were:

(1)	Drum-Type Power Thresher	A. U. Khan
(2)	Table-Type Power Thresher	A. U. Khan
(3)	Tractor Tillage and Mobility Studies	P. Cabanos, A. U. Khan
(4)	Application of Anhydrous Ammonia with Small Tractors	E. O. Casem, A. U. Khan
(5)	Comparative Performance of Threshing Cylinders	E. O. Casem
(6)	Development of a Paddy Stripper-Harvester	A. U. Khan
(7)	Development of a Row Seeder for Lowland Rice	N. Navasero, A. U. Khan
(8)	Development of a Rotary Screen Winnower	A. U. Khan
(9)	Development of a Tractor PTO-Driven Thresher	A. U. Khan
(10)	Survey of Central Luzon	N. Orcino
(11)	Correlation of Yield and Observed Field Conditions	N. Orcino, S. Johnson
(12)	Analysis of Soil Penetrating Resistance	N. Orcino, S. Johnson
(13)	Hand Threshing	N. Orcino, S. Johnson
(14)	Use of Farm Labor	N. Orcino, S. Johnson
(15)	Cost of Production Estimates	N. Orcino, S. Johnson
(16)	Present State of Weeding	N. Orcino

The progress report on the above project follows.

PROGRESS REPORT
January 1, 1969 to June 30, 1969

DRUM-TYPE POWER THRESHER

The release of the drum thresher design to three local manufacturers has been reported. The drum thresher was the feature topic in a recent issue of the IRRI Reporter. Inquiries for engineering drawings on the drum thresher were received from a number of countries and the same were forwarded to the requesting parties. Attention was focused during this period on improving the design of the prototype threshers developed by the three manufacturers.

One of the manufacturers, G. A. Machineries, Inc. (GAMI), has made considerable progress in developing special jigs, fixtures and toolings for manufacturing this thresher. A total of 21 threshers were supplied by GAMI for use and testing by the following organizations:

No. of units	Shipped to	Funded by
1	All-India Coordinated Rice Improvement Project, Hyderabad India	Ford Foundation
1	Central Rice Research Institute Cuttack, India	Ford Foundation
1	The Ford Foundation, Government of W. Pakistan, Lahore, West Pakistan	Ford Foundation
1	Agricultural Machinery Test and Development Center, Maha Illul-pallama, Ceylon	Ford Foundation
1	Farm Superintendent's Office, IRRI, Los Baños, Laguna, Philip-pines	The International Rice Research Institute
1	Agricultural Engineering Dept., IRRI, Los Baños, Laguna, Philip-pines	The International Rice Research Institute
1	Operation SPREAD, Sta. Cruz, Laguna, Philippines	USAID/Manila
1	Farmers' Cooperative Marketing Association, Tanauan, Batangas, Philippines	USAID/Manila

No. of Units	Shipped to	Funded by
1	Farmers' Cooperative Marketing Association, Tarlac, Philippines	USAID/Manila
1	Bureau of Plant Industry, Regional Office, Pampanga, Philippines	USAID/Manila
1	Rice and Corn Production Coordinating Council, Iloilo, Philippines	USAID/Manila
1	Joint Commission on Rural Reconstruction, Taipei, Taiwan	Ford Foundation
6	USAID Mission to Vietnam, Saigon, South Vietnam	USAID/Vietnam
2	East Pakistan Accelerated Rice Research Institute, Dacca, East Pakistan	Ford Foundation
1	Rice Department, Government of Thailand, Bangkok, Thailand	Ford Foundation

In addition, GAMI has sold a number of threshers to individual farmers in various parts of the country. The current retail price of the GAMI thresher, complete with a 4.5-hp engine, is ₱3195.00, which is substantially higher than the initially announced sales price.

The second manufacturer, CLINDISCO (Phil.), also completed a prototype thresher. Their machine was slightly over-designed and heavy. Considerable redesigning was done by the Contract staff to reduce the thresher weight. Three of the redesigned threshers were ordered from the manufacturer for test at IRRI during the 1969 wet harvest season. After the completion of the tests, two of the units will be sent for further testing to the University of the Philippines College of Agriculture, Los Baños, Laguna, and the Mindanao Institute of Technology, Kabacan, Cotabato, Philippines. The third thresher was ordered by the Farm Superintendent's Office, IRRI for use in the Institute's seed production program.

The production cost of the CLINDISCO thresher is relatively higher and the manufacturer feels that their machine may not be very competitive. The manufacturer has requested further assistance in simplifying the design to reduce their costs. The workmanship of the CLINDISCO machine is excellent and it is sturdy enough to withstand rough treatment. Work is now on hand to simplify the design in the interest of lower production costs.

The third manufacturer, F. Bernabe & Sons, has a custom fabrication shop but lacks a sales organization. Two of their machines are being tested

at the Institute. Experience has shown that it is desirable to introduce new machines through manufacturers who are well established and have their own sales organization. Custom fabrication shops may be effective in building made-to-order machines but generally do not have the necessary organization to effectively develop the potential for a new machine.

The Contract Development Engineer visited the Machinery Test and Development Center, Maha Illuppallama, Ceylon during April 1969 and assisted in the demonstrations of the drum thresher in Ceylon. Two demonstrations were held at the Dry Zone Research Station, Maha Illuppallama, for senior government officers, extension workers, and representatives of the interested manufacturers. The Director of Agriculture, Ceylon indicated keen interest in the machine and personally attended one of the demonstrations. The thresher is now being tested at various locations in Ceylon by the Agricultural Machinery Testing and Design Unit, Government of Ceylon.

Contacts are being maintained with the organizations who have received the drum threshers and assistance will be extended to them in popularizing the machine and encouraging local manufacture.

TABLE-TYPE POWER THRESHER

The objectives and designs of the first and the second table thresher prototypes have been discussed in the Semi-Annual Report No. 6 and No. 7. Tests were conducted on the second prototype unit during this period. This machine was designed to drop the threshed straw around the periphery of the machine. The straw dropped on the feet of the operators and was difficult to remove during threshing. It was felt that a single straw outlet would be more desirable than having the opening around the thresher periphery.

A third prototype thresher (Fig. 1) was fabricated with an enclosed housing for straw delivery and an improved two-screen grain-straw separator. Figure 2 illustrates this thresher in operation. The major differences between the second and third prototypes were in the straw delivery, double screen separator and improved threshing teeth. After an initial grain-straw separation at the rotating screen, the straw dropped onto a stationary screen where it was swept by flaps to the straw opening. While the movement of dry straw on the screen was satisfactory, problems were encountered with wet straw.

The sheet metal work of the third prototype machine is somewhat complicated and it may be difficult to manufacture by simple hand fabrication methods. It is now felt that a simpler sheet metal housing which may drop the straw around the periphery would be more desirable from a manufacturing standpoint. Small-scale manufacturers can only fabricate simple manually formed sheet metal components. Simplification of different sheet metal components is essential, even if it may result in sacrificing some desirable features. A fourth prototype unit is now being designed to reduce the machine weight and to facilitate fabrication by small manufacturers.

TRACTOR TILLAGE AND MOBILITY STUDIES

Pushing force test

In continuation of the wetland tillage and mobility studies stated in the Semi-Annual Report No. 7, an adjustable blade rotary tiller was fabricated to determine the optimum blade angle which would develop maximum pushing force. Previous studies have indicated that slower peripheral blade velocities reduce the tractor rear wheel slippage when travelling in the 1st and the 3rd gears. The effect of blade speed on tractor wheel slippage was not significant in the 4th gear. In this study, the pushing forces developed by the tiller at four different blade angles were measured and plotted against pitch of cut.

A 55-hp tractor equipped with a three-point linkage, a 120 kg front end ballast and 163 kg front-wheel ballasts was used for the test. The tractor rear wheels were equipped with rubber-tipped lug wheels.

The experimental adjustable blade rotary tiller, Figs. 3 and 4, has a working width of 1.55 m and a rotor diameter of 0.90 m. The rotor has five sections of 8 blades each. The blade angle can be set at 12.5°, 32.5°, 52.5° and 72.5° by means of mounting holes on the blade assembly. The power from the PTO is transmitted through a four-speed gear box and a chain reduction drive. The specifications of the tiller are listed in Table 1.

Since only a two-channel strain gage recorder system was available, it was necessary to record the pushing force through a single channel. The other channel was used to record the PTO torque. Figures 3, 4 and 5 show the special set-up for the measurement of the pushing force. An extension beam with a hole for the upper-link connection was rigidly attached to the rotary tiller. When the tiller was attached to the tractor with this new arrangement, the upper link was in a vertical position. Analysis of the forces acting on the tiller with the upper link in a vertical position indicates that the total horizontal pushing force between the tiller and the tractor will be transmitted only through the two lower links. Strain gages were attached to the two lower connecting pins on the tiller to measure the bending reactions along the horizontal plane. The reactions from the two lower-link pins were combined and fed into a single channel for recording. During tests the upper link was held in a vertical position by adjusting the length of the link.

The tests were conducted in fields of similar soil characteristics. The fields were flooded with 5 cm of water for 7 days. Heavy vegetation was present in the fields at testing time.

The tractor engine speed was maintained at 1370 rpm to stay within the range of the maximum engine torque. The PTO revolutions and the test duration were recorded by two event markers on the recorder. The distance travelled during each trial was measured by attaching one end of a steel tape to the rear of the tiller. Marks indicating the beginning and end of each trial were simultaneously made on the tape and on the recorder paper.

Attempts were made to maintain a constant depth for meaningful comparison of the results. For each blade angle, the pushing force was measured with

the tractor travelling in the 1st, 2nd and 3rd gears. The fourth gear was skipped since in previous tests the peripheral blade velocity did not show any significant effect on rear wheel slippage. Furthermore, the desired depth of cut was difficult to maintain due to the free floating three-point linkage. For each tractor gear speed, the pushing force for four different tiller blade velocities was recorded. Because of the difficulties involved in controlling the tilling depth, only data from trials which were close to 10 cm tilling depth were plotted against pitch (Tables 2 to 5). The average pushing force was read from the recorder tracings by a planimeter. The number of impacts the blades made on the soil during each test were computed from the PTO revolutions and the tiller/PTO gear ratio. The pitch of cut was computed as follows:

$$\text{Pitch} = \frac{\text{Distance travelled during test}}{\text{Number of blade impacts during test}}$$

The curves indicating the relationship between pushing force and pitch of cut were plotted at all tractor travel speeds. The shape and size of the clod has an important bearing on the pushing force. At a constant depth of cut, the size and shape of the clod is determined by the pitch. At the same time, for a given tractor-tiller combination, the pitch establishes a definite relationship between tractor travel speed and tiller blade velocity. It has been assumed that for the same pitch of cut and within the range of travel speeds used in this experiment (0.46 m/sec to 0.95 m/sec), the shape of clod is not significantly affected by the tractor travel speed. The assumed curves were drawn by linear regression. The degree of confidence for the curves for the 12.5° and 32.5° blade angles is 95 percent while those for the 52.5° and 72.5° are 92 and 91 percent, respectively.

Figures 6, 7, 8 and 9 show individual curves for each blade angle setting. The figures also show typical profiles of the clod, together with four blade positions at 1/25 second intervals under the following conditions:

Tiller shaft speed = 52.4 rpm
Measured tractor travel speed = 0.56 m/sec

These four curves are drawn superimposed in Fig. 10. The 12.5°, 32.5° and 52.5° blade angles indicate a positive slope while the 72.5° blade angle indicates a negative slope. For the 72.5° angle (Fig. 9), it can be seen that the blade contacts the ground initially with its face rather than the tip, and this results in a backward soil reaction at the moment of impact. This reduces the overall forward reaction. This seems to be the reason for the negative slope of the curve. On the other hand, it will be noticed that the pushing force for the 72.5° blade is high at smaller pitch. This is perhaps due to the effect of the blade tip, since at small pitch, only the blade tip contacts the untilled soil.

It will be noticed that up to about 13 cm pitch, the 12.5° blade angle has less pushing force than the 32.5° angle. This may perhaps be due to the difference in depth of cut since the average depth of cut for the 32.5° blade angle was 11.2 cm while for the 12.5° blade angle was 8.64 cm. The difference in ordinates is not significant enough to claim that the 32.5° blade develops more force. There is a scarcity of observed points for the 52.5° and 72.5°

blade angles. At higher tractor speeds, the upward reaction increases considerably due to increased pitch causing the tiller to float, thus limiting the tilling depth.

From a performance standpoint, it was observed that the 12.5° blade angle had a tendency to clog with mud. An increase in water depth, however, minimized this tendency. The 32.5° blade angle exhibited less tendency to clog for it was more easily able to shed the clods.

It can be concluded that the 12.5° blade angle develops the highest pushing force among the blade angles tested. The 32.5° blade angle exhibited better soil shedding and less tendency to clog.

Power requirement test

During the pushing force tests on the IRRI adjustable blade rotary tiller, PTO torque was measured to determine the power delivered to the tiller. A strain gage transducer (Fig. 5) was installed on the tractor PTO shaft. The horsepower requirements were plotted against pitch. Their relationships, however, could not be conclusively determined due to limited data (Tables 6 to 9). Only the curve for the 32.5° blade angle (Fig. 12) was positively linear, with a 96 percent degree of confidence. The results for the 12.5° blade angle (Fig. 11) were considerably scattered and indicated a degree of confidence of only 50 percent.

Considering that both the 32.5° and the 12.5° blade angles had similar characteristics in the pushing force test, it may be inferred that the power input to the tiller at 12.5° blade setting is linear with pitch (see dashed line on Fig. 11) as was the case with the 32.5° blade angle. The slope of the power vs pitch curve of the 32.5° blade is greater than that of the 12.5° blade (Fig. 15). In the pushing force test, however, the 12.5°blade angle exhibited a greater slope for the pushing force curve than the 32.5° blade angle. This seems to indicate that with the 12.5° blade angle, the direction of the soil reaction tends to incline toward the horizontal, so that compared to the 32.5° blade angle, the change in the pushing force is greater than the change in power consumption.

Figures 8 and 9 show the observed points for the 52.5° and 72.5° blades, respectively. It was difficult to draw a curve due to insufficient observations. It seems that the power consumption does not tend to increase with pitch. In the absence of a representative curve and considering the narrow pitch range in the plotted observations, only the average power consumption was calculated, indicating 28.75 hp for the 52.5° blade angle and 32.34 hp for the 72.5° blade angle. With these two blade angles (see blade profiles in Figs. 8 and 9), it can be expected that a major portion of the soil reaction will be composed of the vertical component. Since the upward movement of the tiller was not constrained, the vertical reaction was limited to the weight of the tiller. The torque reaction, being composed of the moments due to the horizontal and the vertical soil reactions, was also influenced by the vertical component which consequently limited the power input. It may be deduced that the power consumption of the 72.5° blade is less than the 52.5° blade

because of a shift in the position of the resultant soil reaction, causing the moment arm for the 72.5° blade angle to become smaller than the moment arm of the 52.5° blade angle.

Some tests indicated a power consumption of about 39 hp. It seems doubtful that the tractor engine could have developed this level of power for the range of engine speeds used during the test. This may be explained by the calibration curve of the torque transducer. The values for torque were taken from a curve drawn by linear regression based on the points arrived at during static calibration. However, the curve connecting the observed points indicated a "hysteresis" loop (Fig. 16). This indicated an error of about 5 percent during the loading cycle and about 15 percent during the unloading cycle in the range of the torque loads of the experiment.

From the power test of the IRRI adjustable blade tiller, it can be concluded that:

1. The 32.5° blade angle has greater power requirement than the other blade angles tested;

2. The 12.5° blade can develop more pushing force with less power.

APPLICATION OF ANHYDROUS AMMONIA WITH SMALL TRACTORS

The development of a six-shank anhydrous ammonia applicator for use with small tractors was reported earlier. The anhydrous ammonia applicator was used by the IRRI Agronomy Department for their experiments during the last crop season. Tests were conducted on flooded rice fields. Their results for transplanted and broadcast methods of planting for two varieties are shown in Table 10 and Fig. 17. The problems encountered during these field tests were noted and the equipment was subsequently modified.

The first prototype applicator had a tank volume of 1000 cu. in. and a capacity to hold 8.5 kg of anhydrous ammonia. This tank, however, did not provide sufficient vaporization for the six applicator nozzles at the desired pressure. At an 80 kg/ha application rate, only 870 sq. m. of land was covered for each tank filling, thus necessitating almost 12 refills per hectare. Also due to the small size of the tank, the operation had to be stopped every 3 minutes to allow sufficient build-up of pressure. At a discharge rate of 542 grams of ammonia per minute, minimum pressure of 25 psi must be maintained.

The tank was subsequently replaced by two larger tanks (Fig. 18) with a combined volume of 4840 cu. in. The tanks have sufficient capacity to fertilize a 2500 sq. m. area per filling at an application rate of 80 kg N/ha. A minimum pressure of 25 psi, at the maximum application rate of 542 grams of NH_3/min, can be adequately maintained with the larger tanks.

A compact regulator distributor was mounted with the new applicator. The shanks of the first prototype applicator were found to be weak and tended to bend in roughly puddled soil. Furthermore, the weeds occasionally collected on the shanks and on the horizontal tubular frame to which the shanks were welded.

Stronger and longer applicator shanks ($17^5/_8$ in.) have been designed with a larger back-swept angle of 45°. The modifications have exhibited improved performance in the preliminary trials. Further tests and development work are in progress.

COMPARATIVE PERFORMANCE OF THRESHING CYLINDERS

Proper threshing of freshly harvested paddy is of prime importance to rice production in the humid tropics. There are three types of threshing cylinders generally used with rice threshing machines: (a) wire loop, (b) peg tooth and (c) rasp bar. Mechanical threshing of freshly harvested paddy requires a careful selection of threshers equipped with a suitable cylinder. A study was undertaken to establish the differences among the three types of cylinders for threshing freshly harvested paddy.

Three test stands utilizing the wire loop, peg tooth and rasp bar cylinders were fabricated (Fig. 19). The peg tooth and the rasp bar cylinders were equipped with concaves while the wire loop cylinder was without a concave. The three cylinders were driven by a 55-hp standard four-wheel tractor through the PTO shaft. Freshly harvested mature IR8 paddy with an approximate straw length of 35 cm., measured from the panicle neck, was used throughout the tests. The mean moisture content of the paddy was 24.8 percent wet basis.

The effect of feeding method and the cylinder peripheral velocity on threshing performance and grain damage was investigated for the three cylinders. Two methods of feeding were used: (a) hold-on feeding, and (b) throw-in feeding. Sixteen cylinder peripheral velocities were used in the test: 900, 1150, 1400, 1650, 1900, 2150, 2400, 2600, 2900, 3150, 3400, 3650, 3900, 4150, 4400 and 4650 fpm.

Investigations in the past indicate that grain damage occurs primarily due to impact during threshing and this is related to the peripheral velocity of the threshing cylinder. In this study, the visible seed damage was determined by inspection and by the percentage of milled paddy. Internal seed damage was determined by the head grain yields (using a Satake Laboratory Rice Husker, No. 2 McGill Miller, and a McGill Grain Sizing Device) and by seed germination tests.

With the throw-in method, an untied bundle of 4 kg paddy, with panicles arranged at one end, was fed evenly into the machine for 16 seconds. With the hold-on feeding method, a 4 kg sample was divided into 4 bundles of 1 kg each to facilitate holding. The 1 kg bundles were then individually threshed by holding them on to the cylinders for a period of 4 seconds. The completely threshed paddy (individually detached), the semi-threshed paddy (in bunches of 2 or more kernels) and the unthreshed paddy (paddy retained on the panicles after threshing) were collected separately during each test.

Threshing performance

A. Hold-on feeding method

The rasp bar and peg tooth cylinders exhibited relatively poor perfor-

mance at the slower velocities (Table 11, Fig. 20). At higher velocities, performance of the rasp bar and wire loop cylinders was slightly better than the peg tooth cylinder. The overall performance of the peg tooth cylinder with this method of feeding was relatively less affected by change in cylinder speed but resulted in slightly more semi-threshed paddy. The wire loop cylinder indicated the best overall performance with this method of feeding. This type of cylinder is widely used in Japanese threshers.

B. Throw-in feeding method

The peg tooth cylinder exhibited the best overall performance throughout the velocity range. The wire loop and rasp bar cylinders performed poorly with this method, specially below the 2650 fpm velocity. If the maximum unthreshed loss is limited to 2 percent, the following minimum cylinder velocities were found necessary (Table 11, Fig. 21): peg tooth, 3900 fpm; rasp bar, 4150 fpm. The wire loop cylinder continued to exhibit a slightly higher than 2 percent threshing loss even at the maximum test velocity of 4650 fpm. From the test, it can be concluded that for the throw-in feeding method, the peg tooth cylinder is better suited, especially if low cylinder velocities are desired.

All the tests indicated an increased threshing performance and a decreased unthreshed and semi-threshed paddy at higher cylinder velocities. A poor quality performance was observed at the 4 kg/16 seconds throw-in feed rate with all the three cylinders as compared with the hold-on method. It is generally accepted that the throw-in type of threshing is more suitable for higher output machines than the hold-on type of threshing. These tests seem to indicate that the users of higher output throw-in type threshers are being penalized by higher losses.

Grain damage

A. Milled paddy

Table 12 and Figs. 22 and 23 indicate the amount of paddy rice which was milled during threshing. At velocities of up to 2150 fpm, the hold-on and throw-in feeding methods did not show any significant milling with all the three cylinders. The milling of paddy began at 2150 fpm velocity with both feeding methods. The increase with the hold-on method, however, was more than with the throw-in method. This seems understandable since for the same peripheral velocity the magnitude of the impact in the hold-on method is generally higher than in the throw-in method because the paddy (in the hold-on method) is stationary during threshing.

At the higher cylinder velocities, the rasp bar indicated relatively less milled paddy (1.323% at maximum test velocity) than the other cylinders. This was perhaps due to greater cushioning effect with a rasp bar cylinder since the serrations on the rasp bar are not large enough like the peg tooth or wire loop to penetrate into the paddy bundle.

If a milled grain damage of 1 percent is to be tolerated, the following cylinder velocities should not be exceeded:

Cylinder type	Hold-on method	Throw-in method
rasp bar	3150 fpm	3900 fpm
peg tooth	3150 fpm	3650 fpm
wire loop	3150 fpm	3650 fpm

B. Head grain yield

As expected, in both the hold-on and throw-in feeding methods, the head grain yield decreased with increased cylinder velocity (Table 13, Figs. 24 and 25). The difference among the three cylinders and the two feeding methods were not too significant. The peg tooth cylinder, however, indicated a slightly higher head yield except at the high end of the velocity range where the rasp bar cylinder did show some improvement.

If a head grain yield of 85 percent (percentage of check) is desired, the following cylinder velocities should not be exceeded:

Cylinder type	Hold-on method	Throw-in method
rasp bar	2900 fpm	3650 fpm
peg tooth	3400 fpm	3400 fpm
wire loop	2650 fpm	2900 fpm

C. Germination test

The germination test indicated that with the hold-on feeding method, the wire loop was slightly better than the peg tooth or rasp bar cylinders (Table 14, Figs. 26 and 27). With the throw-in feeding method, the wire loop resulted in a slight overall superiority, If a minimum of 85 percent germination is desired, the following cylinder velocities should not be exceeded:

Cylinder type	Hold-on method	Throw-in method
rasp bar	2400 fpm	2900 fpm
peg tooth	3400 fpm	1900 fpm
wire loop	2900 fpm	2900 fpm

Based on a 2.0 percent maximum unthreshed paddy (percentage of total paddy weight at 14% m.c., w.b.), a 1.0 percent maximum milled paddy, an 85 percent minimum head grain yield (percentage of head grain yield of hand-threshed check), and an 85.0 percent minimum seed germination (percentage of germination of hand-threshed check), the optimum cylinder peripheral velocities were found to be:

Cylinder type	Hold-on method	Throw-in method
wire loop	2150 fpm[1/]	3400 fpm[3/]
peg tooth	2650 fpm[2/]	3150 fpm[4/]
rasp bar	2400 fpm	3900 fpm[5/]

These tests are indicative of the performance trends for the three types of threshing cylinders. This study, however, is a result of threshing one variety of paddy at one moisture level and as such has obvious limitations. In conclusion, it can be said that the peg tooth cylinder offers a superior performance with the throw-in method whereas the wire loop cylinder performs better with the hold-on method.

1/ There are two other velocities which meet the above requirements but gave poorer performance, namely, 2400 fpm and 2650 fpm.

2/ There are two other velocities which meet the above requirements but gave poorer performance, namely, 2900 and 3150 fpm.

3/ Compromise cylinder peripheral velocity wherein: unthreshed paddy loss - 2.4%; milled paddy at threshing - 0.705%; head grain yield - 80.0%; and germination - 74.2%.

4/ Compromise cylinder peripheral velocity, wherein: unthreshed paddy loss - 2.4%; milled paddy at threshing - 0.826%; head grain yield - 88.9%; and germination - 77.1%.

5/ Compromise cylinder peripheral velocity, wherein: unthreshed paddy loss - 2.6%; milled paddy at threshing - 0.699%; head grain yield - 82.5%; and germination - 65.5%.

DEVELOPMENT OF A PADDY STRIPPER-HARVESTER

A paddy stripper-harvester, which could harvest paddy grain without cutting the paddy plants, offers many advantages for harvesting wetland paddy. The introduction of conventional combines for rice harvesting has been slow in the tropical countries. Conventional combine harvesters handle large volumes of straw. This necessitates heavy and bulky designs which encounter mobility problems under soft wet field conditions.

The objectives of a lightweight paddy stripper-harvester were described in the last report. Figure 28 illustrates the principle of the new stripping harvester concept. An experimental harvester mounted on a 6-hp walking tractor was fabricated (Fig. 29). The experimental machine was designed without grain — straw separating and winnowing components. Once the stripping mechanism is satisfactorily developed, the cleaning and separating components can be added in the future prototype machine.

The machine was initially tried on a simulated field (Fig. 29) since suitable fields with ready to harvest paddy were not available for testing. A simple arrangement permitted the clamping of paddy bundles in two parallel rows with a 25 cm spacing. This permitted repeated laboratory tests and observations of the stripping mechanism. Based on the laboratory trials, a number of modifications were made. The machine was then tried under actual field conditions with satisfactory results.

Some trials were also conducted by mounting a circular threshing drum in place of the deflecting chain mechanism (Fig. 30), but this arrangement was found unsatisfactory. The deflecting chain mechanism shows more promise and work is now on hand to further develop this approach. Some difficulties were encountered in bending the plants onto the threshing belt. The horizontal velocity of the deflecting bars, which was originally based on a zero relative ground velocity, was too slow and was subsequently increased. The position of the deflecting chain sprockets was changed to increase the angle of attack, thereby reducing the number of plants which are gathered by each deflecting rod. Further tests are being planned for the next harvest season.

The first experimental machine is not equipped with crop lifting mechanisms and requires erect standing crop. Mechanisms will be developed to lift and guide the lodged crops into the machine for stripping. After some experience has been gained with the machine, a self-propelled experimental stripper will be designed with a rotary seed cleaning arrangement. Hydrostatic transaxle and other components have been ordered for the self-propelled unit. The use of hydrostatic drive would simplify the operation of the machine and will permit more flexibility in its design.

DEVELOPMENT OF A ROW SEEDER FOR LOWLAND RICE

The problems of direct seeding of rice under puddled wetland conditions were stated in the last report. A project on the development of a low-cost seeder for lowland rice cultivation was initiated during this period.

Seed damage and bridging due to root entanglement are serious problems in metering pre-germinated seeds. The use of agitators to prevent bridging results in increased seed damage. It was felt that a two-step metering device, which could initially meter a larger quantity of pre-germinated seeds from the hopper and then distribute the metered seeds to the individual rows, could reduce the bridging problem.

A portable seeder, patterned after a simple six-row seeder from Ceylon, was fabricated. This experimental seeder (Fig. 31) incorporated an improved manual seed metering arrangement and two additional seed tubes to sow eight rows in one pass. It was equipped with a small hopper of one-half kilogram capacity. The manual seed metering arrangement consisted of a scraper and a set of eight rectangular openings in the hopper. These openings led to the individual seed tubes. A 0.15 m x 2 m skid was fastened to the lower ends of the seed tubes to hold the openings above the mud surface.

During operation, the seeder was pulled by walking backwards. The operator paused momentarily to scrape a strip of seeds into the rectangular

openings. Tests were conducted to study the performance of the machine under actual field conditions. The field was puddled and leveled one day before the test. Some variation in the placement of seeds was observed due to irregularities in the field surface.

The skid provided sufficient flotation, but exhibited some bulldozing effect on extremely soft areas. Some of the bulldozed mud was pushed around the ends and flowed behind the skid. This disturbed the seeds in the previously seeded adjacent row and in the rows being sown by the two end tubes. The variations in seed placement and seed disturbance due to mud displacement indicated the necessity for placement of seeds in small furrows.

The simple hand metering device satisfactorily metered the germinated seeds even in an advanced stage of seed growth (up to a maximum root length of 2 cm). The rate of seeding and the accuracy of seed placement largely depended on the skill of the operator. The backward walking of the operator in deep mud was a tiring operation.

A second experimental seeder was built with features for improved seed metering, seed placement and ease of handling. Figure 32 illustrates the second machine which was equipped with a ground-driven metering device. An adjustable handle permitted the seeder to be pulled with the operator walking in the forward direction. Two plates were mounted to the ends of the skid to reduce the flow of bulldozed mud behind the skid. Wedge-shaped furrow openers were attached to the underside of the skid to improve seed placement. A 23-inch diameter ground-driven wheel provided the power to rotate the metering device and to support the weight of the machine when transporting on hard ground. Four lugs were welded to the wheel spokes to minimize drive wheel slippage and to maintain a uniform seed metering rate.

The ground-driven seed metering device had two main components (Fig. 23): a fluted roller and an adjustable seed distributor with tapered seed channels. A brush cut-off was used with the fluted roller to minimize seed damage during the separation of seeds from the hopper. The distributor with eight tapering channels was located beneath the fluted roller to distribute the seeds into the seed tubes. The excess seeds, which did not drop into the tapering seed channels, were guided into an overflow bag. A wide range of seeding rate was possible by changing the relative position of the distributor with the tapered channels and the fluted roller. The capacity of the seed hopper was 1.6 kg of germinated seeds (based on dry weight at 14% m.c.), which was sufficient to seed a 2 m x 100 m strip.

The machine is being field-tested. Further development work will be focused on simplifying the design to achieve lower costs and to facilitate production. Tests will be conducted to determine the optimum roller speed and the number and size of flutes to obtain different seed rates. Economic feasibility studies of this machine in comparison to other means of seeding and transplanting paddy will be undertaken.

DEVELOPMENT OF A ROTARY SCREEN WINNOWER

Seed cleaners are essential processing equipment which require more development attention. The cleaners used in the developing countries do not satisfactorily separate and clean the chaff and empty kernels from paddy grain. The popular locally made winnower consists of a paddle-type fan mounted on a wooden frame which directs the air blast against the grain and foreign material falling from a hopper. The light material is blown farther away than the heavy solid grain and a set of baffles helps in the separation process. In usual practice, poorly separated seeds are repeatedly recycled to achieve satisfactory separation.

Conventional cleaners primarily depend on pneumatic means to clean the grain by exposing it to a high velocity air for a short duration. A machine which could mechanically separate the large straw and impurities before subjecting the seeds to pneumatic cleaning would be more desirable. It is felt that a longer exposure to a relatively lower air velocity would improve separation and cleaning efficiency. Air flowing through a tumbling mass of seed could provide the long duration exposure and improve the separation of light empty kernels from the heavier grain.

With this approach in mind, the design of a rotary screen seed cleaner (Fig. 34) was initiated. The machine uses two rotating concentric cylindrical screens with a 3-inch clearance. The inner screen has perforations large enough for the grain to pass through and the outer screen has perforations small enough to permit the passing only of dust and other finer impurities. Air is blown through the 3-inch space between the two concentric cylinders only in the lower half portion where the grain is tumbled. The grain to be cleaned is delivered into the inner cylindrical screen. Special sheet metal baffles mounted on the inside of the inner cylinder move the straw and larger impurities while the grain falls through the inner screen perforations into the outer cylinder. The grain is tumbled inside the outer cylinder and is moved axially in the direction opposite to the air movement by spiral baffles. The air blows the empty grain and other light impurities from the tumbling grain while it is moving in the outer cylinder towards the elevator for delivery into a container. The rotary screen design offers possibilities for a high output machine with improved cleaning quality in a single pass. Work on building the first prototype machine has been initiated.

DEVELOPMENT OF A TRACTOR PTO-DRIVEN THRESHER

The introduction of combine harvesters in the advanced countries has led to a decline in the use of threshers. In the developing countries, however, threshers are still in demand since, for many reasons, the introduction of combine harvesters for rice has been difficult. Due to a lack of suitable threshers, the farmers in many tropical countries still use machines which were originally developed over fifty years ago. Threshing paddy by treading under the tractor tires is also practiced in some areas. The development of improved high-output paddy threshers is an urgent necessity.

The hold-on type thresher, such as the IRRI drum thresher, in which the operator has to hold the paddy until threshing is complete, has relatively

limited threshing output. Comments received from many countries indicate the necessity of a machine which would have a much higher output than the drum thresher.

A tractor-mounted throw-in type PTO-driven thresher for standard 30 to 60 hp rubber-tired tractors would be desirable for such application. Such a machine could provide the necessary mobility, high output and low labor requirement features which are essential for custom threshing and larger holdings in the tropics. Considering the threshing requirement in many Asian countries, such a tractor PTO-driven thresher could find a substantial market.

A project on the development of such a thresher was initiated. The drawings were completed during the period of this report. The fabrication of the first prototype has been held up due to a heavy shop schedule. The thresher design (Fig. 35) will use a conventional spike-tooth threshing drum. This, however, will differ from conventional threshers in that the threshed material will move axially rather than circumferentially around the drum. The peripheral velocity of the drum will be lower than that of conventional threshers to minimize grain damage. A set of adjustable baffles mounted on the inside of the drum cover will control the deviation of threshing within the cylinder. It is felt that this feature will provide the necessary adjustment for threshing both dry and wet crops.

The thresher will be equipped with a rotary screen separator similar to our drum thresher. The use of rotary screen separator for combines and threshers is a novel idea and is being tried by manufacturers in the United States, Canada and Europe. Fabrication work on the first prototype machine will be started as soon as the shop schedule will permit.

SURVEY OF CENTRAL LUZON, ISABELA AND COTABATO PROVINCES

In addition to the survey already in progress in Central Luzon and stated in Report No. 6, two surveys were initiated in the provinces of Isabela and Cotabato. These are among the largest rice-growing areas in the Philippines. Use of surface irrigation in Isabela is relatively high and it offers a great potential for further increase. Two areas in Cotabato were chosen to include an irrigated district (Midsayap) and a rainfed rice-corn area (Tacurong). Methods of sampling were generally the same as the other areas.

There are some significant differences among the three survey areas. Rainfall pattern vary significantly from one area to another. The rainfall distribution in Central Luzon and Isabela present an interesting contrast

(Fig. 36). While both have an average annual rainfall of 75 inches, the rainfall patterns are markedly different from each other. In Central Luzon, the monsoon rainfall pattern is quite pronounced, with the rains starting in June reaching a high peak in July and August, and slackening in October and November. On the other hand, in Isabela, while the rain starts at about the same time of the year, there is a bi-modal distribution of rainfall. The rainfall data indicate a peak in July and August, followed by a higher peak a few months later.

Two comments can be made about this contrast in the rainfall pattern. First, in Isabela, with good early rain, farmers may be able to grow two rainfed crops, with the first crop harvested under rainy conditions. Second, with the main harvest in Isabela being later than that of Central Luzon, there is a great possibility for transferring the mechanized threshing teams from Central Luzon to the Isabela area. This is currently being done to some extent with the large McCormick threshers.

The rainfall pattern in Cotabato differs considerably from that of Luzon in that it is more evenly spread throughout the year (Fig. 36). The period of relatively higher amount of rainfall and, hence, the planting date for rainfed farms in Cotabato, coincides with that of Central Luzon. In the dry season there is usually enough moisture in the soil for planting corn in the Tacurong area.

Planting and harvesting cycles, 1967-1968 crop year

The sequence of farm operations and monthly rainfall for Central Luzon and Laguna are presented in Figs. 37 and 38 for each area. It is noted that the rainfall in Central Luzon was earlier than that in Laguna. Due to relatively heavy rainfall in Central Luzon during the month of June, the rainfed sites are planted in July. On the other hand, due to a later start of rains in Laguna, planting of rainfed sites is started in late August. The timing of land preparation is indicative of the dependence of farmers on rain to facilitate land preparation by animals.

The irrigated sites are prepared earlier than the rainfed sites by about two months in Laguna and two weeks in Central Luzon. While the dates of transplanting for two-crop sites in both Laguna and Central Luzon are approximately the same, the Central Luzon crop was harvested earlier than that of Laguna. Consequently, the second planting in Central Luzon was a month earlier.

Figure 39 contains the sequence of farm operations in Isabela Province which is located in the northeastern part of Luzon. The dates at the top of the figure are different from that of Figs. 37 and 38 since these dates and those of the succeeding figures coincide with the actual dates of the survey. The first crop is transplanted in September and October during the major rainfall period. The transplanting "curve" of the one-crop sites is quite steep, indicating that a majority of the farms were transplanted within a very short period. This shows a high seasonal labor requirement. Isabela, therefore, may suffer a serious labor shortage during periods of peak labor demand. The second planting was from April through June, somewhat approximating the onset of the monsoon in Central Luzon.

The sequences of farm operations in Cotabato are presented in Figs. 40 through 43. Figures 40 and 41 present the cumulative sequence of farm operations and planting and harvesting cycles, respectively, for the Midsayap area. The monthly rainfall averages are also plotted in Fig. 41. It can be seen that while the rainfall was spread throughout the year, the largest amount fell in June and July, and it coincided with the planting of the one-crop sites.

This can be compared with the rainfed rice-corn area of Tacurong (Figs. 42 and 43). Figure 42 presents the sequence of operation for the corn crop. Part of the land preparation observations for corn are contained in observations for rice since it was difficult to tell in advance whether the farmers would grow rice or corn. The data on the rice crop are presented in Fig. 43. The information on land preparation was again partly obscured because the observer could not tell whether the farm would be planted to rice or to corn. The number of observations indicating the vegetative stage rose in August, September, and October, followed by a rise in the reproductive stage during November and December. The harvest then occurs in December and January.

CORRELATION OF ESTIMATED YIELD WITH OBSERVATIONS ON THE GROWTH OF CROP

In order to relate the observed variables to the measured yields, a number of regressions were computed for the surveyed rice areas. The various considered factors, the regression coefficients, and the related data are presented in Table 15. The fields were categorized according to those using improved and non-improved varieties, in addition to the classification on whether these were irrigated or not. The crops were separated according to the wet and dry seasons. Due to the large number of variables and the limited number of observations, it is difficult to make definite conclusions. All the data, however, have been included to indicate the extent of work done, and to give some idea of the yield trends.

The results of these regressions can be used only as rough indicators. Further studies would be required to better understand the variations between areas. For instance, in water control, it was generally known that there was a shortage of irrigation water at the end of the 1966-1967 dry season in Laguna. The few observations in the study, however, did not indicate the presence of any serious drought. On the other hand, while the observations

indicated no serious shortage of water, a closer look at the 1967-1968 data indicates that out of 53 fields, 31 were excessively dry, 5 had some conditions of stress, 15 had adequate moisture, and 2 were not planted by the farmers. Thus, some prior information needs to be known about the conditions in the farmers' fields before interpretation of the regression coefficients. Of the two years under study, 1967 had fewer sites indicating dry condition, whereas in 1968, there seems to be not as many wet situations as expected. The 1967-1968 regressions do not indicate that a higher R^2, and, hence, a better correlation of variables to yield, was obtained for the irrigated fields, for the Laguna, Central Luzon and Isabela areas.

It is necessary to study the varieties before interpreting the consistent plus sign on lodging. Tall, higher-yielding indica varieties are more likely to lodge than some of the traditional varieties. If all varieties are short-statured and are less susceptible to lodging, then the coefficients should not be significant.

ANALYSIS OF SOIL PENETRATING RESISTANCE

Two tests were undertaken using the WES cone penetrometer to measure soil resistance under two conditions: a change from dry to wet condition, and from wet to dry condition. Two locations were used at IRRI: one small field surrounded by other water-submerged fields, and the other, a large field located some distance away from other irrigated fields in order to minimize any movement of surface water. Some moisture was present at depths below 1 meter in both fields.

The results of the two tests are presented in Figs. 44 and 45. These figures show hourly soil resistance measurements from the time of initial introduction of water in the two fields. Each measurement represents an average of 5 to 8 readings. It took 10 hours for the first reading to indicate a depth of 30 cm at a penetrating resistance of 70 psi. The fields were flooded throughout the tests. At the conclusion of the flooded test, the fields were drained and measurements were repeated to record the soil resistance as the field dried progressively (Fig. 46). In both cases the fields quickly attained a firm condition. This experiment was conducted under drier field conditions than the one included in Report No. 6 using the TN-4 meter.

The tests indicated that under continuous flooding practice the farmer has relatively little time in which he can expect fields to remain firm.

HAND THRESHING

Threshing by manual means is still common in most areas of the country. A popular manual threshing method is to harvest the crop with long enough straw and then holding the paddy bundle by a trundle and striking the panicles against a rock, log or a "hampasan" wooden threshing frame. Past studies on the hampas method have shown an extremely variable threshing output. The output depends on the amount of grain per bundle (yield), the strength of grain-panicle attachment, performance of the operator, and moisture content of the rice and stalks. The following data, however, is presented as "typical".

During two tests, with paddy at 18 percent moisture content and a yield of 4500 kg/ha, the output was found to be 18 and 22 kg/man-hr, or 220 and 235 man-hrs/ha. Threshing loss was found to be 1 to 2 kg/hr, or from 5.8 to 8.6 percent of the output. The operation of winnowing and cleaning was included in the threshing test duration.

USE OF FARM LABOR

In order to understand the feasibility of mechanization, one has to look into some of the demand and supply parameters of labor. From the data collected in the surveys, it can be concluded that there are seasonal peaks in the demand for labor in farm operations. During personal interviews the farmers, however, have not indicated a shortage of labor in any category except land preparation. A reliance on hired labor, which is a cash cost, can indicate that farmers may be in a position to shift from manual to mechanized methods if savings could be made in production costs.

Tables 16 and 17 present data on average labor inputs for all farms in the wet and dry seasons in Laguna. There is some overlapping of the date period since the timing of operation does not exactly coincide among all farms. The average labor input in 8-hour man-days for the wet and dry seasons were 79 and 72 man-days, respectively.

It can be noted in Table 16 that out of the 79 man-days, a total of 15 man-days were contributed by the operator and his family. The remaining was hired or exchanged labor. During the dry season (Table 17) the operator and his family contributed 15 man-days. Thus, there seems to be a great reliance on hired labor in Laguna. The operations requiring a high amount of labor are harvesting and threshing (mostly by manual methods), weeding (crop care), transplanting, and, to some extent, land preparation. There is a reliance on hired labor for most operations.

Table 18 presents the wet season labor distribution by farm worker category for tractor-prepared and machine-threshed rice farms in the Tacurong region. Of a total labor input of 56 man-days, 13 were contributed by the operator and his family. Transplanting and harvesting labor were the two operations using the largest amount of hired labor. Table 19 lists the labor inputs in farms using carabao and hand threshing methods indicating a contribution of 44 out of 63 man-days by the operator and his family. The seasonal distribution of labor use can be seen for the different types of farms in the tables. This can also be seen graphically in Fig. 42 where the contrast in distribution of labor for two-crop farms using carabao and tractor is shown. Table 20 summarizes the labor use in the two-crop farms for both Laguna and Central Luzon. It can be noted that labor requirement is spread throughout the year, with seasonal peaks in May-July and October-December. And, finally, Fig. 43 compares an irrigated two-crop farm use of labor with that of a single rainfed crop. It can be noted that labor requirement is generally higher in the irrigated farms.

COST OF PRODUCTION ESTIMATES

Average costs have been assembled for the survey areas and are presented in Tables 21 through 24. Allowance should be made for the owner-operated, or part-owner operated farms, as these data are for share rental farms. Since many of the payments are based on the percentage of yield, these costs reflect the current situation in each area.

Costs may be classified into two broad categories: cash costs and non-cash costs. This distinction between cash and non-cash costs is of significance to the individual producer. Cash costs are "out-of-the pocket" costs and are generally difficult to provide before planting. Non-cash costs, on the other hand, represent payments in kind for services rendered and are usually paid after harvest. A classic example of a non-cash cost is the harvesters' and threshers' share. The harvesters and threshers usually get a certain percentage of the produce. Family and operator's labor are non-cash costs while hired labor may either be paid in cash or in kind.

A farmer must be able to earn enough money from the sale of his crop to cover his costs in kind and in cash to remain in business. If he applies fertilizer, he expects to obtain a higher yield to cover the additional expense incurred. So the greater the cash costs, the greater the potential profit - or loss, in the event of crop failure. Because of this risk, it is expected that farmers with bigger farms are more receptive to yield-increasing inputs than those with smaller farms. Along the same lines, farmers with irrigated holdings are likely to invest more money (and are able to raise more capital) than those with rainfall-dependent farms because of the assured second crop due to the availability of adequate irrigation water.

The data of Tables 21 and 22 seem to confirm the above assumption. In Laguna and Central Luzon, cash costs per hectare, on irrigated two-crop farms, amounted to ₱214.34, compared to ₱178.35 and ₱137.13 for irrigated one-crop and rainfed farms, respectively. Expenditures on fertilizer in irrigated two-crop farms were also greater than that of the other two types of farms. This trend in cash expenditure is also indicated for the other areas.

The cost of the operator and family labor were estimated at ₱3.50/man-day and treated as a non-cash cost.

PRESENT STATE OF WEEDING

In the initial survey of Central Luzon farmers in 1966-1967, some data on weeding practices were collected. It was found that one-fourth of the farms were not weeded at all and about three-fourths were only weeded once. However, at the time of the survey, few improved varieties were introduced. It is assumed that the farmers adopting new varieties will also use the necessary inputs to obtain higher yields.

Table 25 presents a summary of weeding practices gathered from farmers in the 1967-1968 crop year surveys. The data indicate that weeding was practiced by most of the farmers included in the survey. In Central Luzon, however,

a significant number of farmers indicated no weeding. A large number of farmers use manually operated Japanese weeders. This is especially true in Isabela where labor is in short supply. Out of the 314 farms, 134 indicated the use of chemical weed control practices. Indications are that the farms planted to improved varieties in Laguna practice no weeding.

WORK PLAN

July 1, 1969 to June 30, 1970

1. Drum Thresher

Drum threshers are being manufactured in the Philippines. Some of these threshers are being exported to other countries for test and evaluation. Assistance will continue to be provided in testing and setting up the manufacture of this thresher in the Philippines and other tropical rice growing countries. Close contact will be maintained with the organizations and farmers using the thresher in order to follow up the field problems and to eliminate design weaknesses. Reports from the field during the first year of operation will provide valuable information on design weaknesses and service problems. Immediate attention will be directed to rectifying the machine's shortcomings. The technical staff will observe the performance of the machine in the various countries and will try to adapt the machine to local conditions.

2. Development of the Table Thresher

The third prototype machine which delivers the chaff and straw to one location is performing satisfactorily. From a manufacturing standpoint, however, the design is a little complicated. The fabrication involves a few relatively difficult sheet metal work. Attention shall be directed towards developing a simpler machine which would, as much as possible, retain the desirable features of the third prototype. On the completion of a simpler design, a fourth prototype table thresher will be fabricated and tested. If it meets both the functional and manufacturing requirements, the design will be released to local manufacturers. Experience gained from the drum thresher indicates that it is desirable for the manufacturer to initially build only a limited number of machines and study their performance in the field before going into regular production.

3. Tractor Tillage and Mobility Studies

Previous studies were limited to only four tiller blade velocities for each tractor travel speed due to a fixed step reduction in the tiller transmission. A hydrostatic transmission will be installed to provide a stepless variation in tiller shaft speed without stopping the machine. This will provide more flexibility in the experiments and will permit a more convenient and precise evaluation of blade velocities and other design parameters for a rotary tiller for wetland cultivation. Based on the experience gained with the big-diameter experimental tiller, a rotary tiller for commercial production will be developed.

4. Power Requirement for Wetland Rotary Tillage

Studies of the power distribution under soft wetland conditions between tractor drive wheels and rotary tiller will be resumed. Work on this project was interrupted due to a failure in the transmission of the hydrostatic drive

tractor which was used for this study. Strain gage torque transducer wheel hubs are now being fabricated to fit a standard tractor with conventional mechanical transmission. The results from this study will be useful in the design of a new wetland rotary tiller intended for commercial production.

5. Cage Wheel Studies

Studies to determine the desirable design parameters of cage wheels by tests of adjustable blade cage wheels will be continued. Cage wheel designs, based on the results of this study, will be developed for standard tractors.

6. Determination of Coefficient of Rolling Resistance of Tractors for Wetland Conditions

Experiments will be conducted to determine the rolling resistance of tractors in wetland conditions. Data available have been lacking in this area, because the variability of soil characteristics have been so wide that information for design have been limited. A tractor-mounted power winch with provisions for pulling force measurements will be used for determining the coefficient of rolling resistance.

7. Application of Anhydrous Ammonia with Small Tractors

The anhydrous ammonia applicator developed at the Institute will be tested under flooded field conditions. Losses of anhydrous ammonia to the atmosphere during application in a mud slurry with the applicator's discharge points at varied depths will be evaluated. Locally available tanks with about 2400 cu. in. capacity will be used.

8. Physical Properties of the Rice Plant and Paddy

Mechanical properties of paddy grain such as impact shear resistance and compressive strength are important engineering data needed to study grain resistance to cracking and size reduction under harvesting and drying conditions.

A simple pendulum will be built to measure energy to rupture grain. A load cell testing apparatus will also be built using strain gages as the sensing device to measure the applied load and the amount of grain deformation with respect to time. Electronic equipment will be used for amplifying and recording the signal from the strain gage transducer.

9. Row Seeder for Lowland Rice

Simplification of the design to facilitate the fabrication of the row seeder for pre-germinated paddy seeds will be made. Following a satisfactory development of the row seeder, extensive field tests will be undertaken and an economic evaluation of its performance as compared to other methods of planting will be made. The final design will eventually be released to interested manufacturers.

10. Development of a Paddy Stripper Harvester

The experimental machine, fabricated to evaluate a new stripping concept, has shown encouraging results. A number of problems have been encountered with this machine but these are problems which can be solved in due course. More knowledge and experimentation is needed to establish an optimum speed for the gathering chain mechanism and the threshing belt. More tests will be conducted to improve the stripping mechanism. After more experience is gained on the stripping mechanism, a new self-propelled machine will be fabricated which will include the mechanisms for lifting lodged crops, grain-straw separation, and final grain cleaning. In its final form, a self-propelled stripping harvester, capable of harvesting 4 rows of paddy at 25 cm spacing, is visualized. The machine will have a hydrostatic transmission to facilitate a more precise control of field speeds to provide optimum stripping action.

11. Development of Equipment for Multiple Cropping

The Multiple Cropping Department at IRRI has developed a system of intensive cultivation which combines some activities of dry and wet land farming in the tropics. This method of cultivation looks promising for the small holding of a few hectare size. Since a major portion of the land in the tropics is cultivated by small farmers, it is felt that the mechanization of this system can play an important role in its acceptance by farmers. A basic tractive machine with attachments to do the different operations of rotavating, plowing, harrowing, harvesting, planting, weeding and spraying is needed. A project in cooperation with the Multiple Cropping Department will be initiated to develop a system of mechanical cultivation for multiple cropping in the tropics.

12. Test and Evaluation of Paddy Dryers

It has been estimated that due to the high percentage of rural population in the tropics, nearly 50 to 75 percent of the paddy rice crop is consumed without reaching the commercial grain market. This paddy rice is generally sun-dried. Numerous attempts are being made in the tropical countries to improve and upgrade large commercial grain drying and handling facilities.

Relatively little attention is being directed, however, towards the problems of on-the-farm or village level drying of paddy rice in the tropics. In Japan, nearly a million and a half small batch or continuous flow dryers are used for drying paddy rice by individual or small-group farmers. A project will be initiated to evaluate the performance of such small dryers and to study their economic feasibility under tropical conditions.

13. Conduction Drying of Paddy Rice

Conventional dryers use hot air as a drying medium. Heat is introduced through convectional means by blowing hot air through a stationary or moving mass of grain. Heat can be transferred more efficiently by conduction methods. Localized heating of grain, however, is a major problem when using conduction

drying methods. Tests on a simple conduction dryer by Chancellor[1/] indicated that, except for problems of localized heating of paddy grain, conduction dryers can be used to dry paddy rice. Conduction drying of grain has not been fully investigated and there is a shortage of available information on the subject. A project is being initiated to establish basic information on conduction drying and to study the various approaches to build dryers utilizing conduction drying principles.

14. Tractor PTO-Driven Thresher

The objectives and a description of the tractor PTO-driven thresher have been mentioned in this report. Engineering drawings have been prepared, and fabrication of a prototype will be undertaken as soon as shop schedules will permit. The first machine will be field-tested at IRRI and development work will be continued until satisfactory performance is obtained. A final prototype will be fabricated and the design will be released for field evaluation in the Philippines.

15. Development of an Experimental Drying Furnace Using Rice Hull

Rice hull is a good source of heat energy for drying paddy rice crop. The disposal of rice hull at the rice mill is a serious problem. With the interest directed towards the development of small-size dryers, the use of rice hull as fuel looks promising. Design and fabrication of a small furnace using rice hull as fuel will be initiated.

16. Differential Slip for Wetland Tillage

A major problem of land preparation in wetland conditions is tractor mobility. Soft clayey soils are extremely difficult to till with conventional tractor-drawn equipment. In some countries, cage wheel-equipped tractors without any implement have been used for wetland tillage. Tillage and mobility may be accomplished by varying the relative speed between the front and rear wheels. In areas with serious tractor bogging problems, the front and rear wheels can be driven at the same speed to attain maximum traction. Two hand tractors will be coupled by articulated chassis to conduct some preliminary studies. With this arrangement, the speed of the front wheels will be independently controlled. Cage wheels with detachable adjustable blade sections will be fabricated to permit changing of blade angle and number of blades. A hydrostatic transmission will be used with one tractor to avail of maximum engine torque at all rotor speeds. If the concept shows promise, a special-purpose machine utilizing a single engine will be fabricated.

17. An Analysis of Hand Tractor Ownership

The hand tractor has been gaining popularity among small paddy farmers in the tropics. Information is needed on the economics of owning and operating

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1/ Chancellor, W. J. A simple grain dryer using conducted heat, IRRI Thursday Seminar, June 5, 1969.

the machines. Desirable and undesirable design features need to be studied to assist manufacturers in designing suitable small tractors for tropical farmers. In 1966 and 1967, a survey on small tractors was conducted under the project in the Laguna area. A new survey which would include some of the farmers from the first survey will be initiated to study the farmers' experience with small tractors and to evaluate their views on desirable small tractor features for tropical conditions. In addition, new tractor owners will be included to determine trends in the small tractor market. There is widespread controversy among many authorities about the introduction of small vs large tractors in the tropical countries. This survey may serve to indicate the trends in the acceptance of small tractors among farmers. This information would be useful to tractor manufacturers, various government officials and design engineers.

PROJECT PERSONNEL

Personnel and their respective man-months engaged in the project for the past six months, January 1, 1969 to June 30, 1969, are presented below. Anticipated personnel needs for the coming year are presented in the last two columns.

Name	Category	Actual 1-1-69 to 6-30-69	Projected 7-1-69 to 12-31-69	Projected 1-1-70 to 6-30-70
1. Amir U. Khan[1]	Project Leader and Development Engineer	4.5	4.5	4.5
2. Stanley S. Johnson	Agricultural Economist	.75	0	0
3. Open	Application Engineer	0	6	6
4. P. Cabanos	Asst. Design Engineer	2.5	6	6
5. A. Manalo	Asst. Agr. Engineer	0	4	6
6. N. Navasero	Research Assistant	6	6	6
7. N. Orcino	Research Assistant	6	6	6
8. A. Amilhussin	Research Aide	3	6	6
9. F. Cabrales	Draftsman	6	6	6
10. C. Ll. Jizmundo	Secretary	6	6	6
11. V. Go	Clerk-Typist	6	6	6
12. S. Gutierrez	Shop Foreman	1	6	6
13. F. Dungo	Tinsmith	6	6	6
14. R. Santos [illegible]	Tinsmith	6	6	6
15. J. Silos, Jr.	Mechanic-Operator	6	6	6
16. Z. Borja	Machinist	6	6	6
17. A. Barot	Welder	6	6	6
18. R. Dignadice	Mechanic	6	6	6
19. M. Castro	Laborer	6	6	6
20. J. Munar[1]	Field Assistant	4	0	0
21. F. Babac[1]	Field Assistant	4.5	0	0
22. F. de la Cruz[1]	Field Assistant	2.5	0	0
23. B. Ramos[1]	Student Assistant	2	2	2
24. C. Sumayao[1]	Student Assistant	2	0	0
25. N. Akhtar[1]	Student Assistant	1.5	0	0
26. V. Gonzales[1]	Student Assistant	1.5	0	0

[1]Part-time.

TABLE 1. Specifications of the IRRI adjustable blade rotary tiller:

Tilling width	1.55 m
No. of blade sections	5
No. of blades per section	8
Blade arrangement	Blades in a section offset from blades in preceding row by 22.5°
Rotor peripheral diameter	0.9 m
Blade angle settings*	(a) 12.5° (b) 32.5° (c) 52.5° (d) 72.5°
Tiller speed ratios**	1st gear - 9.46 2nd gear - 7.52 3rd gear - 6.70 4th gear - 5.32
Weight	490 kg

*Blade angle is the angle between the radial line and the blade face intersecting at the outer mounting bolt circle (Fig. 3).

**PTO rpm/tiller shaft rpm.

TABLE 2. Data sheet for the IRRI adjustable blade rotary tiller pushing force test.

Field condition: Irrigated for 7 days; 5 cm water depth; thickly covered with vegetation.

Date: June 18, 1969
Place: Plot R-9, IRRI
Blade angle: 12.5°

Test No.	Penetrometer reading** 35 psi	Penetrometer reading** 70 psi	Tilling depth*** cm	PTO rpm	PTO rpm per tiller shaft rpm	Actual distance travelled in.	No. of PTO revolutions	Pitch cm	Pushing force kg
1	Tiller clogged with soil								
2	6.6	19.6	15.2	410	9.46	9.67	168	-	525
3	9.9	22.6	8.8	440	9.46	-	-	-	470
4*	8.3	23.2	9.6	430	9.46	9.33	117	9.35	515
5	7.8	26.9	1.4	450	9.46	8.76	60	-	295
6*	19.2	31.6	10.6	430	9.46	8.40	63	15.80	700
7*	17.1	22.0	11.3	430	5.32	8.47	164	3.41	390
8	16.8	25.7	19.2	410	5.32	8.57	167	-	375
9	15.8	23.6	15.2	420	5.32	8.48	107	-	330
10	16.5	26.2	8.2	420	5.32	8.21	100	-	355
11*	16.0	25.6	10.0	380	5.32	8.33	62	8.94	450
12	14.0	23.6	15.0	360	5.32	8.463	61	-	475
13*	11.3	20.4	12.8	440	7.52	8.64	165	4.92	365
14*	13.7	24.3	10.6	460	7.52	8.36	168	4.47	295
15*	15.2	23.9	12.8	420	7.52	8.64	105	7.72	435
16	14.3	23.8	15.6	420	7.52	8.45	102	-	525
17	16.1	24.5	18.2	380	7.52	8.40	62	-	655
18	12.0	22.6	18.4	260	7.52	9.25	-	-	645
19	13.5	21.3	13.7	460	6.7	8.20	164	-	265
20*	13.4	23.8	13.7	440	6.7	8.45	153	5.02	315
21	12.8	22.8	13.8	420	6.7	8.64	113	-	445
22	12.8	22.8	18.9	420	6.7	8.65	110	-	475
23	Engine stalled - overloaded								
24	Shallow			440	6.7	10.03	61	-	-
25*	Slight stall			280	6.7	8.67	58	12.50	935
26*	-	-	-	300	6.7	9.11	60	12.70	730

*Used for curve fitting. **Average of 15 readings. ***Average of 5 readings.

TABLE 3. Data sheet for IRRI adjustable blade rotary tiller pushing force test.

Field condition: Irrigated for 7 days; 5 cm water depth; thickly covered with vegetation.

Date: June 16, 1969
Place: Plot R-10, IRRI
Blade angle: 32.5°

Test No.	Penetrometer reading** 35 psi	Penetrometer reading** 70 psi	Tilling depth*** cm	PTO rpm	PTO rpm per tiller shaft rpm	Actual distance travelled in.	No. of PTO revolutions	Pitch cm	Pushing force kg
1*	11.8	31.8	10.3	420	9.46	7.65	163	5.56	380
2*	10.4	31.8	12.22	410	9.46	8.86	169	6.22	530
3*	9.4	24.0	10.4	410	9.46	9.08	97	11.1	575
4*	12.9	24.42	12.6	410	9.46	9.07	103	10.04	510
5*	10.1	24.1	10.8	420	9.46	11.51	67	24.0	670
6*	10.5	22.4	9.7	410	9.46	11.66	62	22.2	868
7	- Tiller	-	-	-	9.46	8.30	-	-	-115
8	-	-	-	-	9.46	8.02	-	-	-118
9	-	-	-	-	9.46	7.75	-	-	-134
10	-	-	-	-	9.46	7.07	-	-	-130
11	-	-	-	-	9.46	7.48	-	-	-154
12	- trailed	-	-	450	6.7	-	-	-	268
13*	10.2	29.3	11.4	430	6.7	9.24	162	4.77	370
14*	16.9	36.6	11.4	420	6.7	7.86	106	7.0	474
15*	6.0	25.9	10.0	-	6.7	9.45	72	11.0	710
16*	4.5	22.9	12.0	410	7.52	9.82	131	7.05	519
17	4.2	24.5	13.2	430	7.52	9.87	290	-	519
18	8.7	24.1	8.1	430	7.52	9.39	104	-	560
19*	12.0	31.8	13.2	430	7.52	9.23	100	8.725	480
20	11.3	30.4	8.8	410	7.52	9.67	67	-	645
21*	11.3	28.9	9.9	420	7.52	8.88	64	12.9	635
22	12.6	27.1	14.8	410	5.32	8.53	159	-	382
23*	10.6	26.7	10.9	420	5.32	8.53	144	3.91	292
24	6.2	24.1	9.0	Overloaded					
25	6.2	24.1	9.0	450	5.32	-	105	-	170
26*	9.0	25.3	12.2	410	5.32	9.28	95	6.49	400
27	Overloaded				5.32	-	33	-	550
28	Unstable				5.32	-	66	-	515
29	-	-	-	-	-	8.30	-	-	410

*Used for curve fitting. **Average of 15 readings. ***Average of 5 readings.

TABLE 4. Data sheet for IRRI adjustable blade rotary tiller pushing force test.

Field condition: Irrigated for 7 days; 5 cm water depth; thickly covered with vegetation.

Date: June 19, 1969
Place: Plot R-9, IRRI
Blade angle: 52.5°

Test No.	Penetrometer reading**		Tilling depth***	PTO rpm	PTO rpm per tiller shaft rpm	Actual distance travelled	No. of PTO revolutions	Pitch	Pushing force
	35 psi	70 psi	cm			in.		cm	kg
1	13.55	23.2	8.5	440	6.7	8.28	-	-	310
2*	15.55	23.2	9.5	410	6.7	8.84	119	6.2	370
3	8.44	19.4	6.0	410	6.7	8.53	-	-	500
4	11.3	21.8	6.5	410	6.7	8.95	-	-	-
5	12.6	22.7	10.4	410	7.52	8.54	-	-	-
6*	14.8	24.3	8.9	420	7.52	8.26	104	7.46	355
7*	12.7	24.7	11.4	430	7.52	8.65	171	4.75	335
8*	12.0	27.0	8.2	420	7.52	8.75	111	7.41	375
9	12.0	24.0	8.2	430	7.52	8.97	-	-	235
10	17.4	30.4	20.6	350	5.32	7.9	175	-	315
11*	17.4	30.4	10.4	440	5.32	8.51	171	3.31	120
12	11.9	25.2	8.9	430	5.32	8.36	108	-	265
13*	13.1	23.0	13.4	400	5.32	8.57	67	8.49	340
14*	11.6	20.4	11.4	440	9.46	8.60	163	6.25	270
15*	13.1	23.0	13.4	440	9.46	7.28	107	8.02	270
16*	13.1	23.0	13.4	440	9.46	10.03	68	-	-

*Used for curve fitting.
**Average of 15 readings.
***Average of 5 readings.

TABLE 5. Data sheet for the IRRI adjustable blade rotary tiller pushing force test.

Field condition: Irrigated for 7 days; 5 cm water depth; thickly covered with vegetation.

Date: June 25, 1969
Place: Plot B-14, IRRI
Blade angle: 72.5°

Test No.	Penetrometer reading**		Tilling depth***	PTO rpm	PTO rpm per tiller shaft rpm	Actual distance travelled	No. of PTO revolutions	Pitch	Pushing force
	35 psi	70 psi	cm			in.		cm	kg
1*	9.3	25.8	10.6	430	9.46	9.01	165	6.46	395
2*	11.2	25.2	9.4	440	9.46	8.85	106	9.88	413
3	11.2	25.2	9.4	320	9.46	-	51	-	405
4*	10.7	26.72	9.0	440	9.46	9.1	60	2.11	460
5*	9.0	22.2	13.4	310	5.32	8.69	156	3.69	423
6	9.1	24.1	10.4	400	5.32	9.20	107	-	470
7*	10.1	24.3	8.8	350	5.32	9.03	64	9.37	375
8*	10.2	34.12	10.8	490	6.7	9.50	170	4.68	390
9*	12.7	26.1	9.4	470	6.7	8.80	106	6.95	373
10	10.5	28.42	7.2	460	6.7	9.14	61	-	433
11*	7.9	29.2	8.4	450	7.52	9.19	163	5.3	438
12	10.4	35.4	6.4	440	7.52	9.37	106	-	418
13	12.1	36.0	-	150	-	-	21	-	183
14	-	-	-	420	-	9.07	62	-	338

*Used for curve fitting.
**Average of 15 readings.
***Average of 5 readings.

TABLE 6. Data sheet for IRRI adjustable blade rotary tiller power test.

Blade angle: 12.5°

Data collected from the same experiment shown in Table 2.

Treatment*	Tilling Depth* cm	PTO RPM*	Pitch* cm	Torque kg-m	HP
4	9.6	430	9.35	41.0	24.3
6	10.6	430	15.80	50.0	29.7
7	11.3	430	3.41	49.5	29.4
11	10.0	380	8.94	65.5	34.4
13	12.8	440	4.92	40.3	24.5
14	10.6	460	4.47	31.3	19.9
15	12.8	420	7.72	47.0	27.2
20	13.7	440	5.02	39.0	23.7
25	None	300	12.70	73.5	30.4

*Repeated from Table 2.

TABLE 7. Data sheet for IRRI adjustable blade rotary tiller power test.

Blade angle: 32.5°

Data collected from the same experiment shown in Table 3.

Treatment*	Tilling depth* cm	PTO RPM*	Pitch* cm	Torque cm	HP
1	10.3	460	5.56	37.5	23.8
2	12.2	410	6.22	50.0	28.3
3	10.4	410	11.10	52.5	29.7
4	12.6	410	10.04	51.0	28.8
5	10.8	420	24.00	58.0	33.6
6	9.7	410	22.20	69.0	39.0
13	11.4	430	4.77	39.0	22.8
14	11.4	420	7.00	48.5	28.1
16	12.0	410	7.05	52.0	29.4
19	13.2	430	8.73	44.5	26.4
21	9.9	420	12.90	64.5	37.4
23	10.9	420	3.92	42.0	24.3
26	12.2	410	6.49	57.5	32.5

*Repeated from Table 3.

Blade angle: 52.5°

Data collected from the same experiment in Table 4.

Treatment*	Tilling depth* cm	PTO RPM*	Pitch* cm	Torque kg-m	HP
2	9.5	410	6.20	50.5	28.6
6	8.9	420	7.46	49.5	28.7
7	11.4	430	4.75	50.5	30.0
8	8.2	420	7.41	50.0	29.0
11	10.4	440	3.31	39.0	23.7
13	13.4	400	8.49	72.0	39.7
14	11.4	440	6.25	42.5	25.8
15	13.4	440	8.02	46.0	27.9
16	13.4	440	17.40	42.0	25.5

*Repeated from Table 4.

TABLE 9. Data sheet for IRRI adjustable blade rotary tiller power test.

Blade angle: 72.5°

Data collected from the same experiment in Table 5.

Treatment*	Tilling depth* cm	PTO RPM*	Pitch* cm	Torque kg-m	HP
1	10.6	430	6.46	32.0	18.98
2	9.4	440	9.88	29.5	17.90
4	9.0	440	2.11	31.0	18.82
5	13.4	310	3.69	54.5	23.30
7	8.8	350	9.37	56.5	27.30
8	10.8	490	4.68	42.0	28.40
9	9.4	470	6.95	42.0	27.24
11	8.4	450	5.30	40.0	24.80

*Repeated from Table 5.

TABLE 10. Effects of levels of nitrogen as anhydrous ammonia on the plant characters, grain yield and yield components of IR8 and IR127-80-1-10 under two methods of planting, IRRI, 1969 dry season.*

Variety	Method of planting	Nitrogen applied kg/ha	No. of tillers/ sq. m.	No. of panicles/ sq. m.	Average panicle weight g	No. of grains per panicle	Percent unfilled grains	Weight of 100 grains g	Grain/ straw ratio	Dry matter produced at harvest kg/ha	Grain yield at 14% moisture kg/ha
IR8	Broadcast	0	437	426	1.27	55	14.0	2.56	1.02	7813	4592
		40	493	476	1.44	67	16.1	2.66	.91	11263	6230
		80	520	498	1.62	74	20.2	2.78	.94	15013	8434
		120	557	539	1.99	98	20.2	2.76	.86	15964	8558
		160	591	573	2.22	116	24.6	2.81	.88	15671	8564
	Mean		520	502	1.71	82	19.0	2.71	.92	13145	7276
IR127-80-1-10	Broadcast	0	368	361	1.65	116	21.2	1.84	1.06	9192	5493
		40	397	387	2.04	136	24.8	1.96	.95	13050	7261
		80	515	505	2.16	152	22.3	1.98	.98	14761	8504
		120	549	533	2.44	144	29.6	2.08	.96	15601	8870
		160	550	542	2.81	164	37.9	2.06	.89	17025	9318
	Mean		476	466	2.22	142	27.2	1.98	.97	13926	7889
IR8	Trans-planted	0	272	260	1.84	68	11.0	2.61	1.34	6658	4404
		40	317	307	2.25	89	12.0	2.75	1.13	10377	6390
		80	364	354	2.27	93	12.4	2.89	1.12	13094	8064
		1[illegible]	360	347	2.24	92	14.3	2.85	1.08	13962	8414
		1[illegible]	372	358	2.38	104	19.4	2.81	1.01	15860	8956
	Mean		337	325	2.20	89	13.8	2.78	1.14	11990	7246
IR127-80-1-10	Trans-planted	0	190	185	2.31	166	15.9	1.86	1.20	6670	4216
		40	180	176	3.28	184	20.9	1.98	1.24	9214	5922
		80	236	233	3.43	183	23.8	2.01	1.11	13165	8022
		120	278	271	3.85	205	26.6	1.95	1.10	14049	8410
		160	288	275	3.88	209	31.7	2.04	1.07	15095	9036
	Mean		234	228	3.35	189	23.8	1.97	1.14	11639	7121

*Experiments conducted by Agronomy Department, IRRI.

TABLE 11. Comparative threshing efficiency of the three types of threshing cylinders. Paddy moisture at 14% w.b.

Threshing cylinder peripheral velocity (ft/min)	Total paddy weight (grams)						Threshed paddy % of total paddy weight					
	Wire-loop		Peg-tooth		Rasp-bar		Wire-loop		Peg-tooth		Rasp-bar	
	Hold	Throw	Hold	Throw	Hold	Throw	Hold	Throw	Hold	Throw	Hold	Throw
900	963.6	833.6	939.6	901.7	917.0	821.4	80.0	45.2	71.4	76.4	60.3	28.5
1150	815.6	890.2	920.0	884.1	953.1	900.2	82.6	57.6	74.5	83.0	67.8	32.9
1400	825.3	914.9	898.3	870.8	930.3	912.8	86.3	61.7	81.0	86.3	82.3	38.3
1650	990.9	899.1	971.6	939.2	932.3	995.7	90.8	67.9	83.9	87.5	87.8	57.7
1900	814.5	821.2	1001.5	1070.7	866.4	829.0	94.1	69.3	87.4	87.9	89.8	67.3
2150	901.4	913.5	1026.5	982.1	840.9	927.2	97.6	71.2	90.4	88.9	93.1	74.6
2400	886.1	898.5	936.4	936.5	940.3	882.8	97.9	77.1	91.9	90.3	95.4	76.0
2650	994.2	922.4	1022.5	1041.4	846.5	824.8	97.4	88.7	94.2	91.5	97.6	83.4
2900	819.3	1055.0	993.9	935.5	915.4	925.6	97.5	91.9	97.5	91.8	97.7	86.7
3150	914.9	926.3	1085.9	933.3	850.5	989.4	98.3	93.0	97.6	92.5	97.6	87.6
3400	881.4	957.5	984.7	1025.0	900.2	875.2	98.5	94.3	97.4	92.7	97.7	89.1
3650	950.0	898.4	996.6	998.2	829.1	879.8	98.4	96.1	97.5	92.9	97.8	89.2
3900	845.7	934.5	1068.3	878.9	902.6	910.7	99.1	96.0	97.6	93.7	97.9	91.0
4150	892.0	1073.5	1087.3	943.7	867.0	883.5	98.8	96.2	98.2	93.8	98.1	93.3
4400	871.6	936.7	968.4	881.1	878.3	907.6	99.2	96.2	97.9	94.5	98.3	94.6
4650	934.4	1023.6	918.0	964.5	919.7	822.1	99.2	96.4	98.2	95.9	98.2	95.4

Threshing cylinder peripheral velocity (ft/min)	Semi-threshed paddy % of total paddy weight						Unthreshed paddy % of total paddy weight					
	Wire-loop		Peg-tooth		Rasp-bar		Wire-loop		Peg-tooth		Rasp-bar	
	Hold	Throw	Hold	Throw	Hold	Throw	Hold	Throw	Hold	Throw	Hold	Throw
900	9.5	13.9	15.3	11.7	9.7	18.5	10.5	40.9	13.3	11.9	30.0	53.0
1150	8.1	12.3	14.3	7.6	8.0	16.9	9.3	30.1	11.2	9.4	24.2	50.2
1400	5.7	12.3	12.0	5.9	7.2	16.7	8.0	26.0	7.0	7.8	10.5	45.0
1650	4.1	12.0	10.2	5.5	6.8	15.7	5.1	20.1	5.9	7.0	5.4	26.6
1900	3.7	11.3	9.2	5.4	6.0	13.8	2.2	19.4	3.4	6.7	4.2	18.9
2150	1.4	10.7	6.5	5.3	4.3	9.2	1.0	18.1	3.1	5.8	2.6	16.2
2400	1.3	8.8	5.7	5.2	3.1	9.1	0.8	14.1	2.4	4.5	1.5	14.9
2650	1.7	5.3	3.8	5.2	1.6	8.9	0.9	6.0	2.0	3.3	0.8	7.7
2900	1.7	3.9	1.6	5.1	1.7	8.1	0.8	4.2	0.9	3.1	0.6	5.2
3150	1.0	3.4	1.5	5.1	1.8	8.1	0.7	3.6	0.9	2.4	0.6	4.3
3400	0.9	3.3	1.8	5.0	1.9	7.7	0.6	2.4	0.8	2.3	0.4	3.2
3650	1.0	1.5	1.8	4.9	1.9	7.6	0.6	2.4	0.7	2.2	0.3	3.2
3900	0.5	1.5	1.7	4.6	1.9	6.4	0.4	2.5	0.7	1.7	0.2	2.6
4150	0.7	1.4	1.3	4.6	1.8	4.7	0.5	2.4	0.5	1.6	0.1	2.0
4400	0.4	1.5	1.5	4.2	1.6	3.5	0.4	2.3	0.6	1.3	0.1	1.9
4650	0.5	1.3	1.4	3.0	1.7	3.1	0.3	2.3	0.4	1.1	0.1	1.5

TABLE 12. Milled paddy at threshing.

Threshing cylinder peripheral velocity ft/min	Percentage of milled paddy at threshing					
	Wire loop		Peg tooth		Rasp bar	
	Hold-on	Throw-in	Hold-on	Throw-in	Hold-on	Throw-in
900	0.000	0.000	0.000	0.000	0.000	0.000
1150	0.000	0.000	0.000	0.000	0.000	0.000
1400	0.000	0.000	0.000	0.000	0.000	0.000
1650	0.000	0.000	0.000	0.000	0.000	0.000
1900	0.000	0.000	0.000	0.135	0.000	0.000
2150	0.000	0.135	0.000	0.000	0.000	0.000
2400	0.261	0.000	0.141	0.146	0.135	0.000
2650	0.397	0.138	0.268	0.000	0.303	0.000
2900	0.664	0.256	0.403	0.125	0.430	0.149
3150	0.896	0.518	0.845	0.286	0.775	0.260
3400	1.340	0.705	1.279	0.688	1.163	0.262
3650	2.000	0.899	1.551	0.852	1.907	0.526
3900	2.688	1.195	2.344	1.346	1.976	0.699
4150	3.571	1.416	3.252	2.030	2.471	1.127
4400	4.032	2.092	4.130	3.038	2.789	1.262
4650	4.348	2.278	4.040	3.979	3.193	1.323

TABLE 13. Head grain yield of mechanically threshed IR8 paddy compared with hand-threshed check samples (125 grams per sample at 14% m.c., w.b.).

Threshing cylinder peripheral velocity	Head grain, percentage of total milled grain at 14% m.c., w.b.						Head grain, percentage of check at 14% m.c., w.b.					
	Wire loop		Peg tooth		Rasp bar		Wire loop		Peg tooth		Rasp bar	
ft/min	Hold-on	Throw-in	Hold-on	Throw-in	Hold-on	Throw-in	Hold-on	Throw-in	Hold-on	Throw-in	Hold-on	Throw-in
900	64.4	65.3	60.9	62.3	55.8	57.6	99.4	98.0	102.0	99.2	98.6	97.0
1150	64.6	66.0	60.3	62.3	55.9	56.5	99.7	99.1	101.0	99.2	98.8	95.1
1400	64.2	65.7	58.8	61.6	55.5	56.5	99.1	98.6	98.5	98.1	98.1	95.1
1650	63.1	65.2	59.1	61.0	55.2	55.8	97.4	97.9	99.0	97.1	97.5	93.9
1900	62.5	64.8	57.9	60.2	54.8	55.4	96.5	97.3	97.0	95.9	96.8	93.3
2150	60.8	64.5	57.2	59.8	54.4	54.7	93.8	96.8	95.8	95.2	96.1	92.1
2400	58.1	63.1	56.7	59.7	53.6	54.2	89.7	94.7	95.0	95.1	94.7	91.2
2650	56.0	61.8	55.3	58.3	52.9	53.8	86.4	92.8	92.6	92.8	93.5	90.6
2900	53.8	57.3	54.6	56.7	49.8	53.0	83.0	86.0	91.5	90.3	88.0	89.2
3150	52.7	54.7	52.0	55.8	47.4	52.8	81.3	82.1	87.1	88.9	83.7	88.9
3400	49.3	53.3	51.2	54.2	45.3	50.6	76.1	80.0	85.8	86.3	80.0	85.2
3650	47.7	51.6	48.7	51.5	43.2	50.5	73.6	77.5	81.6	82.0	76.3	85.0
3900	45.5	47.4	44.7	47.6	42.6	49.0	70.2	71.2	74.9	75.8	75.3	82.5
4150	43.6	42.3	41.1	44.4	39.8	47.6	67.3	63.5	68.8	70.7	70.3	80.1
4400	41.2	39.4	38.8	40.1	38.5	46.9	63.6	59.2	65.0	63.9	68.0	79.0
4650	38.3	37.5	26.3	36.3	38.2	44.7	59.1	56.3	60.8	57.8	67.5	75.3
Hand-threshed check	64.8	66.6	59.7	62.8	56.6	59.4	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 14. Germination of mechanically-threshed IR8 seeds compared with hand-threshed check samples (100 grains per sample)

Threshing cylinder peripheral velocity ft/min	Number of sprouted seeds per sample						Percentage of control					
	Wire loop		Peg tooth		Rasp bar		Wire loop		Peg tooth		Rasp bar	
	Hold-on	Throw-in	Hold-on	Throw-in	Hold-on	Throw-in	Hold-on	Throw-in	Hold-on	Throw-in	Hold-on	Throw-in
900	86	87	79	80	88	86	96.6	97.8	95.2	96.4	101.1	98.9
1150	88	85	81	78	84	87	98.9	95.5	97.6	94.0	96.6	100.0
1400	84	86	79	78	86	85	94.4	96.6	95.2	94.0	98.9	97.7
1650	85	85	77	77	84	82	95.5	95.5	92.8	92.8	96.6	94.3
1900	85	83	78	75	82	83	95.5	93.3	94.0	90.4	94.3	95.4
2150	83	84	76	69	78	81	93.3	94.4	91.6	83.1	89.7	93.1
2400	79	78	77	68	76	82	88.8	87.6	92.8	81.9	87.4	94.3
2650	82	79	74	66	71	74	92.1	88.8	89.2	79.5	81.6	85.1
2900	80	77	73	65	70	76	89.9	86.5	88.0	78.3	80.5	87.4
3150	75	72	73	64	65	70	84.3	80.9	88.0	77.1	74.7	80.4
3400	69	66	71	63	67	65	77.5	74.2	85.5	75.9	77.0	74.7
3650	67	68	62	52	62	62	75.3	76.4	74.7	62.7	71.3	71.3
3900	61	64	57	47	56	57	68.5	71.9	68.7	56.6	64.4	65.5
4150	60	61	49	42	50	52	67.4	68.5	59.0	50.6	57.5	59.8
4400	57	54	46	39	44	48	64.0	60.7	55.4	47.0	50.6	55.2
4650	54	50	46	38	41	45	60.7	56.2	55.4	45.8	47.1	51.7
Hand-threshed check	89	89	83	83	87	87	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 15. Results of regressions on yields for the 1967-68 season, for rice fields in Central Luzon, Laguna and Isabela Provinces: a listing of the regression coefficients.*

Variables	LAGUNA							CENTRAL LUZON					ISABELA						
	Irrigated farms							Irrigated farms			Rainfed farms	All farms	Irrigated farms			Rainfed farms			All farms
	Wet season			Dry season			Both seasons	Wet season	Dry season	Both seasons	Wet season	Both seasons	Wet season			Wet season			Both seasons
	Improved varieties	Other varieties	All varieties	Improved varieties	Other varieties	All varieties	All varieties	All varieties	All varieties	All varieties	All varieties	All varieties	Improved varieties	Other varieties	All varieties	Improved varieties	Other varieties	All varieties	All varieties
x_1 = yield																			
x_2 = number of weeks in rice	-401.7	337.4*	-110.1	-118.0	-300.9	-290.6	-55.25	149.1	234.3	248.7*	-81.42	-3.717	-26.24	-75.22	66.04	-271.7	-9.461	-4.697	26.31
x_3 = number of weeks of weeding need	-140.6	-95.77	-65.43	32.92	-174.2	-51.23	-75.98	5.247	119.3	21.31	7.315	9.703	-25.80	-77.65	-4.692	169.2	15.43	12.17	3.923
x_4 = water management: 1 = good 2 = average 3 = dry	-56.59	96.63	173.9	-1333.0*	-2671.0	-1109.0*	-657.2**	38.38	-331.8	-74.35	-107.3	-140.0	-669.5*	399.9	-210.1	658.6	-296.2	-27[illegible]	-333.3**
x_5 = number of weeks of leaf blight	-622.0	-715.2*	-630.3	-1056.0	-1454.0	-1033.0	-687.8*	5.290	-668.2	-211.4	67.01	-93.87	-487.7	-149.7	-225.1	671.3	-160.0	-21.22	-116.2
x_6 = number of weeks of blast	-659.0	-1699.0**	-740.3	-1390.0	163.9	-1059.0	-954.2**	41.67	107.8	-138.0	200.1	13.41	-746.2	120.0	86.41	714.0	-202.1	-71.93	-44.76
x_7 = number of weeks of white head	-662.1	1512.0*	-860.4	-245.3	4626.0	374.0	-333.2	44.76	-731.1	-[illegible].627	-496.5	-227.1	241.6	85.53	20.93	-	-	-	-169.5
x_8 = number of weeks of dead heart	-616.0	727.0*	151.3	-	167.[illegible]	294.6	-2.099	-339.9	796.8	195.6	42.58	164.4	1007.0	986.1	630.8	611.2	-206.9	-41.67	113.9
x_9 = number of weeks of lodging (during reproductive stage)	60.09	-1421.0**	-146.2	157.2	421.6	503.9	104.2	296.4	673.7*	531.8**	165.0	309.7*	-532.1	201.8	165.3	-137.1	149.0	124.[illegible]	165.1
x_{10} = field was flooded (yes-no)	-974.4	-3587.0**	-1162.0	-	-	-	-1104.0	0.218	10.73	-1.523	7.982	2.825	12.98	44.74*	20.21*	31.53	13.67	11.09	17.93*
x_{11} = amount of nitrogen fertilizer used	-2.328	-0.820	-4.650	-14.26	-14.32	-4.580	-1.787	-	-	-440.5	-	125.7	-	-	-237.9	-	-	297.5	-95.61
x_{12} = variety: 1 = improved 2 = semi-improved 3 = traditional	-	-	13.03	-	-	100.9	-63.54	-	-	-	-	-	-	-	-	-	-	-	-
x_{13} = wet or dry season	-	-	-	-	-	-	413.7	-	-	-	-	-	-	-	-	-	-	-	-
R^2	0.65	0.99	0.55	0.85	0.79	0.72	0.51	0.24	0.82	0.53	0.18	0.17	0.54	0.48	0.29	0.37	0.14	0.10	0.16
Significance test (F)	2.05^{ns}	35.8**	2.76*	4.79*	2.57^{ns}	5.30**	4.77**	0.36^{ns}	4.09*	3.01*	0.62^{ns}	1.30^{ns}	1.59^{ns}	1.56^{ns}	1.49^{ns}	0.15^{ns}	0.78^{ns}	0.58^{ns}	2.09*
Sample size (n)	22	15	37	16	16	32	69	20	18	38	36	74	22	25	47	11	48	59	106
Number of variables included in the regression	11	11	12	9	10	13	13	10	10	11	10	11	10	10	11	9	9	10	11

*Indicates 5% level of significance.

**Indicates 1% level of significance.

^{ns}Not significant.

TABLE 16. Labor input (man-days/ha), irrigated two-crop sites using tractor and carabao, hand-threshed, Laguna, wet season, 1967. (n = 20).

Operation	1967												Total
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
1. Seedbed preparation & care	-	-	-	0.29	0.21	1.48	0.22	-	-	-	-	-	2.20
a. Operator	-	-	-	.03	.12	1.12	.22	-	-	-	-	-	1.49
b. Family	-	-	-	.20	-	.28	-	-	-	-	-	-	.48
c. Hired	-	-	-	.06	.09	.03	-	-	-	-	-	-	.13
d. Exchange	-	-	-	-	-	.05	-	-	-	-	-	-	.05
2. Plowing	-	-	-	0.19	1.69	1.58	0.23	-	-	-	-	-	3.69
a. Operator	-	-	-	-	.90	.47	.01	-	-	-	-	-	1.38
b. Family	-	-	-	-	.02	-	-	-	-	-	-	-	.02
c. Hired	-	-	-	.19	.77	.45	.22	-	-	-	-	-	1.63
d. Exchange	-	-	-	-	-	.66	-	-	-	-	-	-	.66
3. Harrowing	-	-	-	0.31	1.05	2.81	0.32	-	-	-	-	-	4.49
a. Operator	-	-	-	.18	.37	1.11	-	-	-	-	-	-	1.66
b. Family	-	-	-	-	-	-	-	-	-	-	-	-	-
c. Hired	-	-	-	-	.50	1.22	.32	-	-	-	-	-	2.04
d. Exchange	-	-	-	.13	.18	.48	-	-	-	-	-	-	.79
4. Repair & cleaning of dikes	-	-	-	0.25	0.52	2.20	0.12	-	-	-	-	-	3.09
a. Operator	-	-	-	.18	.52	1.30	.10	-	-	-	-	-	2.10
b. Family	-	-	-	.07	-	.57	-	-	-	-	-	-	.64
c. Hired	-	-	-	-	-	.33	.02	-	-	-	-	-	.35
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Pulling seedlings & transplanting	-	-	-	0.96	-	7.73	0.86	-	-	-	-	-	9.55
a. Operator	-	-	-	-	-	.29	.02	-	-	-	-	-	.31
b. Family	-	-	-	.33	-	-	-	-	-	-	-	-	.33
c. Hired	-	-	-	.63	-	7.44	.84	-	-	-	-	-	8.91
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Care of crop	-	-	-	1.47	0.22	4.11	9.35	1.15	-	-	-	-	16.30
a. Operator	-	-	-	.71	.13	1.24	3.25	-	-	-	-	-	5.33
b. Family	-	-	-	.05	.07	1.29	-	-	-	-	-	-	1.41
c. Hired	-	-	-	.71	.02	1.58	6.10	1.15	-	-	-	-	9.56
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Harvesting	-	-	-	-	-	-	-	-	5.08	12.88	0.05	-	18.01
a. Operator	-	-	-	-	-	-	-	-	-	.09	-	-	.09
b. Family	-	-	-	-	-	-	-	-	-	-	-	-	-
c. Hired	-	-	-	-	-	-	-	-	5.08	12.20	.05	-	17.33
d. Exchange	-	-	-	-	-	-	-	-	-	.59	-	-	.59
8. Threshing	-	-	-	-	-	-	-	-	8.47	13.47	0.05	-	21.99
a. Operator	-	-	-	-	-	-	-	-	-	.02	-	-	.02
b. Family	-	-	-	-	-	-	-	-	-	-	-	-	-
c. Hired	-	-	-	-	-	-	-	-	8.47	12.87	.05	-	21.39
d. Exchange	-	-	-	-	-	-	-	-	-	.58	-	-	.58
9. All operations	-	-	-	3.47	3.69	19.91	11.10	1.15	13.55	26.35	0.10	-	79.32
a. Operator	-	-	-	1.10	2.04	5.53	3.60	-	-	.11	-	-	12.38
b. Family	-	-	-	.65	.09	2.14	-	-	-	-	-	-	2.88
c. Hired	-	-	-	1.59	1.38	11.05	7.50	1.15	13.55	25.07	.10	-	61.39
d. Exchange	-	-	-	.13	.18	1.19	-	-	-	1.17	-	-	2.67

TABLE 17. Labor input (man-days/ha), irrigated two-crop sites, using both tractor and carabao, hand-threshed, Laguna, dry season, 1967-1968. (n = 20).

Operation	1967						1968						Total
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	
1. Seedbed preparation & care	-	0.14	-	0.24	0.59	1.14	-	-	-	-	-	-	2.11
a. Operator	-	.14	-	.24	.30	.91	-	-	-	-	-	-	1.59
b. Family	-	-	-	-	.20	.15	-	-	-	-	-	-	.35
c. Hired	-	-	-	-	.09	.08	-	-	-	-	-	-	.17
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Plowing	-	-	0.30	0.28	1.75	0.50	-	-	-	-	-	-	2.83
a. Operator	-	-	.08	.06	.20	.08	-	-	-	-	-	-	.42
b. Family	-	-	-	-	-	-	-	-	-	-	-	-	-
c. Hired	-	-	.22	.22	1.55	.42	-	-	-	-	-	-	2.41
d. Exchange	-	-	-	-	-		-	-	-	-	-	-	-
3. Harrowing	-	-	-	0.65	2.10	0.53	-	-	-	-	-	-	3.28
a. Operator	-	-	-	.02	1.06	.18	-	-	-	-	-	-	1.26
b. Family	-	-	-	-	-	-	-	-	-	-	-	-	-
c. Hired	-	-	-	.63	.76	.22	-	-	-	-	-	-	1.61
d. Exchange	-	-	-	-	.28	.13	-	-	-	-	-	-	.41
4. Repair & cleaning of dikes	-	-	-	0.33	1.48	1.21	-	-	-	-	-	-	3.02
a. Operator	-	-	-	.22	1.15	.62	-	-	-	-	-	-	1.99
b. Family	-	-	-	-	.07	.57	-	-	-	-	-	-	.64
c. Hired	-	-	-	.11	.26	.02	-	-	-	-	-	-	.39
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Pulling seedlings & transplanting	-	-	-	0.47	2.45	5.70	0.52	-	-	-	-	-	9.14
a. Operator	-	-	-	-	-	.20	-	-	-	-	-	-	.20
b. Family	-	-	-	-	-	.03	-	-	-	-	-	-	.03
c. Hired	-	-	-	.47	2.45	5.47	.52	-	-	-	-	-	8.91
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Care of crop	-	-	-	-	1.60	5.21	9.27	0.39	0.02	0.06	-	-	16.55
a. Operator	-	-	-	-	1.01	2.74	3.89	.29	.02	.06	-	-	8.01
b. Family	-	-	-	-	-	.13	.30	-	-	-	-	-	.43
c. Hired	-	-	-	-	.59	2.34	5.08	.10	-	-	-	-	8.11
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Harvesting	-	-	-	-	-	-	0.60	-	3.82	12.72	0.40	-	17.54
a. Operator	-	-	-	-	-	-	-	-	-	.06	-	-	.06
b. Family	-	-	-	-	-	-	-	-	-	-	-	-	-
c. Hired	-	-	-	-	-	-	.60	-	3.82	12.66	.40	-	17.48
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Threshing	-	-	-	-	-	-	0.60	-	3.82	12.66	0.40	-	17.48
a. Operator	-	-	-	-	-	-	-	-	-	-	-	-	-
b. Family	-	-	-	-	-	-	-	-	-	-	-	-	-
c. Hired	-	-	-	-	-	-	.60	-	3.82	12.66	.40	-	17.48
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
9. All operations	-	0.14	0.30	1.97	9.97	14.29	10.99	0.39	7.66	25.44	0.80	-	71.95
a. Operator	-	.14	.08	.54	3.72	4.73	3.89	.29	.02	.12	-	-	13.53
b. Family	-	-	-	-	.27	.88	.30	-	-	-	-	-	1.45
c. Hired	-	-	.22	1.43	5.70	8.55	6.80	.10	7.64	25.32	.80		56.56
d. Exchange	-	-	-	-	.28	.13	-	-	-	-	-	-	.41

TABLE 18. Labor input (man-days/ha), irrigated two-crop farms using tractor, machine threshed, Tacurong, Cotabato, 1967-1968 rice wet season. (n = 17).

Operation	1967									1967			Total
	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	
1. Seedbed preparation & care	-	1.31	0.58	0.58	-	-	-	-	-	-	-	-	2.08
a. Operator	-	.40	.37	.19	-	-	-	-	-	-	-	-	.96
b. Family	-	.20	-	-	-	-	-	-	-	-	-	-	.20
c. Hired	-	.64	.09	-	-	-	-	-	-	-	-	-	.73
d. Exchange	-	.07	.12	-	-	-	-	-	-	-	-	-	.19
2. Plowing	0.02	0.21	1.24	-	-	0.04	-	-	-	-	-	-	1.51
a. Operator	-	.03	.58	-	-	-	-	-	-	-	-	-	.61
b. Family	-	-	.19	-	-	-	-	-	-	-	-	-	.19
c. Hired	.02	-	.16	-	-	.04	-	-	-	-	-	-	.22
d. Exchange	-	.18	.31	-	-	-	-	-	-	-	-	-	.49
3. Harrowing	-	0.63	0.33	2.53	-	0.04	-	-	-	-	-	-	3.53
a. Operator	-	.10	.26	1.34	-	-	-	-	-	-	-	-	1.70
b. Family	-	.34	.01	.33	-	-	-	-	-	-	-	-	.68
c. Hired	-	.01	.02	.53	-	.04	-	-	-	-	-	-	.60
d. Exchange	-	.18	.04	.33	-	-	-	-	-	-	-	-	.55
4. Repair & cleaning of dikes	-	-	0.75	2.81	0.12	0.54	-	-	-	-	-	-	4.22
a. Operator	-	-	.02	.45	.12	-	-	-	-	-	-	-	.59
b. Family	-	-	-	.48	-	-	-	-	-	-	-	-	.48
c. Hired	-	-	.38	1.73	-	.54	-	-	-	-	-	-	2.65
d. Exchange	-	-	.35	.15	-	-	-	-	-	-	-	-	.50
5. Pulling seedlings & transplanting	-	-	1.48	11.95	2.29	-	0.53	-	-	-	-	-	16.25
a. Operator	-	-	-	.56	.09	-	-	-	-	-	-	-	.65
b. Family	-	-	.32	.61	.42	-	-	-	-	-	-	-	1.35
c. Hired	-	-	1.16	10.57	1.46	-	.53	-	-	-	-	-	13.72
d. Exchange	-	-	-	.21	.32	-	-	-	-	-	-	-	.53
6. Care of crop	-	-	-	0.96	3.33	3.49	1.66	0.44	0.03	0.12	-	-	10.03
a. Operator	-	-	-	.31	.99	1.05	.35	-	-	-	-	-	2.70
b. Family	-	-	-	.39	.04	1.50	-	-	-	-	-	-	1.93
c. Hired	-	-	-	.26	.90	.84	1.31	.44	.03	.12	-	-	3.90
d. Exchange	-	-	-	-	1.40	.10	-	-	-	-	-	-	1.50
7. Harvesting	-	-	-	-	-	0.36	0.43	7.93	6.99	-	0.44	-	16.15
a. Operator	-	-	-	-	-	-	.11	.07	.37	-	-	-	.55
b. Family	-	-	-	-	-	-	.32	-	-	-	-	-	.32
c. Hired	-	-	-	-	-	.36	-	7.51	3.14	-	.44	-	11.45
d. Exchange	-	-	-	-	-	-	-	.35	3.48	-	-	-	3.83
8. Threshing	-	-	-	-	-	-	0.13	0.39	0.74	0.41	0.29	0.01	1.97
a. Operator	-	-	-	-	-	-	-	.05	.11	.02	-	-	.18
b. Family	-	-	-	-	-	-	-	-	-	-	-	-	-
c. Hired	-	-	-	-	-	-	.13	.34	.63	.39	.29	.01	1.79
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
9. All operations	0.02	2.15	4.38	18.44	5.74	4.47	2.75	8.76	7.76	0.53	0.73	0.01	55.74
a. Operator	-	.53	1.23	2.85	1.20	1.05	.46	.12	.48	.02	-	-	7.94
b. Family	-	.54	.52	1.81	.46	1.50	.32	-	-	-	-	-	5.15
c. Hired	.02	.65	1.81	13.09	2.36	1.82	1.97	8.29	3.80	.51	.73	.01	35.06
d. Exchange	-	.43	.82	.69	1.72	.10	-	.35	3.48	-	-	-	7.59

TABLE 19. Labor input (man-days/ha), irrigated two-crop farms using carabao, hand-threshed, Tacurong, Cotabato, 1967-1968 rice wet season.

Operation	1967									1968			Total
	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	
1. Seedbed preparation & care	-	1.45	1.21	-	-	-	-	-	-	-	-	-	2.66
a. Operator	-	.90	.88	-	-	-	-	-	-	-	-	-	1.78
b. Family	-	.48	.23	-	-	-	-	-	-	-	-	-	.71
c. Hired	-	-	.10	-	-	-	-	-	-	-	-	-	.10
d. Exchange	-	.07	-	-	-	-	-	-	-	-	-	-	.07
2. Plowing	2.07	2.87	2.77	1.48	-	-	-	-	-	-	-	-	9.19
a. Operator	1.26	2.34	1.76	.70	-	-	-	-	-	-	-	-	6.06
b. Family	.81	.47	.67	.37	-	-	-	-	-	-	-	-	2.32
c. Hired	-	.06	.02	.25	-	-	-	-	-	-	-	-	.33
d. Exchange	-	-	.32	.16	-	-	-	-	-	-	-	-	.48
3. Harrowing	1.38	1.21	4.61	2.56	0.25	-	-	-	-	-	-	-	10.01
a. Operator	.46	.34	2.60	1.67	-	-	-	-	-	-	-	-	5.07
b. Family	.92	.87	1.37	.44	-	-	-	-	-	-	-	-	3.60
c. Hired	-	-	.10	-	.25	-	-	-	-	-	-	-	.35
d. Exchange	-	-	.54	.45	-	-	-	-	-	-	-	-	.99
4. Repair & cleaning of dikes	0.43	-	1.64	2.37	0.40	-	-	-	-	-	-	-	4.84
a. Operator	.12	-	.50	1.15	.12	-	-	-	-	-	-	-	1.89
b. Family	-	-	.77	.29	.28	-	-	-	-	-	-	-	1.34
c. Hired	.31	-	.37	.74	-	-	-	-	-	-	-	-	1.42
d. Exchange	-	-	-	.19	-	-	-	-	-	-	-	-	.19
5. Pulling seedlings & transplanting	0.53	-	3.18	6.78	2.42	-	-	-	-	-	-	-	12.91
a. Operator	.15	-	.49	.38	.11	-	-	-	-	-	-	-	1.13
b. Family	.38	-	1.69	2.13	1.15	-	-	-	-	-	-	-	5.35
c. Hired	-	-	1.00	3.90	1.16	-	-	-	-	-	-	-	6.06
d. Exchange	-	-	-	.37	-	-	-	-	-	-	-	-	.37
6. Care of crop	-	1.56	-	0.43	1.65	4.31	2.10	-	-	-	-	-	10.05
a. Operator	-	.92	-	.31	1.28	1.83	1.52	-	-	-	-	-	5.86
b. Family	-	.64	-	.12	.37	1.00	.58	-	-	-	-	-	2.71
c. Hired	-	-	-	-	-	1.48	-	-	-	-	-	-	1.48
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Harvesting	-	-	-	0.77	-	-	1.15	1.12	6.97	1.15	-	-	11.16
a. Operator	-	-	-	.13	-	-	-	.12	.47	.15	-	-	.87
b. Family	-	-	-	.32	-	-	-	.38	2.40	-	-	-	3.10
c. Hired	-	-	-	.32	-	-	1.15	.62	4.10	1.00	-	-	7.19
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Threshing	-	-	-	-	-	-	-	0.22	0.91	1.54	-	-	2.67
a. Operator	-	-	-	-	-	-	-	-	.50	-	-	-	.50
b. Family	-	-	-	-	-	-	-	-	.41	-	-	-	.41
c. Hired	-	-	-	-	-	-	-	.22	-	1.54	-	-	1.76
d. Exchange	-	-	-	-	-	-	-	-	-	-	-	-	-
9. All operations	4.41	7.09	13.41	14.39	4.72	4.31	3.25	1.34	7.88	2.69	-	-	63.49
a. Operator	1.99	4.50	6.23	4.34	1.51	1.83	1.52	.12	.97	.15	-	-	23.16
b. Family	2.11	2.46	4.73	3.67	1.80	1.00	.58	.38	2.81	-	-	-	19.54
c. Hired	.31	.06	1.59	5.21	1.41	1.48	1.15	.84	4.10	2.54	-	-	18.69
d. Exchange	-	.07	.86	1.17	-	-	-	-	-	-	-	-	2.10

TABLE 20. Monthly labor use per hectare, irrigated two-crop farms, Laguna and Central Luzon, 1967-1968.

Operation	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1. Seedbed preparation & care	0.04	0.03	0.11	0.12	1.01	0.82	0.11	0.14	0.40	0.71	0.27	0.38	4.14
2. Plowing: carabao	0.05	-	0.06	0.10	0.74	0.91	0.19	0.05	0.30	0.27	0.23	0.10	3.00
tractor	-	0.03	-	0.08	0.14	0.30	0.01	0.02	0.05	0.14	0.21	0.17	1.15
total	0.05	0.03	0.06	0.18	0.88	1.21	0.20	0.07	0.35	0.41	0.44	0.27	4.15
3. Harrowing: carabao	0.03	-	0.34	0.16	0.66	1.66	0.40	0.26	0.14	0.98	0.76	0.14	5.53
tractor	0.10	0.03	0.01	0.03	0.16	0.35	0.27	0.04	0.05	0.06	0.22	0.39	1.71
total	0.13	0.03	0.35	0.19	0.82	2.01	0.67	0.30	0.19	1.04	0.98	0.53	7.24
4. Plowing and harrowing	0.18	0.06	0.41	0.37	1.70	3.22	0.87	0.37	0.54	1.45	1.42	0.80	11.39
5. Repair & cleaning of dikes	0.01	0.02	0.04	0.17	0.68	0.94	0.29	0.07	0.17	0.55	0.52	0.45	3.91
6. Pulling seedlings & transplanting	0.42	0.11	0.12	0.22	0.75	3.35	2.36	0.38	0.29	1.55	2.40	1.38	13.33
7. Irrigating & draining	0.45	0.34	0.03	0.33	0.18	0.72	0.50	0.48	0.30	0.27	0.63	0.56	4.79
8. Weeding	1.66	0.73	0.09	0.21	0.40	0.78	2.54	1.32	0.51	0.64	0.79	0.86	10.53
9. Fertilizing	0.18	0.07	0.03	0.04	0.03	0.12	0.17	0.18	0.08	0.07	0.12	0.18	1.27
10. Spraying	0.17	0.08	0.02	0.03	0.02	0.09	0.26	0.14	0.06	0.09	0.10	0.13	1.19
11. Harvesting	0.66	1.37	1.34	1.67	0.22	0.04	0.15	0.34	1.12	2.91	0.53	0.08	10.43
12. Threshing: manual	0.52	0.55	0.77	0.99	0.12	0.04	0.26	0.84	1.00	2.62	0.75	0.08	8.54
machine	-	0.01	0.01	0.01	0.02	-	-	-	-	-	-	-	0.05
total	0.52	0.56	0.78	1.00	0.14	0.04	0.26	0.84	1.00	2.62	0.75	0.08	8.59
All operations	4.29	3.37	2.97	4.16	5.13	10.12	7.51	4.26	4.47	10.86	7.53	4.90	69.57

TABLE 21. Cost of producing rice per hectare, Laguna and Central Luzon, 1967-1968.

Items	Irrigated		Rainfed	All farms
	2 crops	1 crop		
Number of farms	76	7	32	115
Average size of farm (ECA)*	4.83	3.95	3.42	4.38
Average yield, cavans/hectare	66.70	46.60	55.50	62.30
Cash Cost:	- - - - - pesos per hectare - - - - -			
Hired labor including food	129.61	100.30	106.77	121.47
Fertilizer	46.60	37.52	28.73	41.07
Insecticide	7.47	28.89	1.46	7.10
Weedicide	2.94	1.96	0.17	2.11
Fuel and oil	2.72	5.11	-	2.11
Irrigation fee	25.00	4.57	-	16.80
Total Cash Cost	214.34	178.35	137.13	190.66
Non-Cash Cost:				
Landlord's share	412.78	311.11	297.44	374.50
Value of unpaid labor**	87.15	101.28	87.95	88.23
Seeds used	21.91	16.71	16.27	20.02
Services***	161.49	96.67	133.89	149.86
Total Non-Cash Cost	683.33	525.77	535.55	632.61
TOTAL COST	897.67	704.12	672.68	823.27

*Effective crop area.
**Entered at the rate of ₱3.50/man-day.
***Shares in kind for services like harvesting and threshing.

TABLE 22. Average farm expenses per hectare, Isabela Province, 1967-1968.

Items	Irrigated 1-crop farms	Rainfed farms	All farms
Number of farms	55	69	124
Cash Cost:	- - - - - - - - - in pesos - - - - - - - - -		
Hired labor including food	79.46	58.62	67.86
Fertilizer	15.36	11.13	13.01
Insecticide	7.25	2.31	4.50
Weedicide	0.45	0.11	0.26
Pesticide	-	0.03	0.02
Fuel and oil	0.59	-	0.26
Irrigation fee	22.89	-	10.15
Total Cash Cost	126.00	72.20	96.06
Non-Cash Cost:			
Value of landlord's share	53.62	39.22	45.61
Operator's labor*	32.76	36.96	35.10
Unpaid family labor*	11.16	18.70	15.36
Services**	13.06	8.27	10.39
Total Non-Cash Cost	110.60	103.15	106.46
TOTAL COST	236.60	175.35	202.52

*Entered at the rate of ₱3.50/man-day.
**Shares in kind for services like harvesting and threshing.

TABLE 23. Average farm expenses per hectare, Midsayap, Cotabato, 1967-1968

Items	Irrigated		Rainfed	All farms
	2 crops*	1 crop		
Number of farms	21	8	16	45
Cash Cost:	- - - - - - - - - in pesos - - - - - - - - -			
Hired labor including food	70.21	77.72	76.73	73.86
Fertilizer	0.82	23.78	11.61	8.74
Insecticide	0.67	4.42	2.82	2.10
Weedicide	0.82	4.96	3.44	2.49
Pesticide	0.27	-	-	0.51
Fuel and oil	4.82	-	-	2.25
Irrigation fee	28.57	15.00	-	16.00
Total Cash Cost	106.18	125.88	95.67	105.95
Non-Cash Cost:				
Value of landlord's share	200.62	212.26	113.00	171.54
Operator's labor**	-	-	39.44	14.02
Unpaid family labor**	56.51	11.51	22.49	36.41
Services	121.39	157.21	107.46	122.84
Total Non-Cash Cost	378.52	380.98	282.39	344.81
TOTAL COST	484.70	506.86	378.06	450.76

*Classified as irrigated farms growing 2 rice crops although the second crop was not yet harvested.

**Labor entered at the rate of ₱3.50 per man-day.

TABLE 24. Average farm expenses per hectare, Tacurong, Cotabato, 1967-1968.

Items	Wet season		Dry season		All farms	
	Rice farms	Corn farms	Rice farms	Corn farms	Rice farms	Corn farms
Number of farms	41	17	7	38	48	55
Cash Cost:	- - - - - - - - - pesos per hectare - - - - - - - -					
Hired labor including food	91.94	46.29	146.70	37.85	99.92	40.46
Fertilizer	1.74	-	5.94	-	2.35	-
Insecticide	1.37	0.44	0.46	0.54	1.24	0.51
Weedicide	1.04	0.98	3.33	0.27	1.37	0.49
Pesticide	1.04	0.14	0.23	0.20	0.92	0.18
Fuel and oil	1.62	1.07	1.43	-	1.59	0.33
Irrigation fee	0.49	1.76	-	0.26	0.42	0.72
Total Cash Cost	99.24	50.68	158.09	39.12	107.81	42.69
Non-Cash Cost:						
Value of landlord's share	23.41	28.52	88.85	16.81	32.95	20.43
Operator's labor*	54.14	25.55	-	-	46.24	7.70
Unpaid family labor*	38.69	21.56	9.04	21.88	34.37	21.78
Services**	17.49	25.58	48.85	5.19	22.06	11.49
Total Non-Cash Cost	133.73	101.21	146.74	43.88	135.62	61.40
TOTAL COST	232.97	151.89	304.83	83.00	243.43	104.09

*Entered at the rate of ₱3.50/man-day.
**Shares in kind for services like harvesting and threshing.

TABLE 25. Weeding method, 1967-1968.

Area	No weeding	1 hand weeding	1 rotary weeding	1 hand, 1 rotary weeding	2 hand weeding	Weed spray	No. of observations
Laguna							
Variety:							
Improved	1	2	3	14	1	10	21
Local	1	11	2	8	3	8	25
Mixed	-	-	1	2	-	3	3
All	2	13	6	24	4	21	49
Central Luzon							
Variety:							
Improved	6	-	1	1	1	3	9
Local	22	17	1	4	6	22	50
Mixed	-	1	1	-	-	1	2
All	28	18	3	5	7	26	61
Isabela							
Variety:							
Improved	-	-	3	3	1	1	7
Local	-	17	12	2	-	3	31
Mixed	-	29	29	9	8	14	75
All	-	46	44	14	9	18	113
Midsayap, Cotabato							
Variety:							
Improved	-	-	12	-	-	11	12
Local	-	1	19	-	-	19	20
Mixed	1	3	6	-	-	8	10
All	1	4	37	-	-	38	42
Tacurong, Cotabato							
Variety:							
Improved	3	2	1	2	-	4	8
Local	3	12	8	-	4	16	27
Mixed	1	6	2	3	-	11	12
All	7	20	11	5	4	31	47
All areas							
Variety:							
Improved	10	4	20	20	3	29	57
Local	26	58	42	14	13	68	153
Mixed	.2	39	39	14	8	37	102
All	38	101	101	48	24	134	312

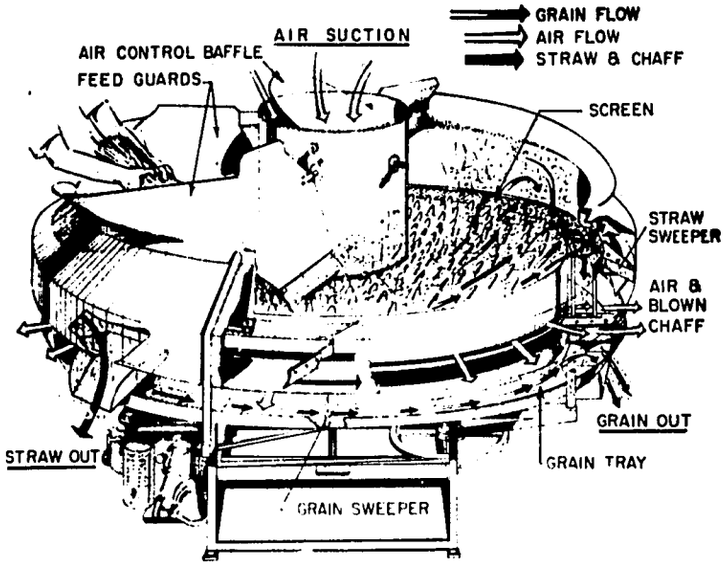


Fig. 1. Schematic drawing of third prototype table-type paddy thresher.

Fig. 2. Table-type paddy thresher in operation.

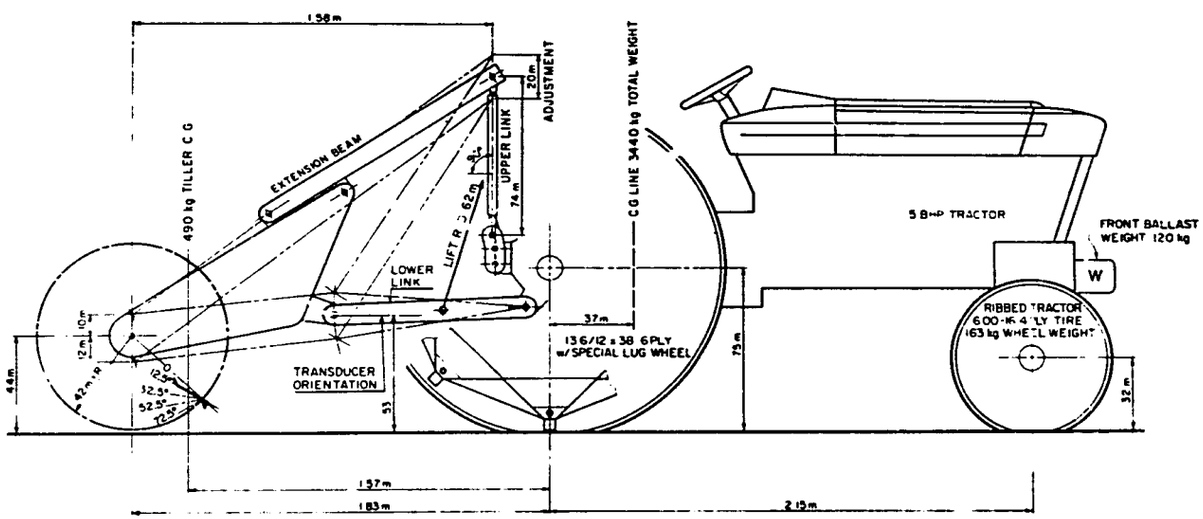


Fig. 3. Set-up for pushing force measurement.

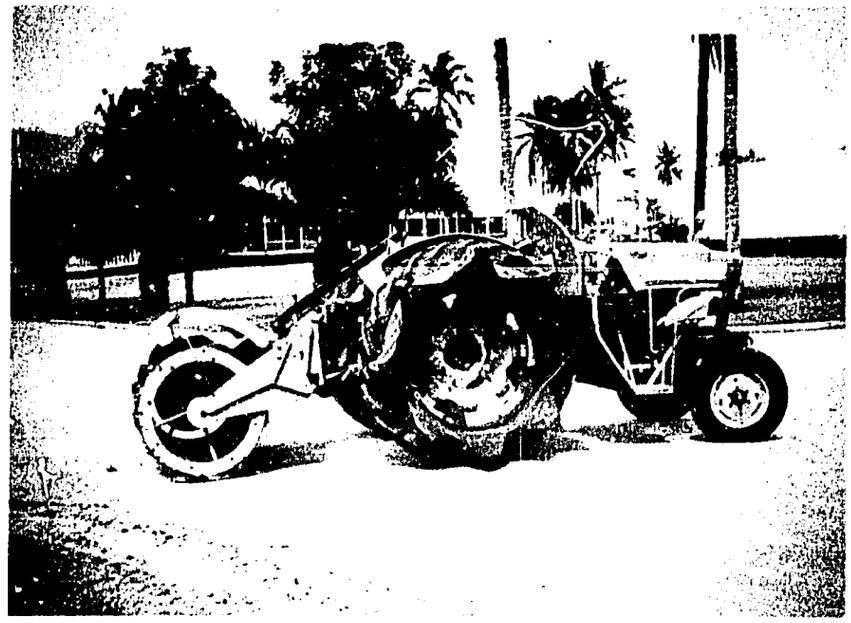


Fig. 4. IRRI adjustable blade rotary tiller attached to tractor with rubber tipped lug wheels.

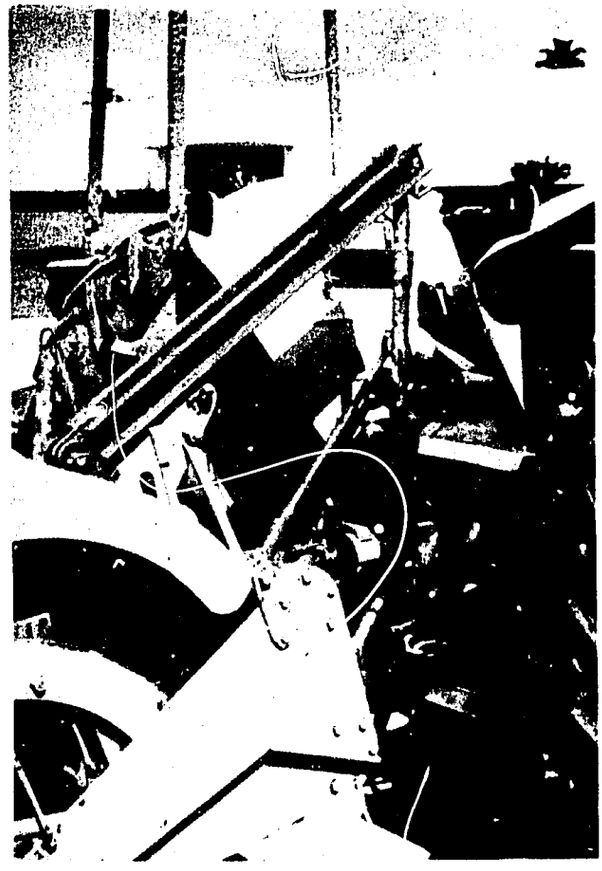


Fig. 5. Close-up of extension beam and PTO torque transducer.

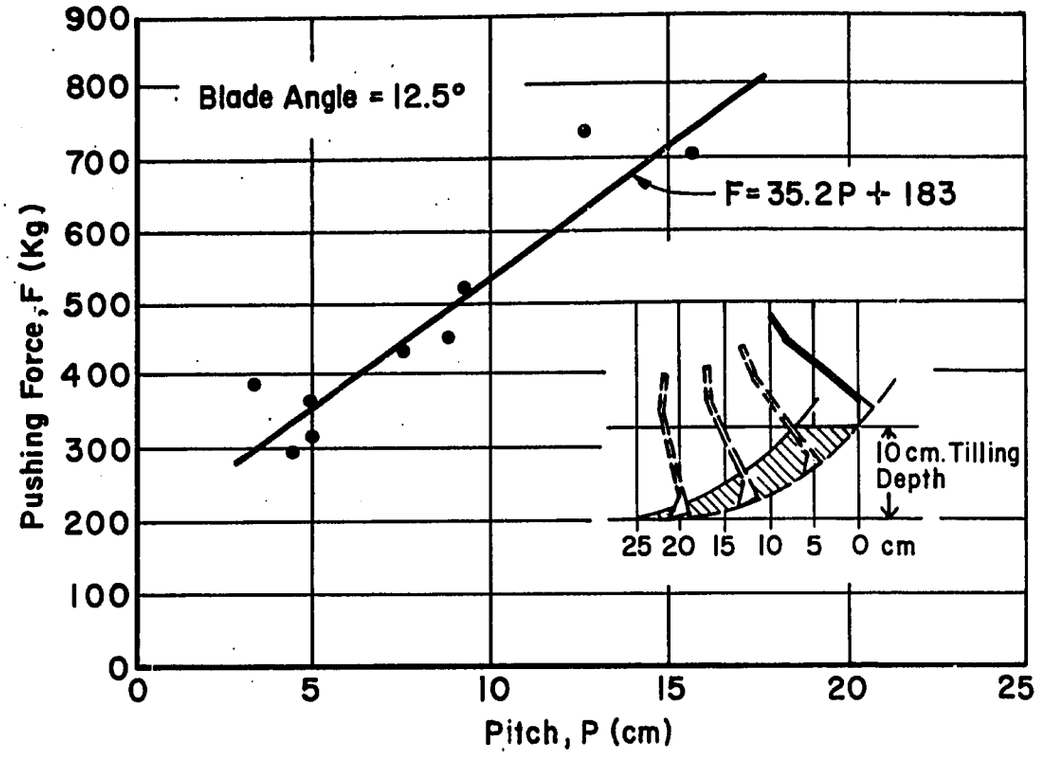


Fig. 6. Relationship between pushing force and pitch of cut for 12.5° blade angle.

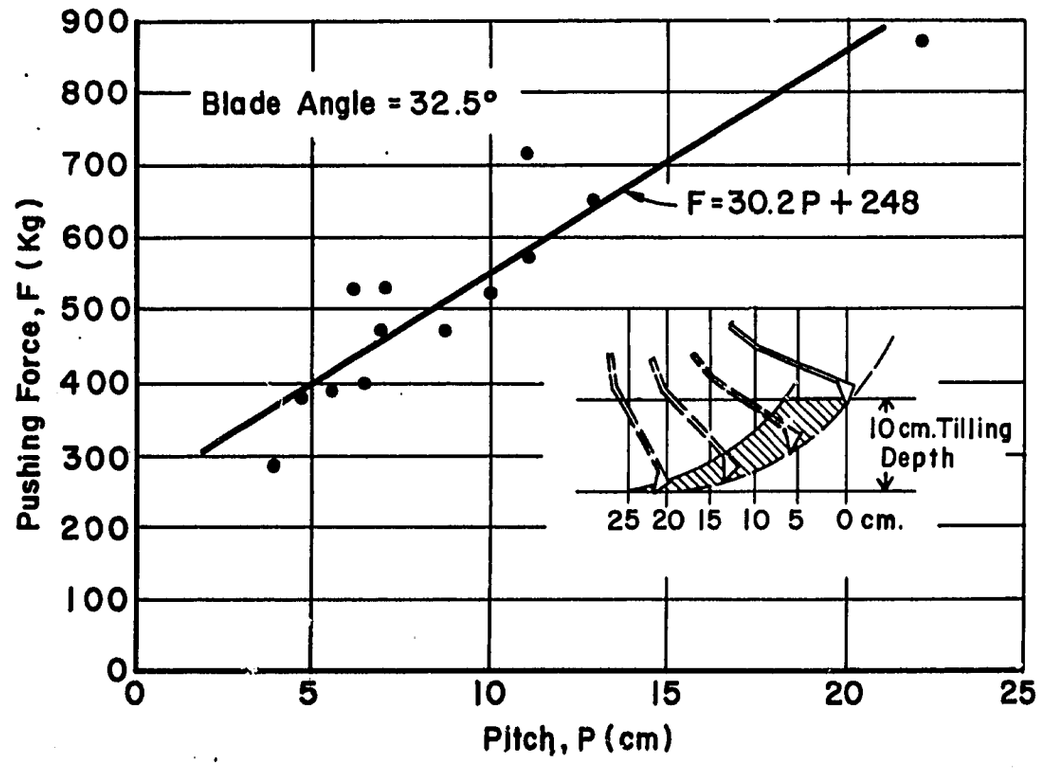


Fig. 7. Relationship between pushing force and pitch of cut for 32.5° blade angle.

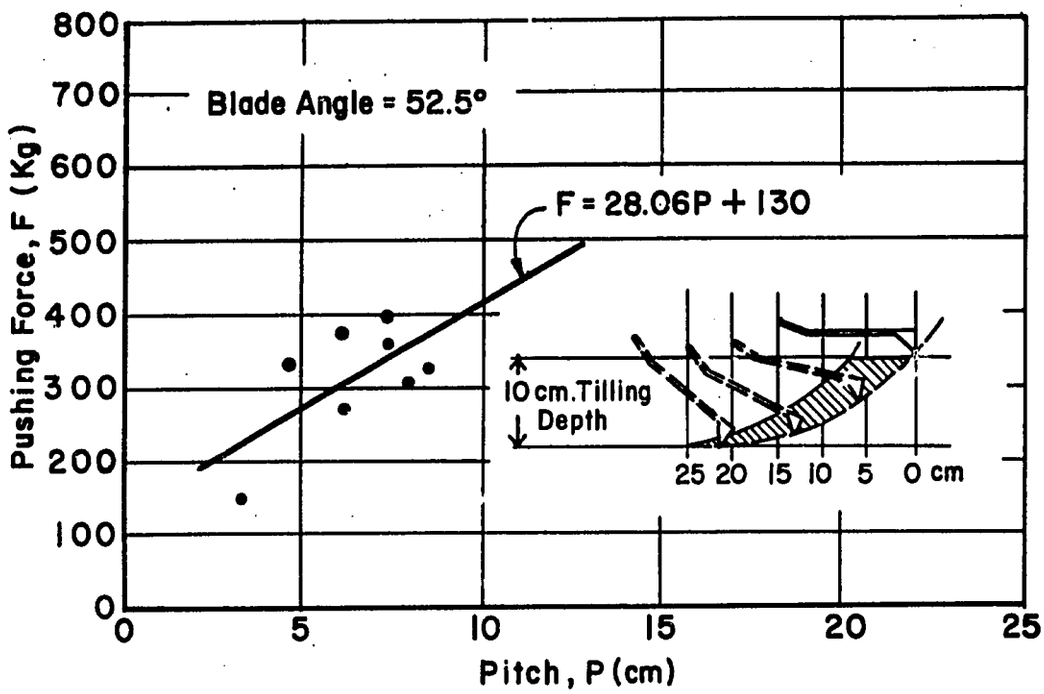


Fig. 8. Relationship between pushing force and pitch of cut for 52.5° blade angle.

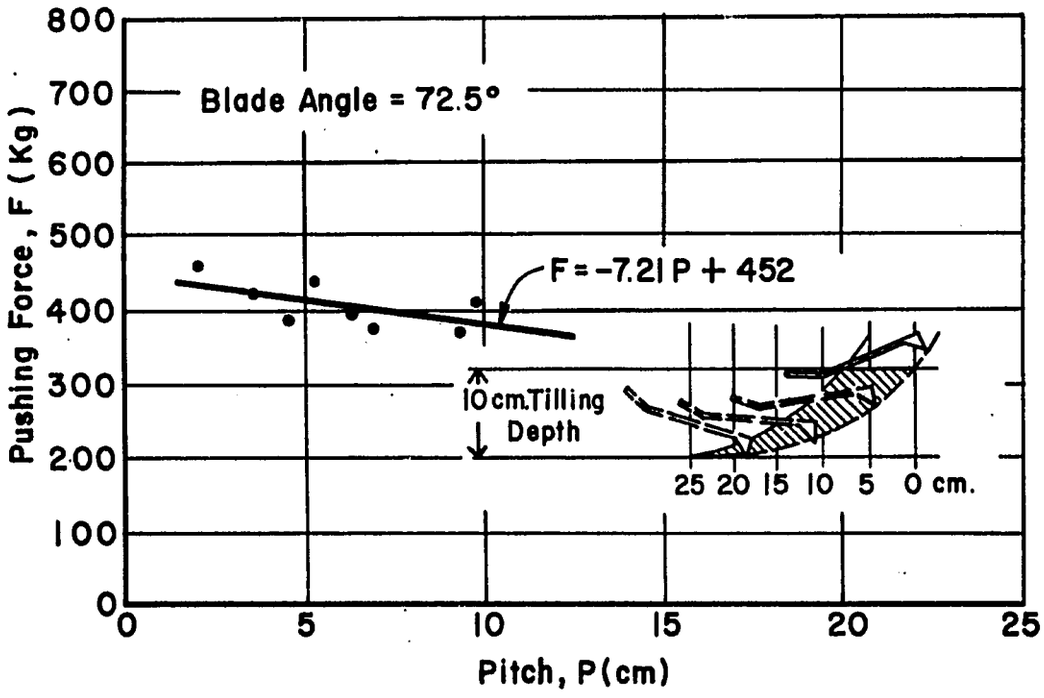


Fig. 9. Relationship between pushing force and pitch of cut for 72.5° blade angle.

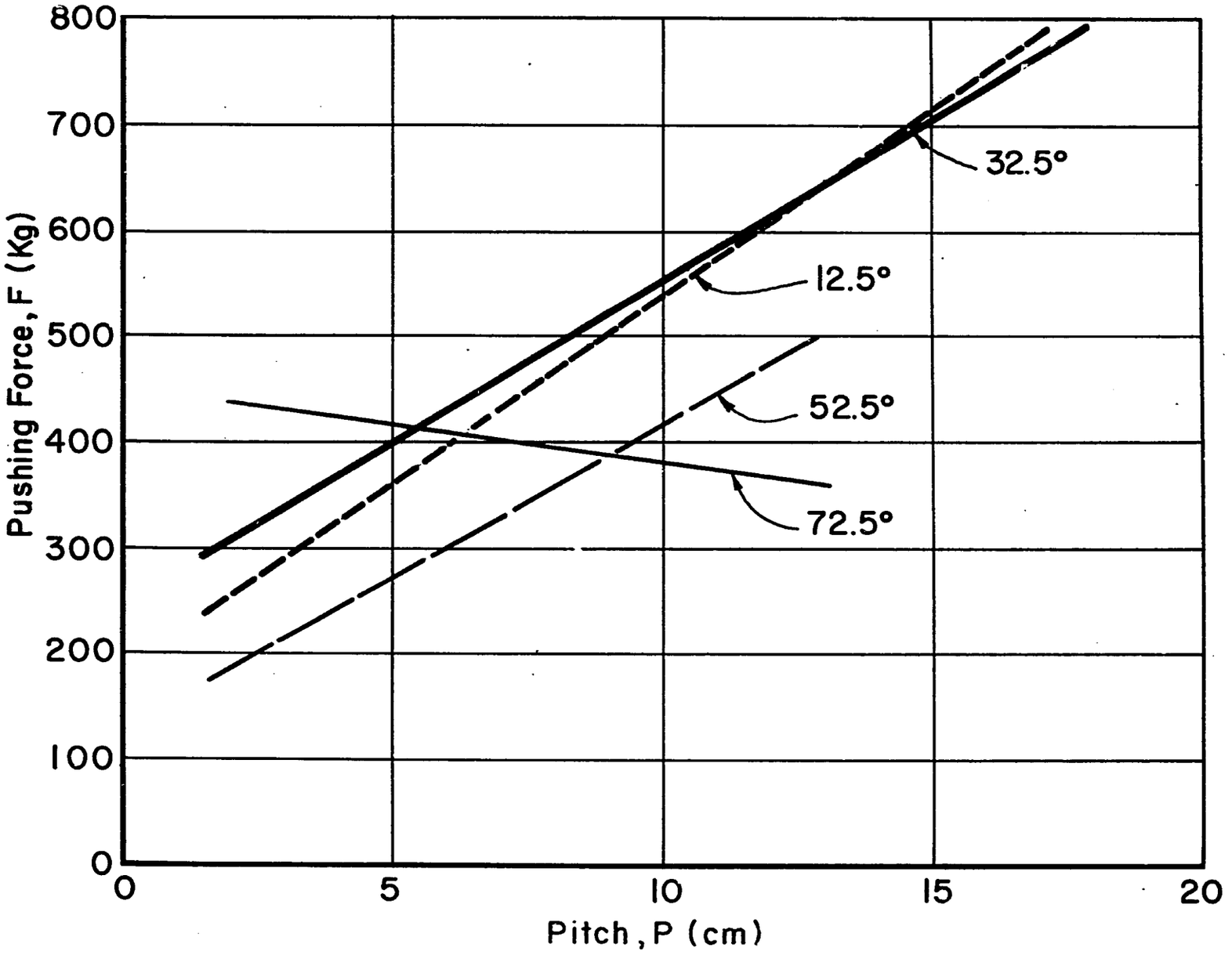


Fig. 10. Pushing force vs. pitch of cut at four blade angles.

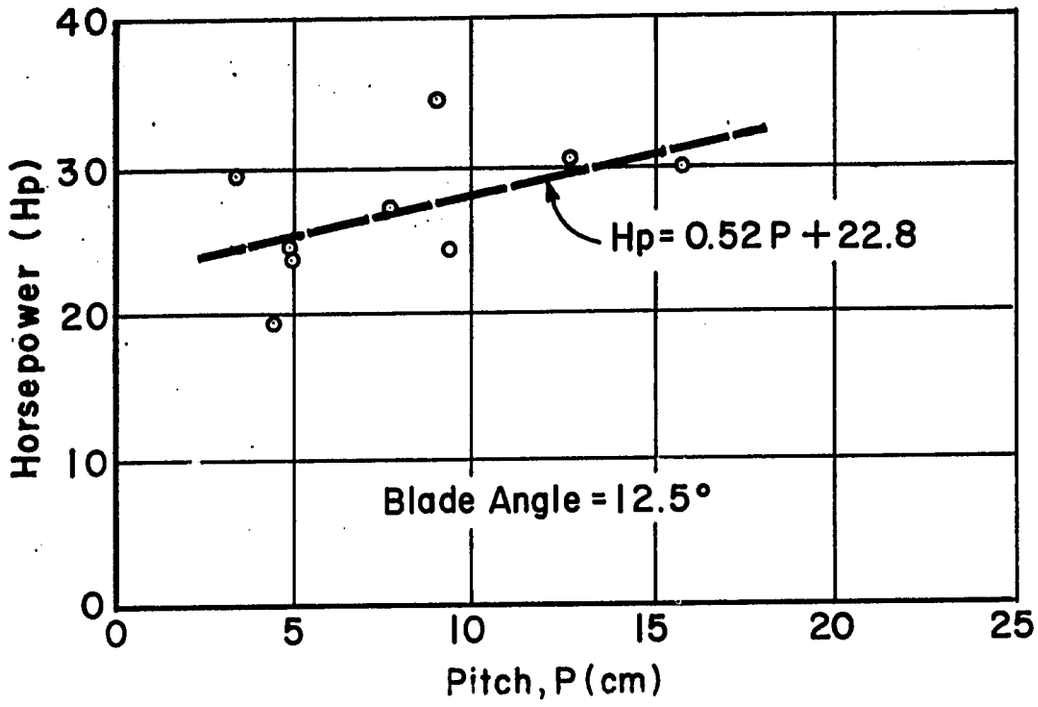


Fig. 11. Relationship between horsepower and pitch of cut for 12.5° blade angle.

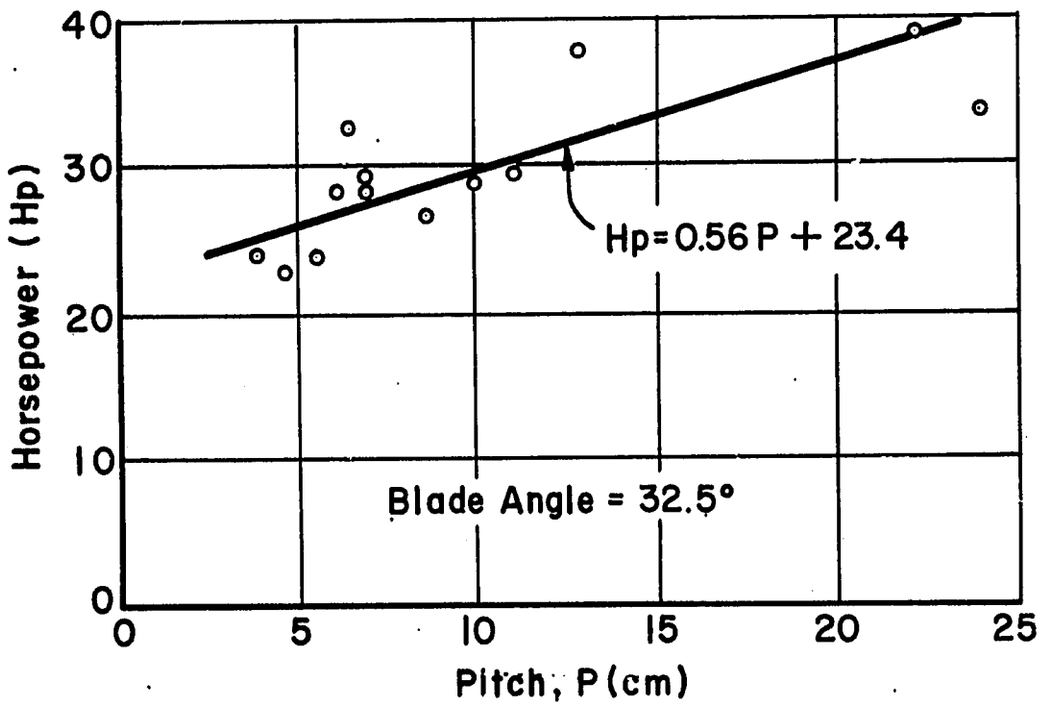


Fig. 12. Relationship between horsepower and pitch of cut for 32.5° blade angle.

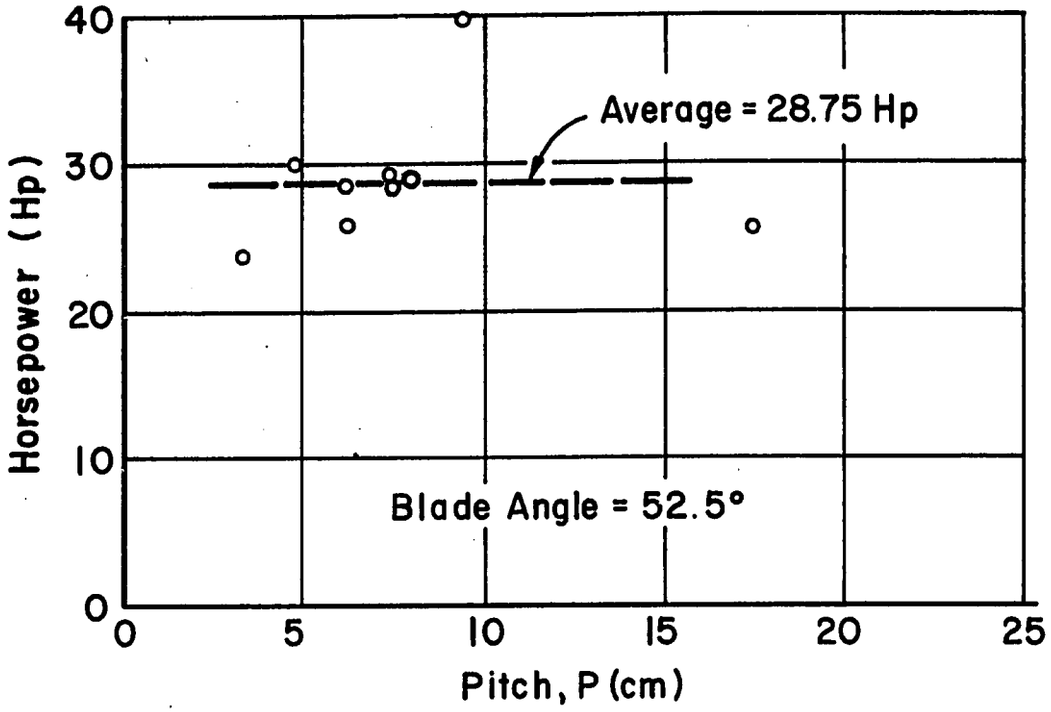


Fig. 13. Average horsepower requirement of rotary tiller for 52.5° blade angle.

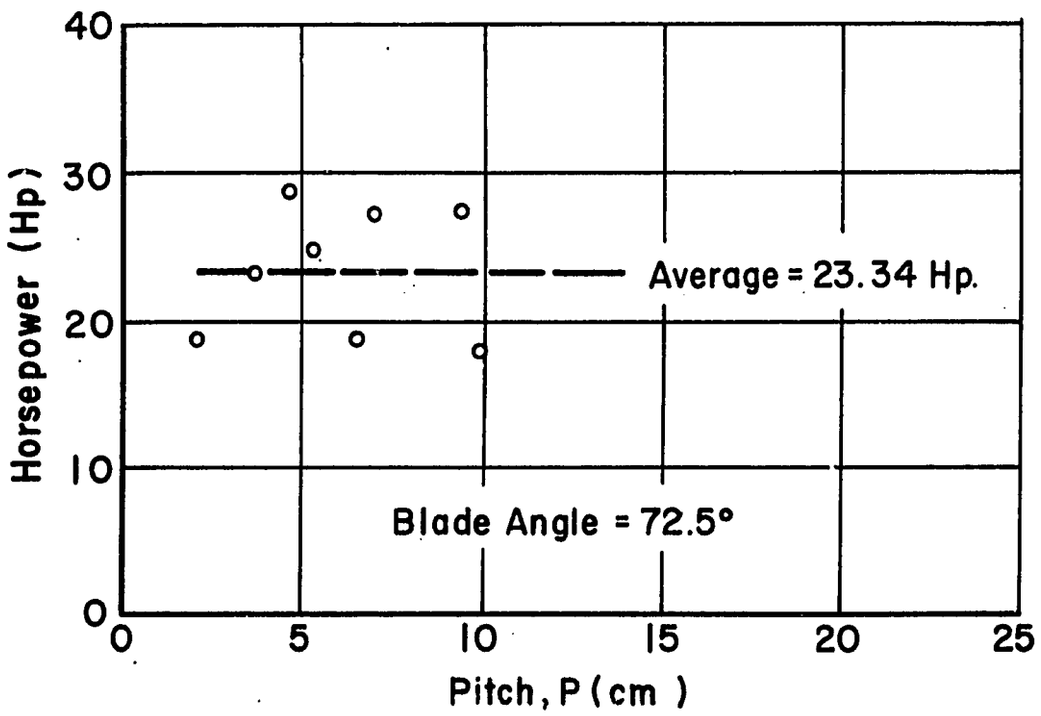


Fig. 14. Average horsepower requirement of rotary tiller for 72.5° blade angle.

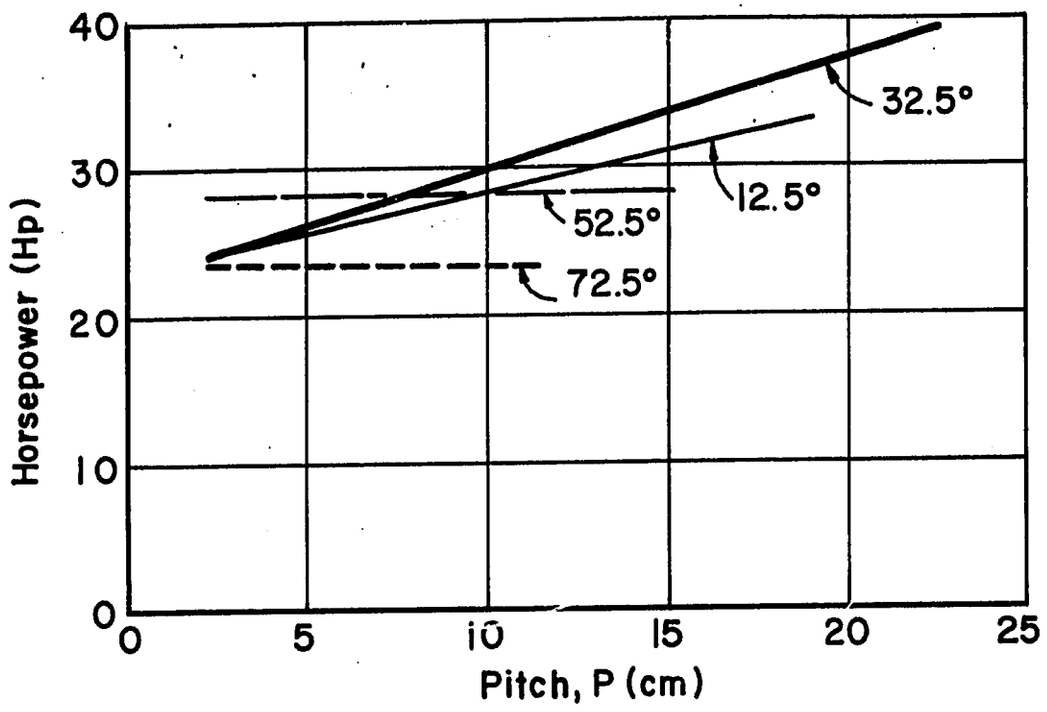


Fig. 15. Horsepower vs. pitch for four blade angles.

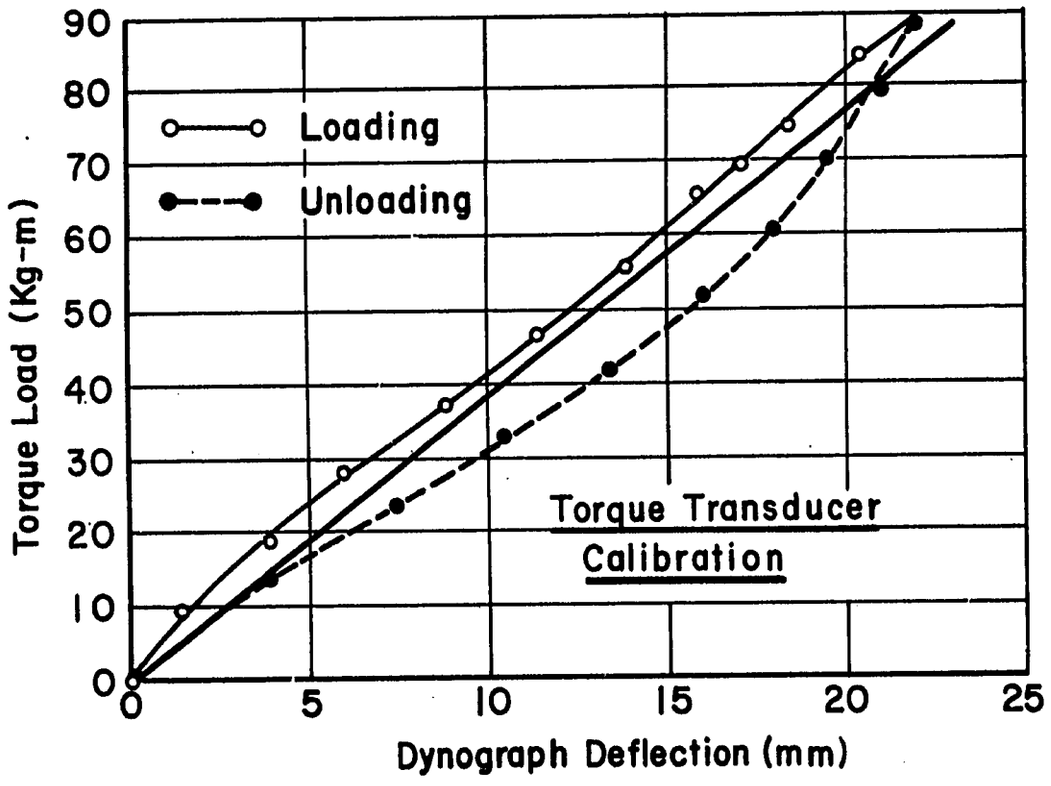


Fig. 16. Torque transducer calibration showing "hysteresis loop".

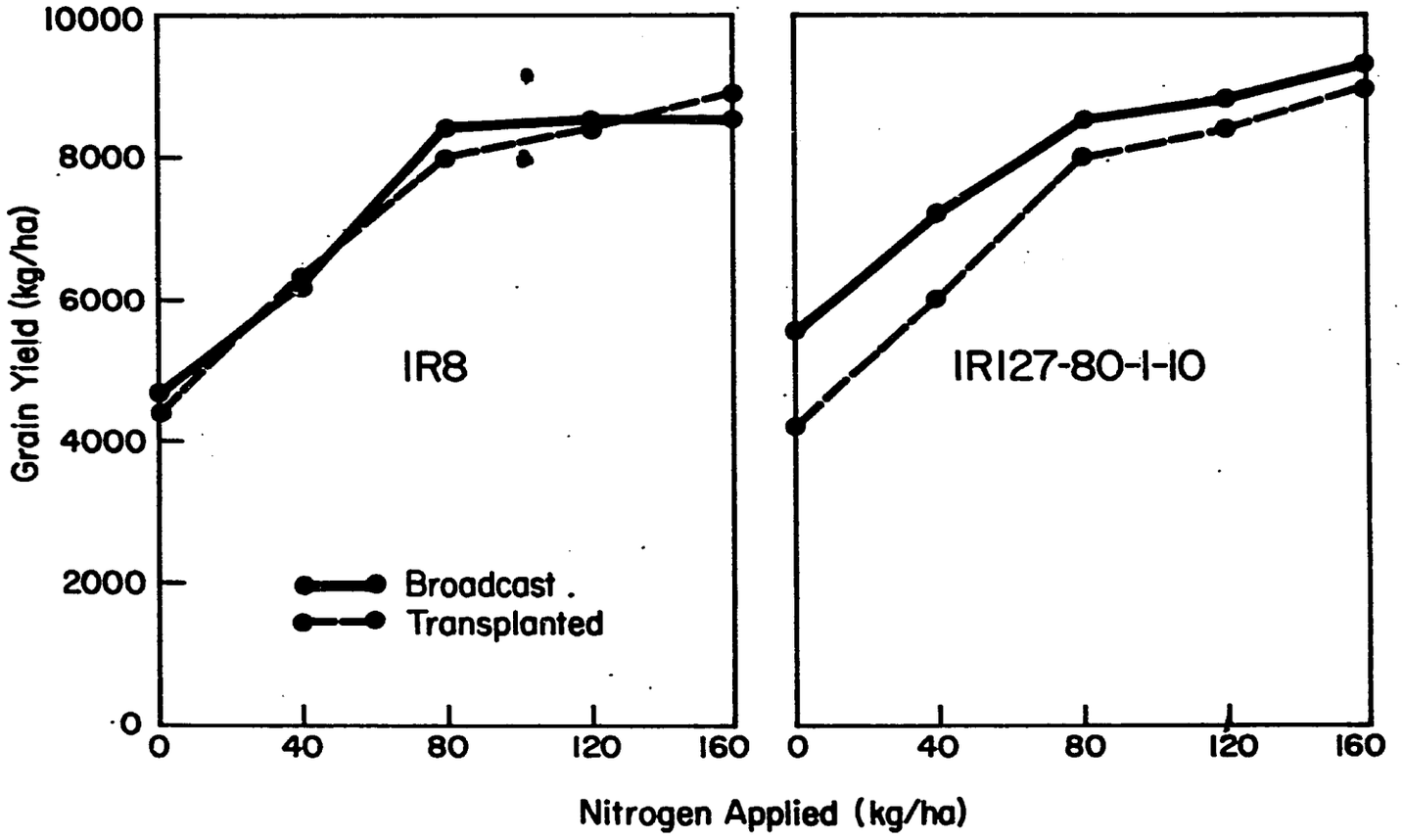


Fig. 17. Effect of levels of nitrogen as anhydrous ammonia (applied at 15-cm depth) and methods of planting on the grain yield of flooded rice. IRRI, 1969 dry season.

Fig. 18. Second prototype anhydrous ammonia applicator.

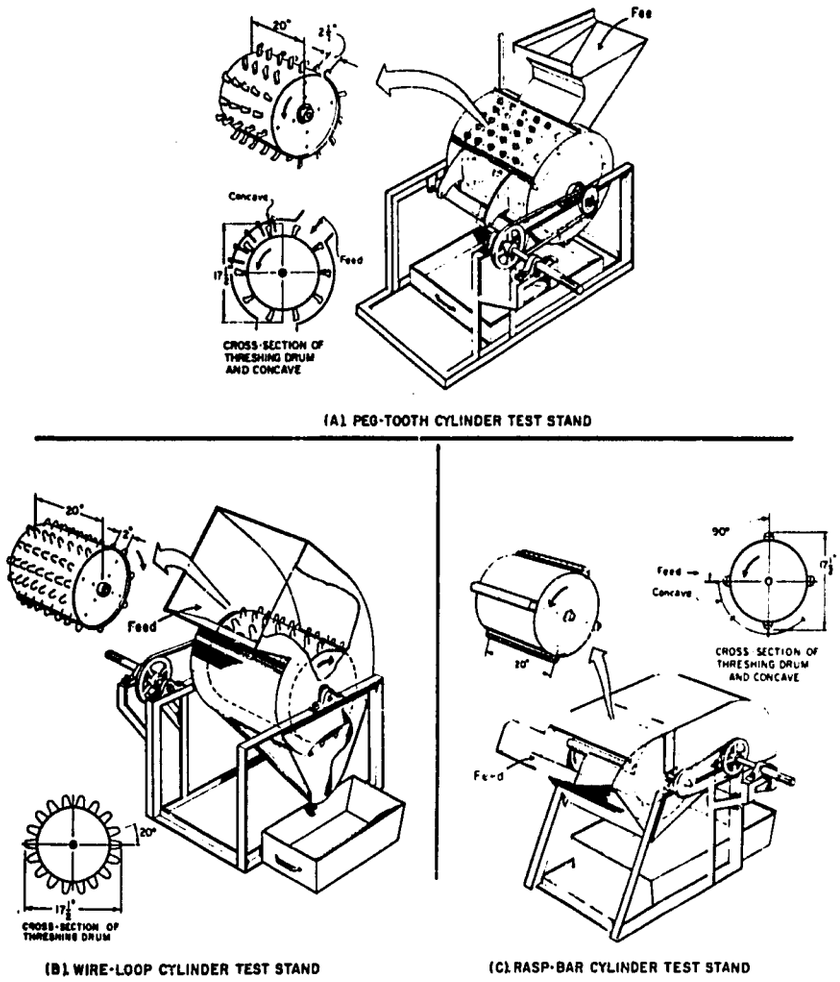


Fig. 19. Test stands used in comparative performance of threshing cylinders.

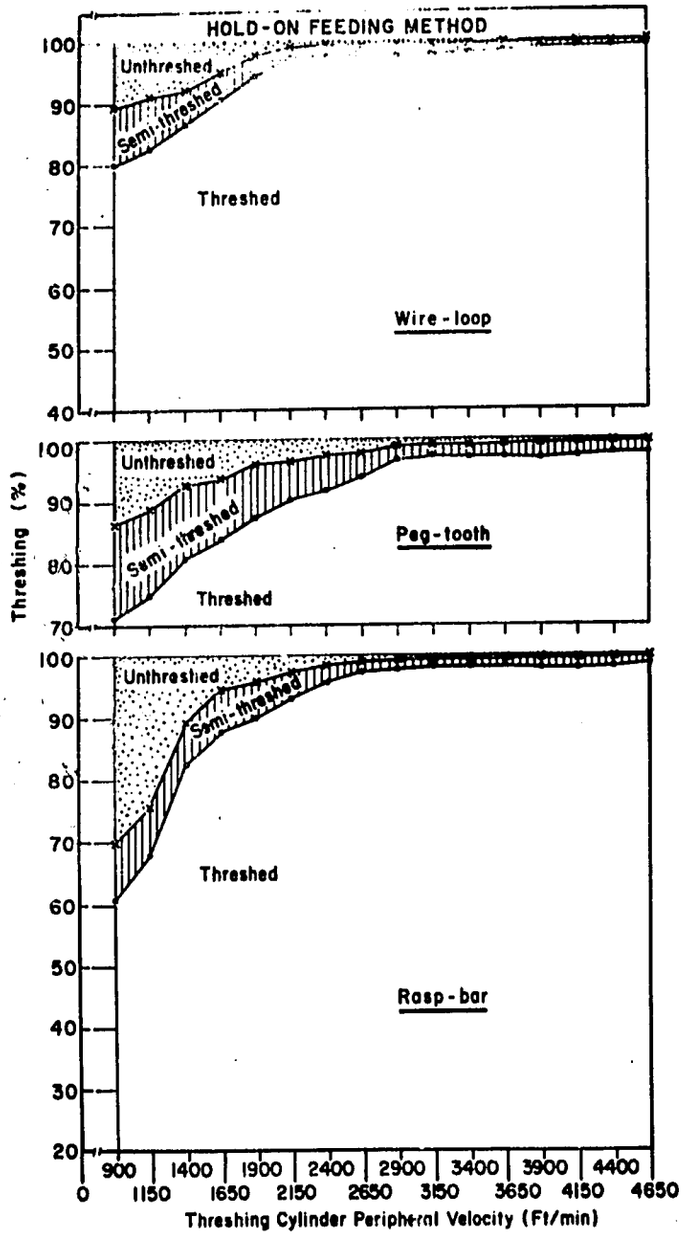


Fig. 20. Relationship between threshing cylinder peripheral velocity and threshing for the hold-on feeding method.

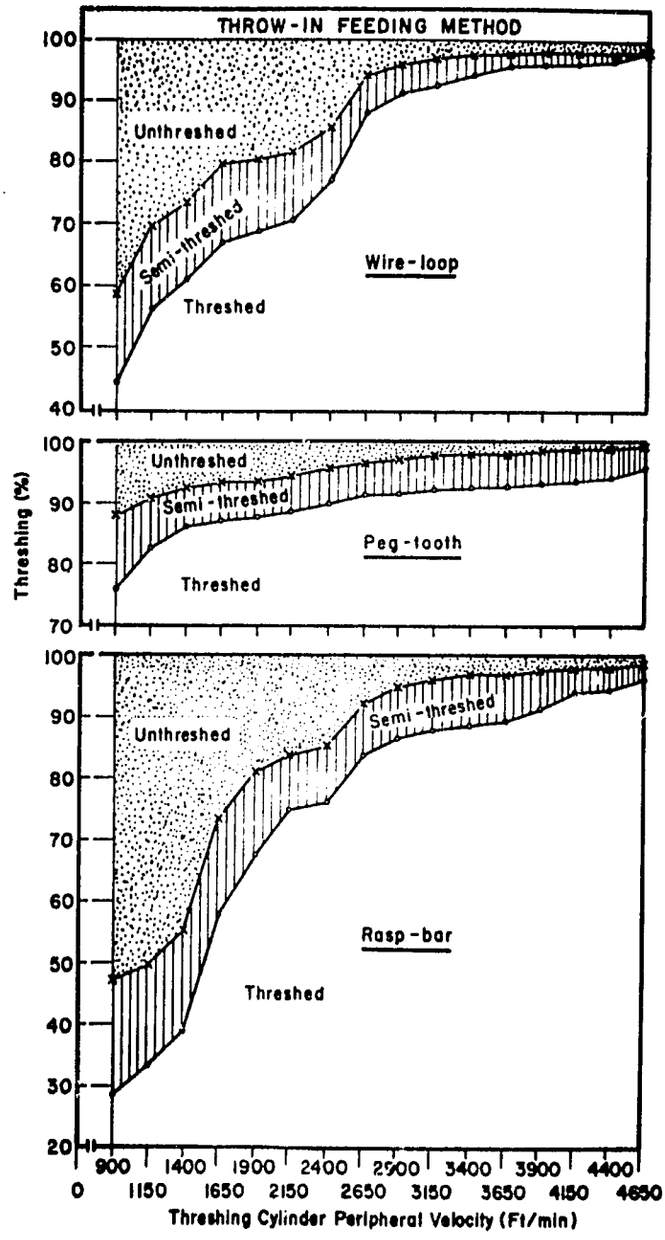


Fig. 21. Relationship between threshing cylinder peripheral velocity and threshing for the throw-in feeding method.

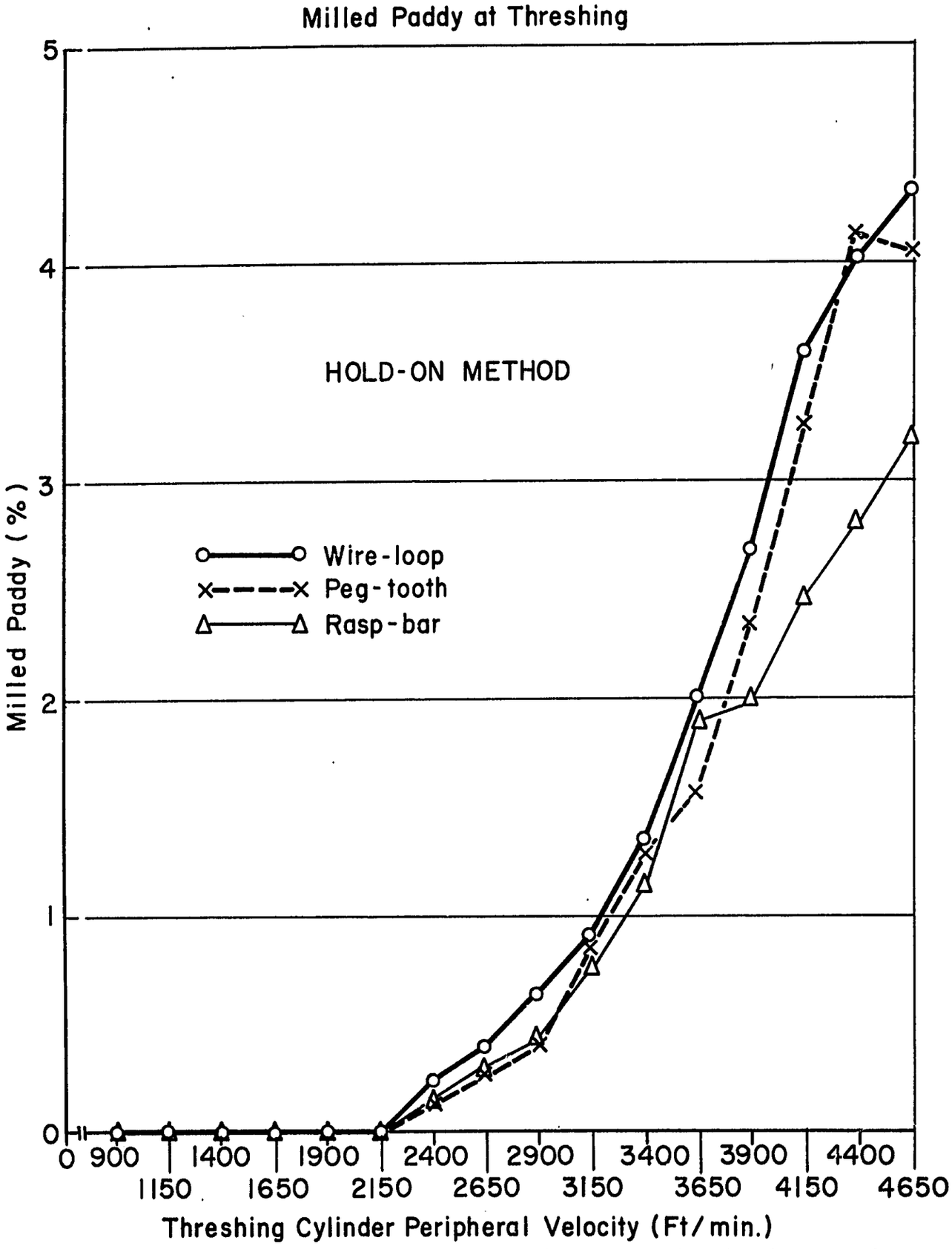


Fig. 22. Relationship between threshing cylinder peripheral velocity and milled paddy at threshing for the hold-on feeding method.

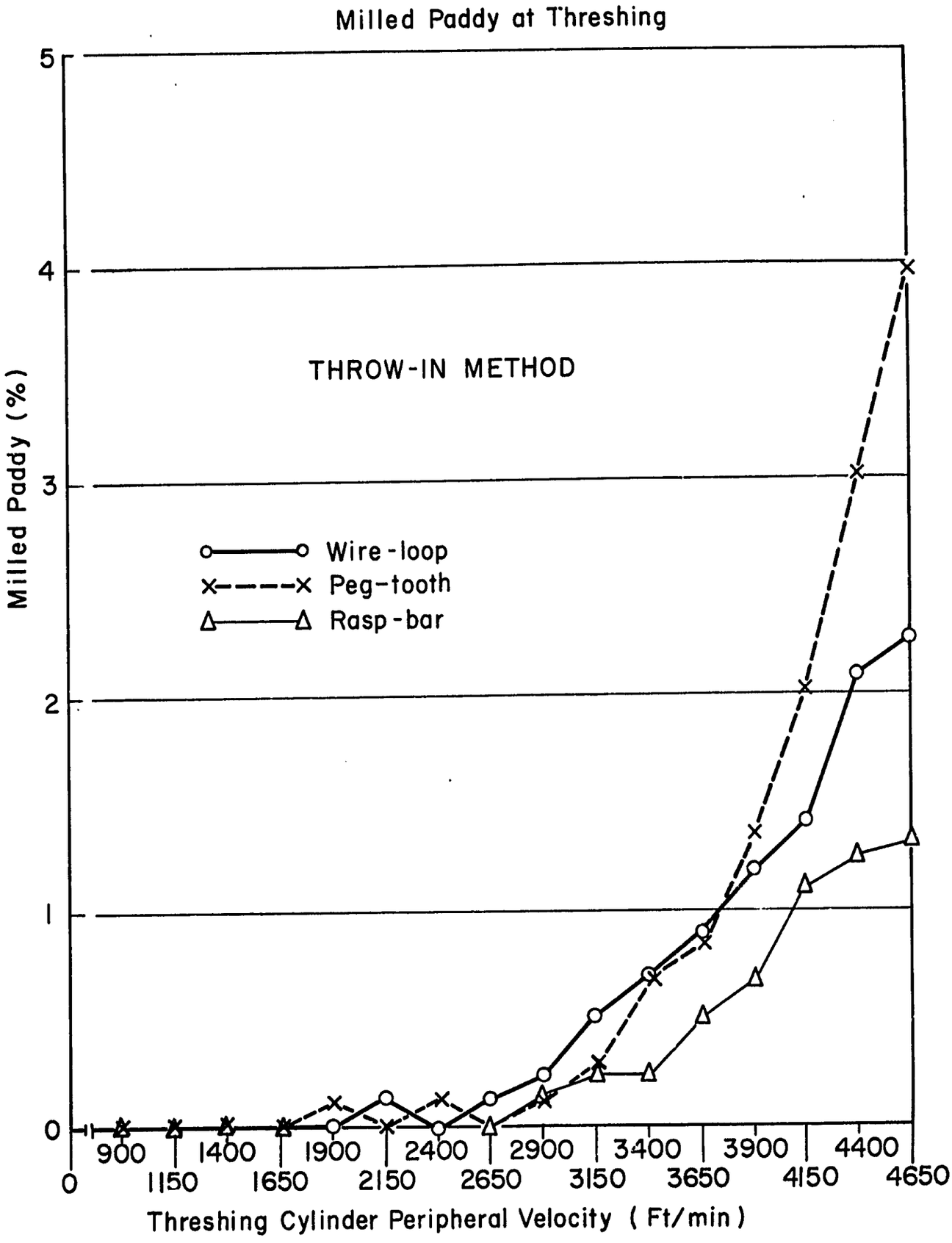


Fig. 23. Relationship between threshing cylinder peripheral velocity and milled paddy at threshing for the throw-in feeding method.

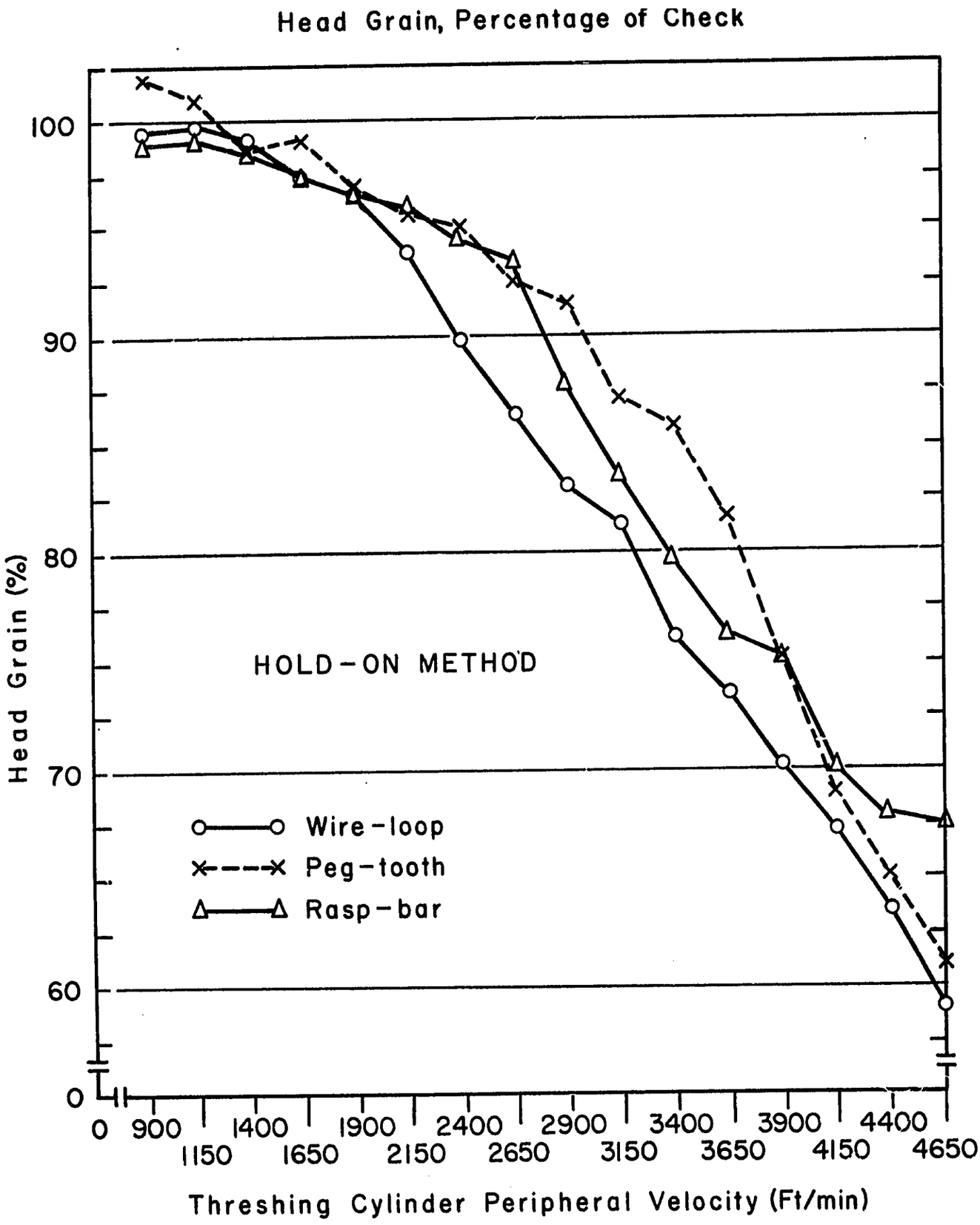


Fig. 24. Relationship between threshing cylinder peripheral velocity and head grain yield for the hold-on feeding method.

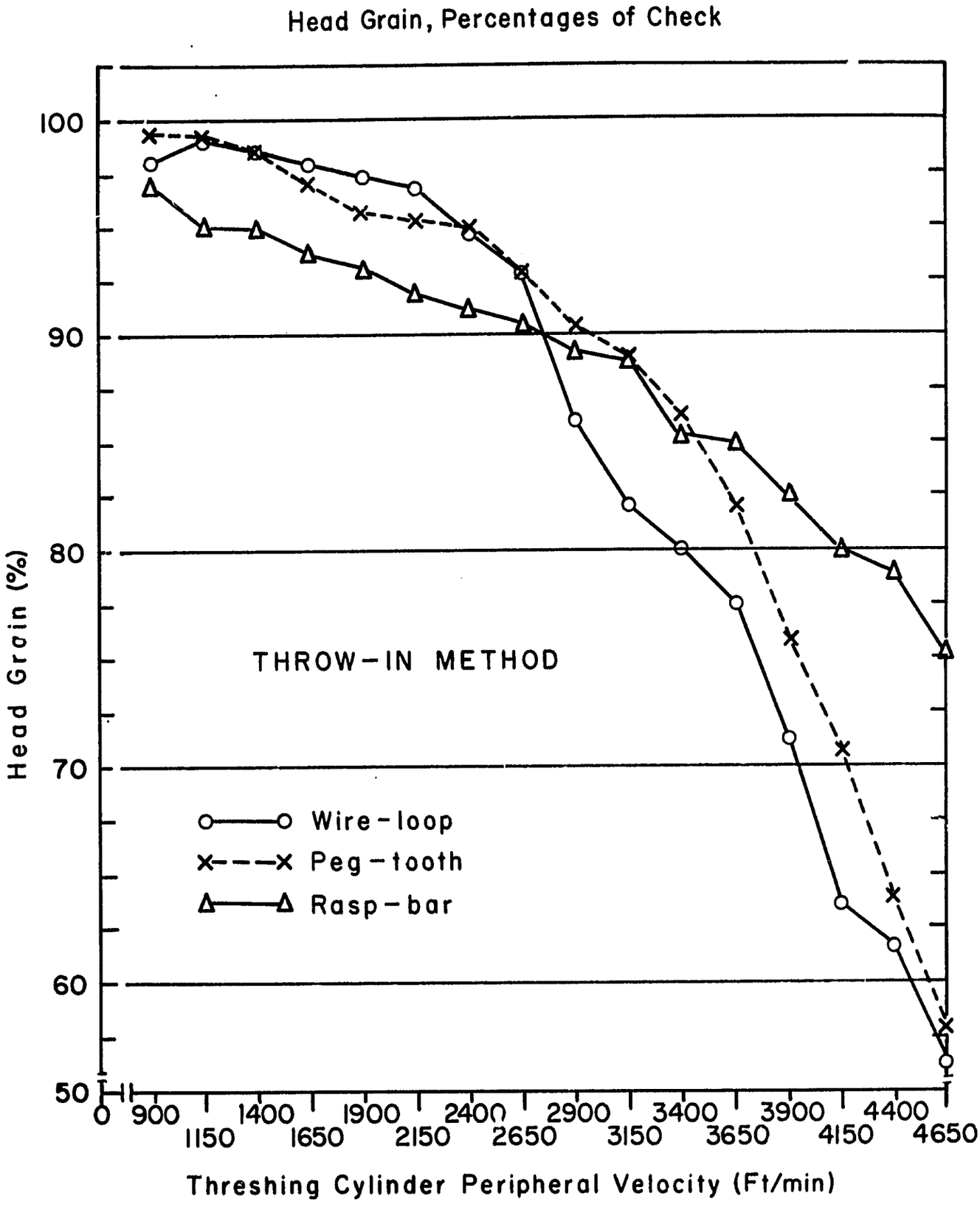


Fig. 25. Relationship between threshing cylinder peripheral velocity and head grain yield for the throw-in feeding method.

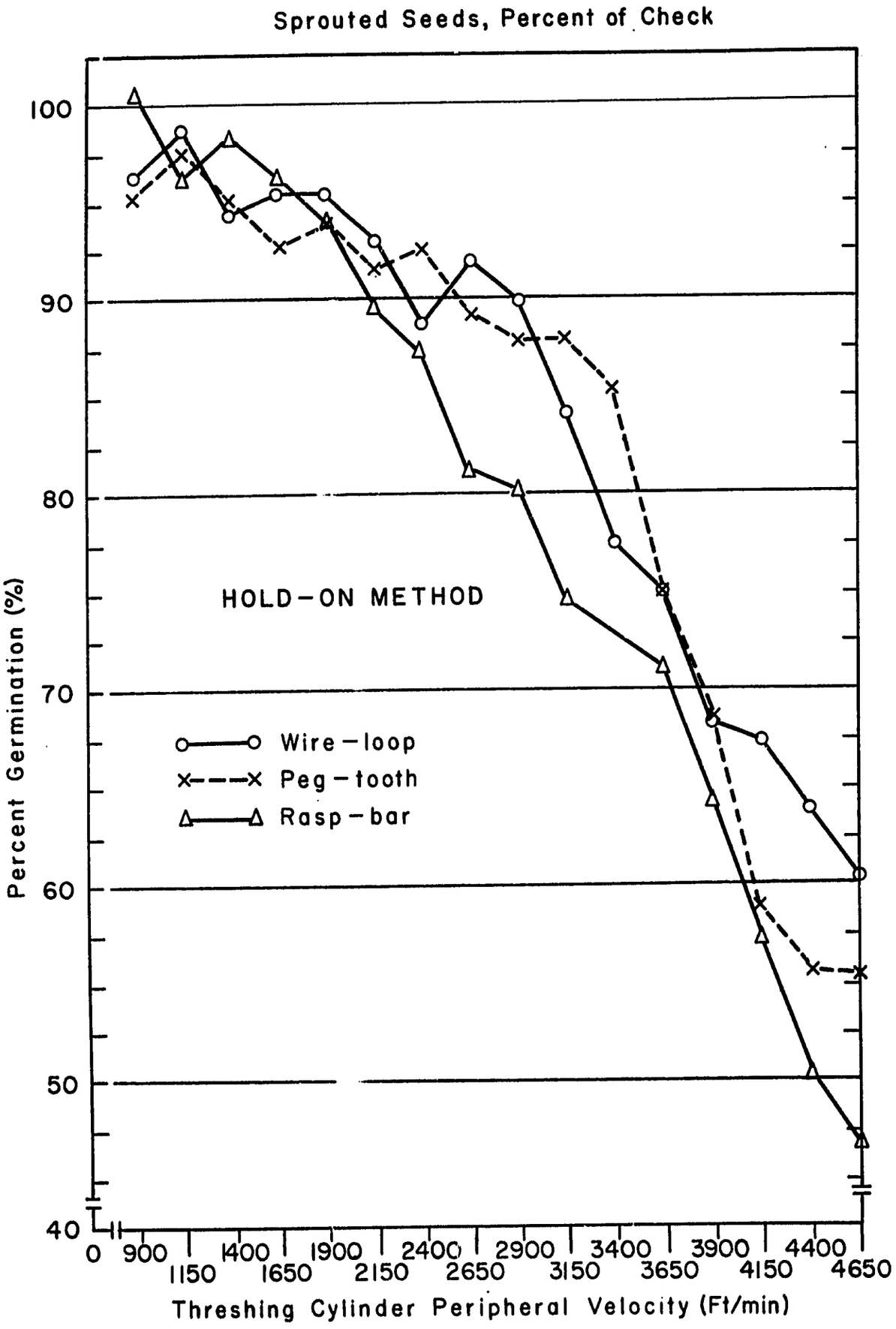


Fig. 26. Relationship between threshing cylinder peripheral velocity and germination of IR8 seeds for the hold-on feeding method.

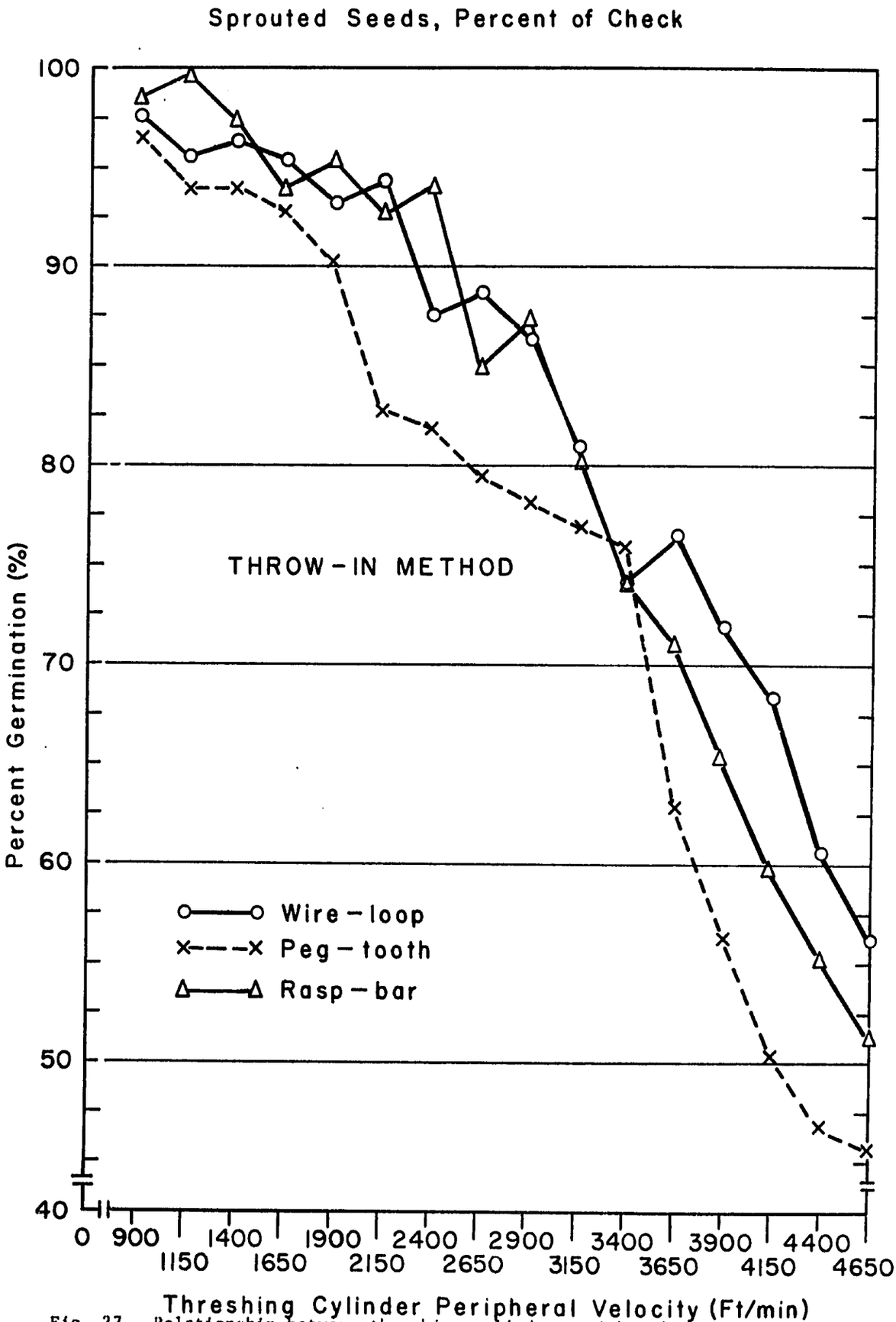


Fig. 27. Relationship between threshing cylinder peripheral velocity and germination of IR8 seeds for the throw-in feeding method.

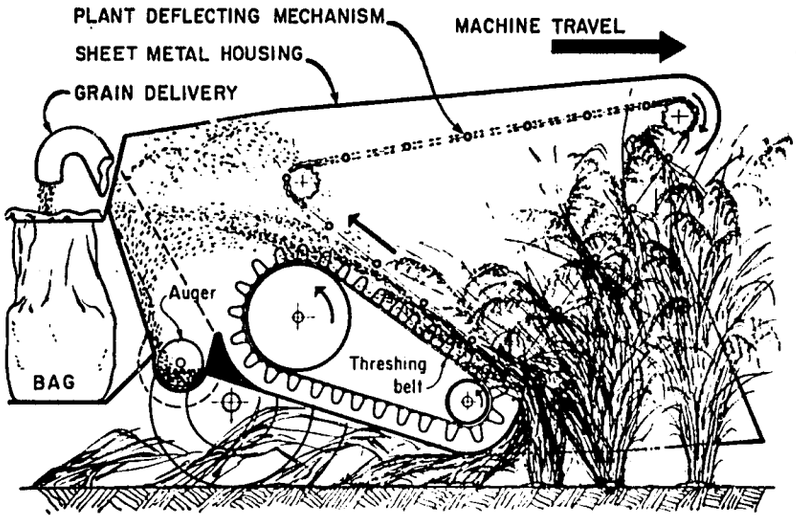


Fig. 28. Schematic drawing of paddy stripper harvester.

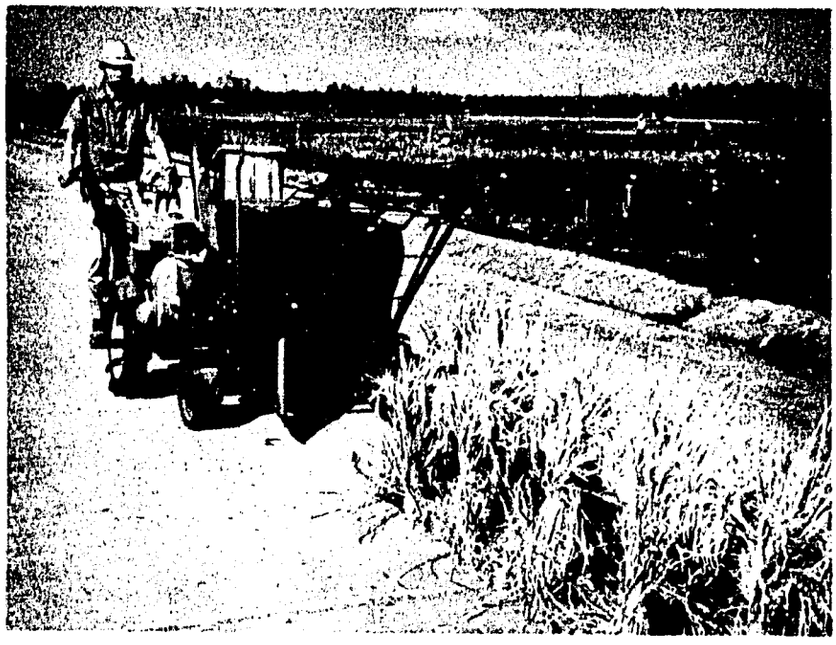


Fig. 29. Simulated field test of stripper-harvester.

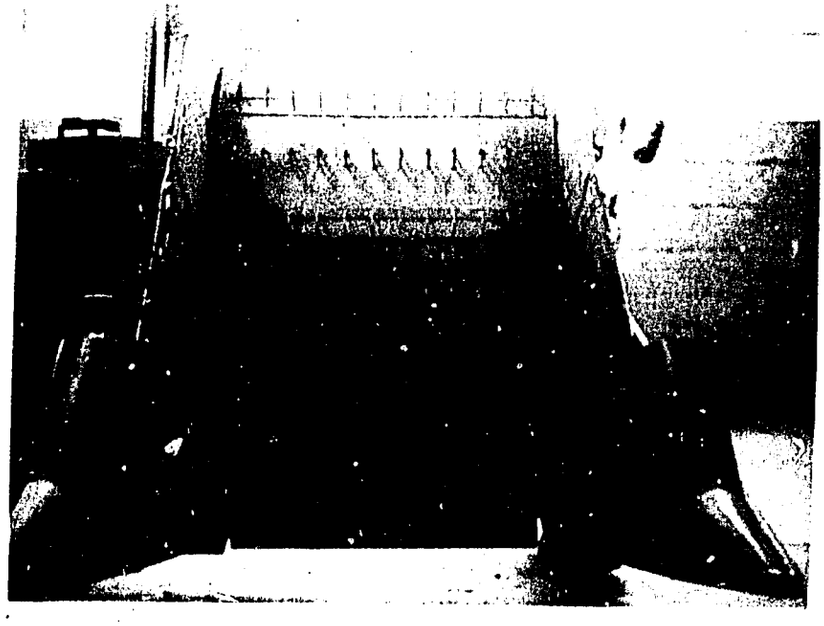
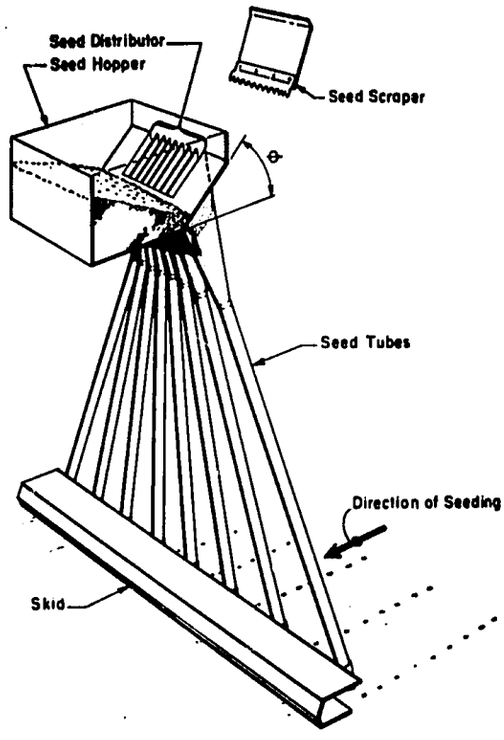
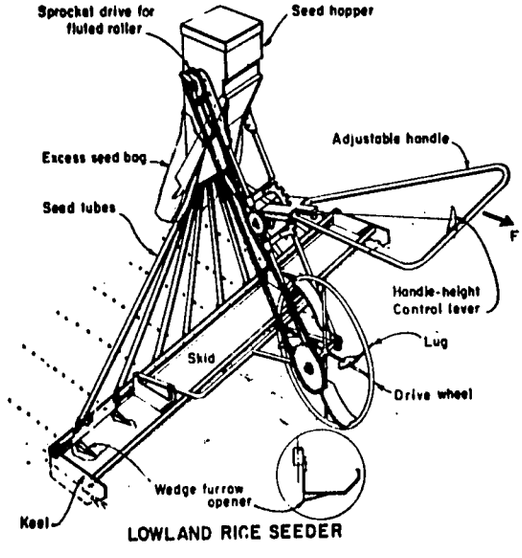


Fig. 30. Paddy stripper harvester with rotary drum plant deflecter.

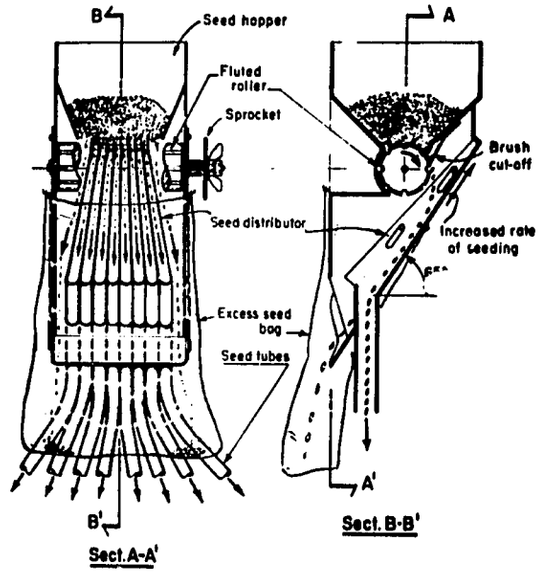


EXPERIMENTAL LOWLAND SEEDER

Fig. 31. Schematic drawing of first experimental lowland seeder



LOWLAND RICE SEEDER



METERING DEVICE FOR A LOWLAND RICE SEEDER

Fig. 32. Schematic drawing of second prototype lowland seeder.

Fig. 33. Schematic drawing of metering device for pre-germinated seeds.

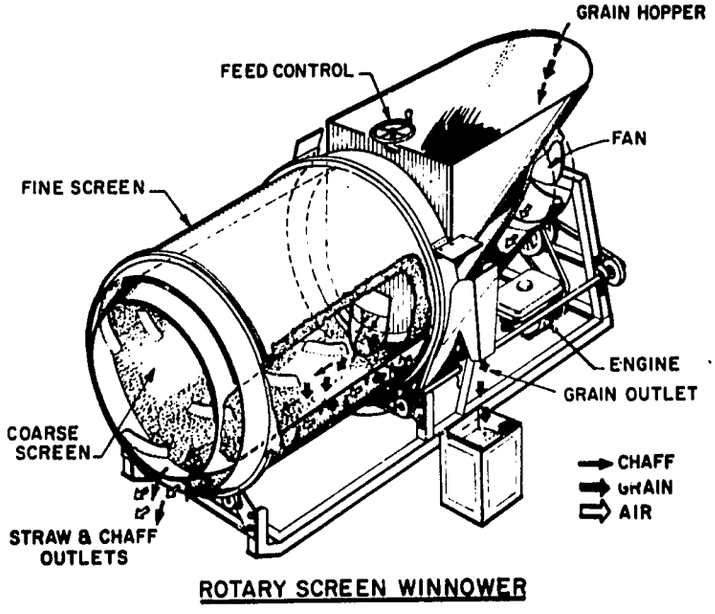


Fig. 34. Schematic drawing of rotary screen winnower.

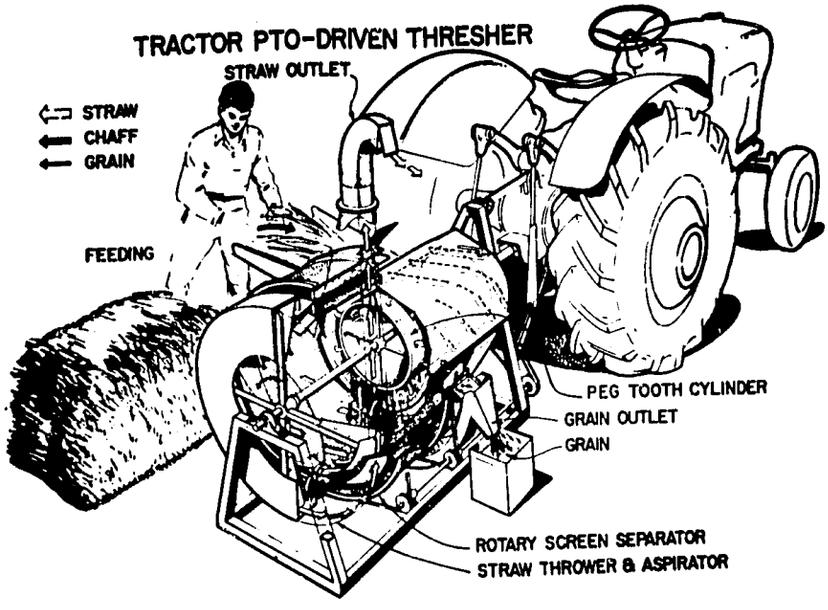
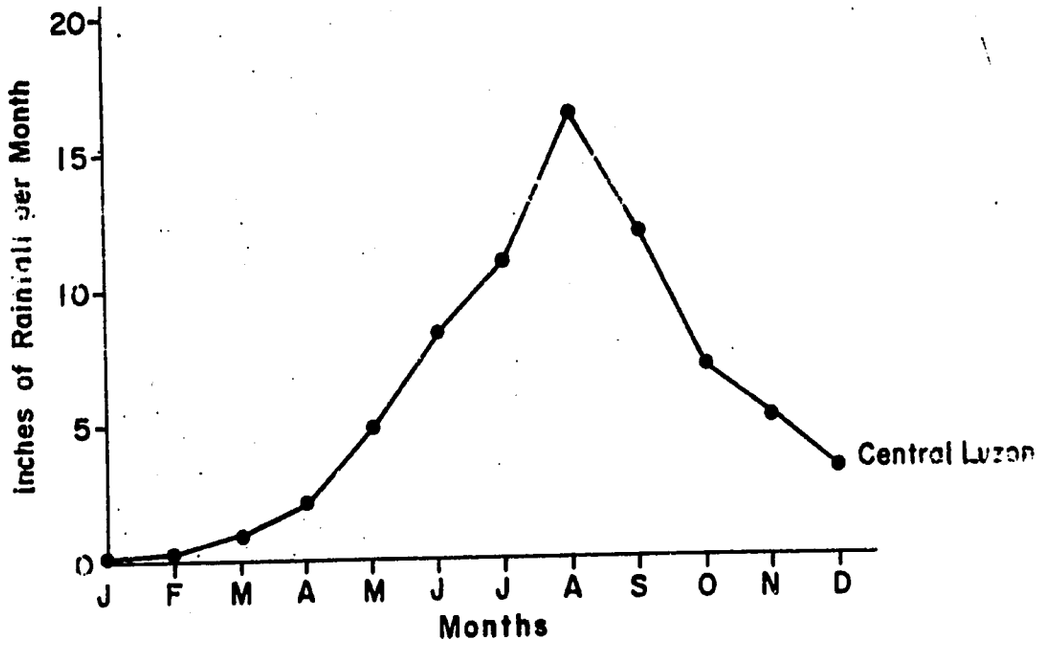


Fig. 35. PTO-driven paddy thresher with rotary screen separator.



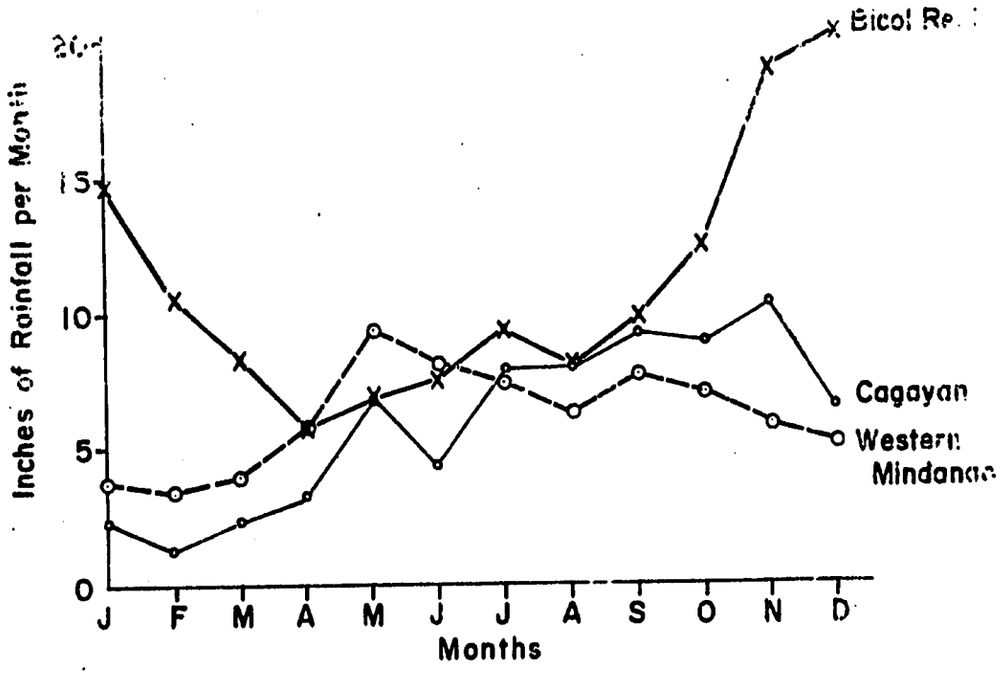


Fig. 36. Average annual rainfall for the following regions: Central Luzon (Cabanatuan City, Nueva Ecija); Cagayan Valley (Echague, Isabela Province); Bicol Region (Legaspi, Albay Province); Western Mindanao (Kabacan, Cotabato Province).

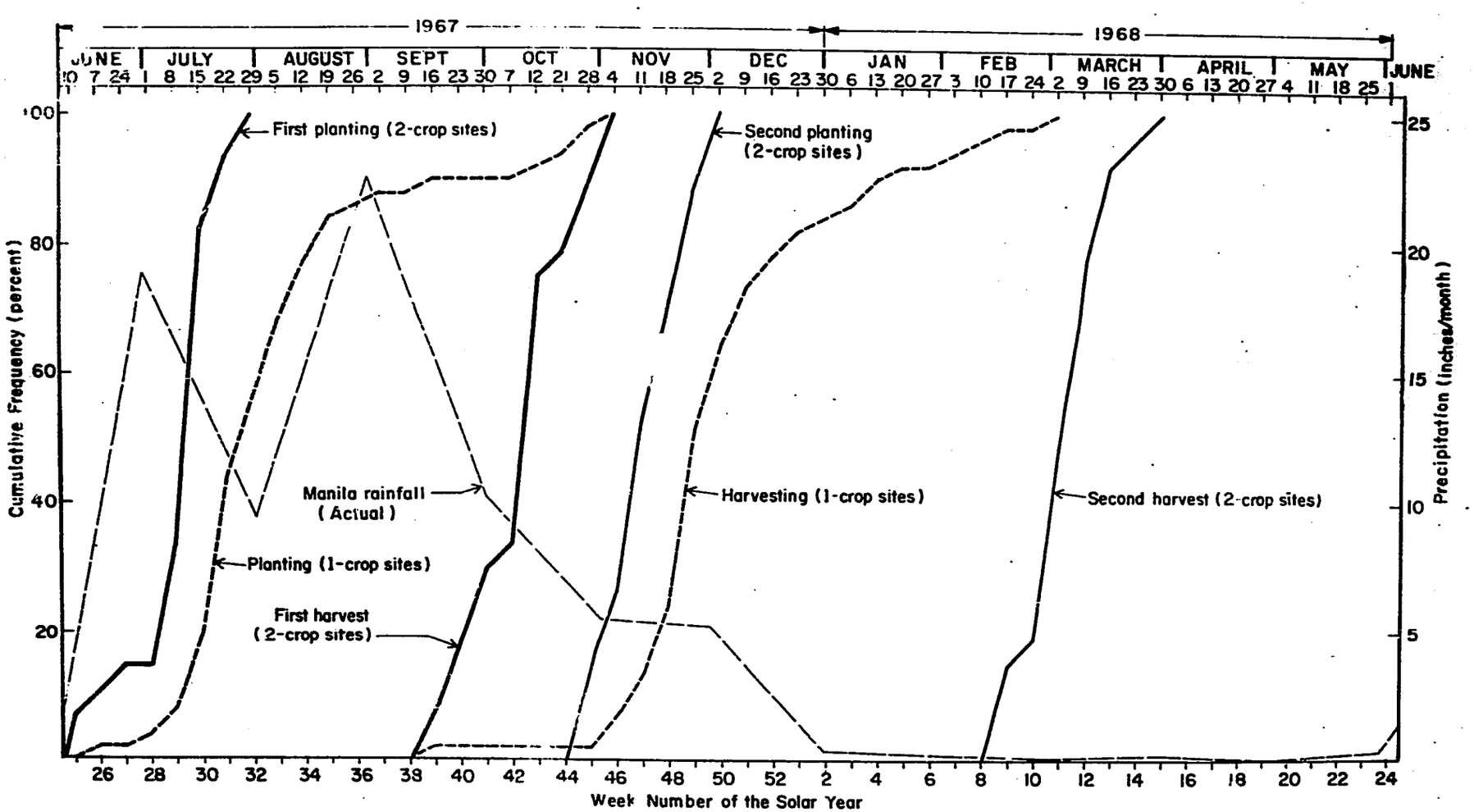


Fig. 37. Planting and harvesting [illegible] 27 two-crop sites and 56 one-crop sites, Central Luzon, 1967-1968.

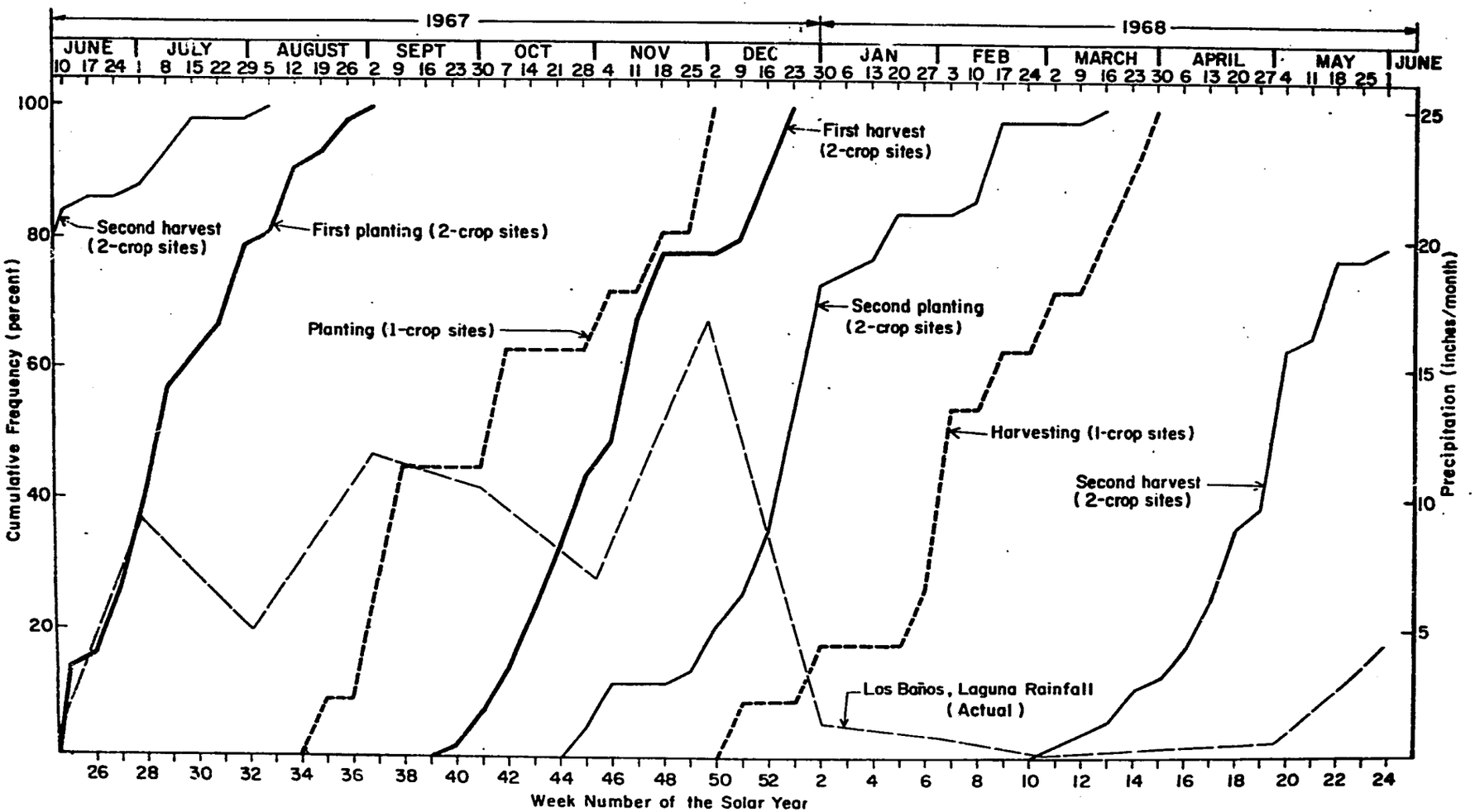


Fig. 38. Planting and harvesting cycles, 42 two-crop sites and 11 one-crop sites, Laguna, 1967-1968

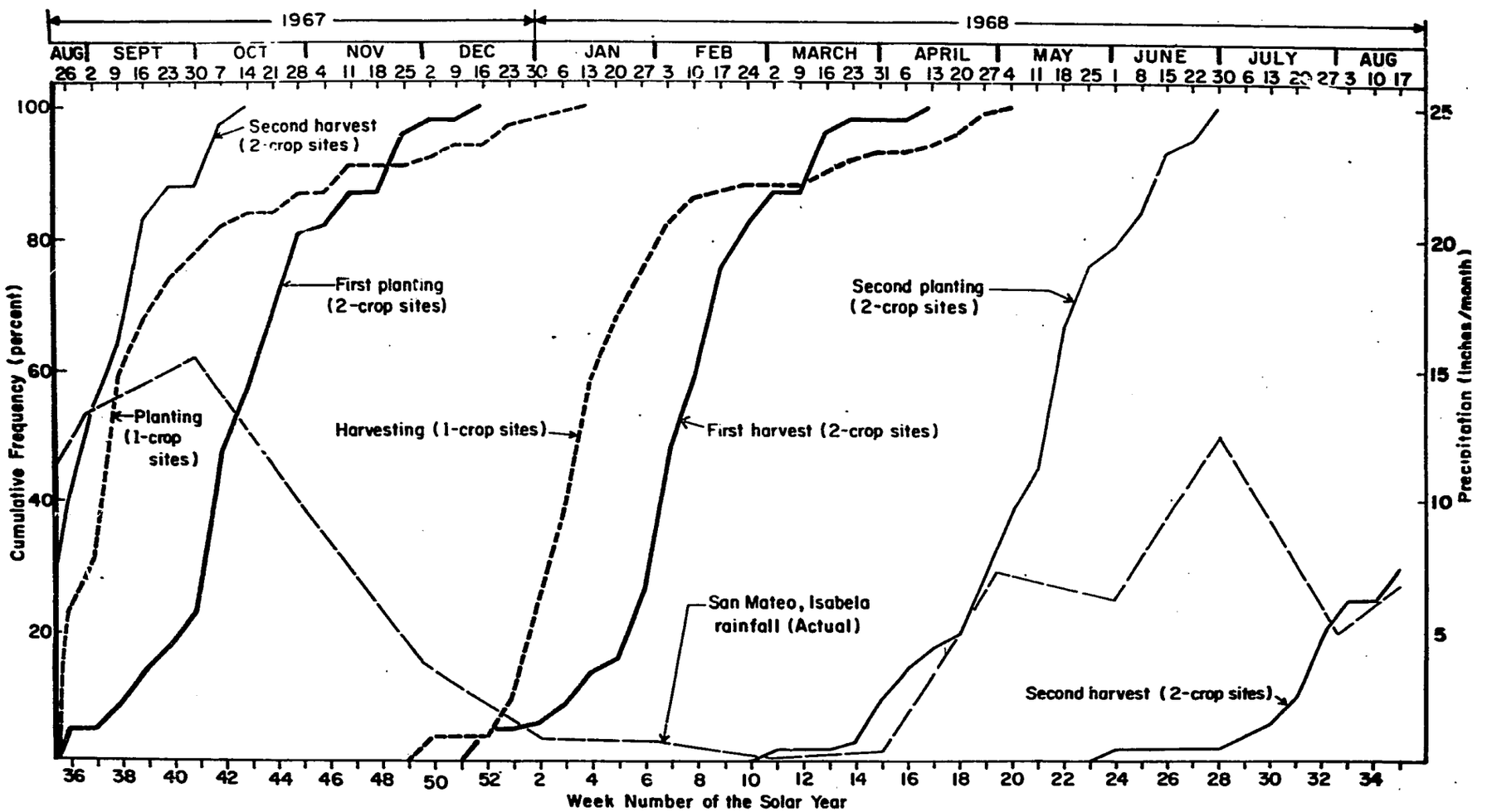


Fig. 39. Planting and harvesting cycles, 58 two-crop sites and 71 one-crop sites, Isabela, 1967-1968.

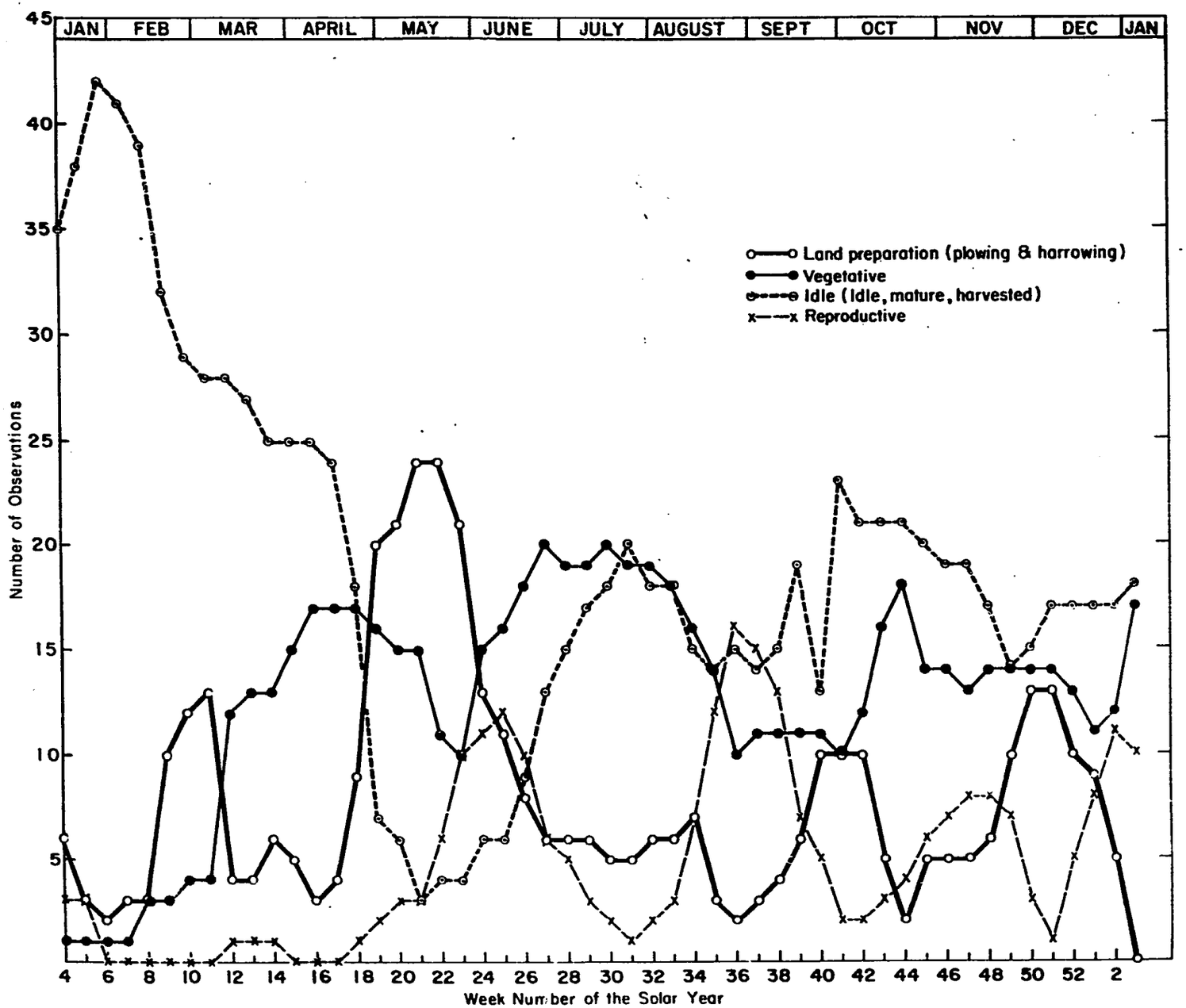


Fig. 40. Sequence of farm operations, Midsayap, Cotabato, 1968-1969.

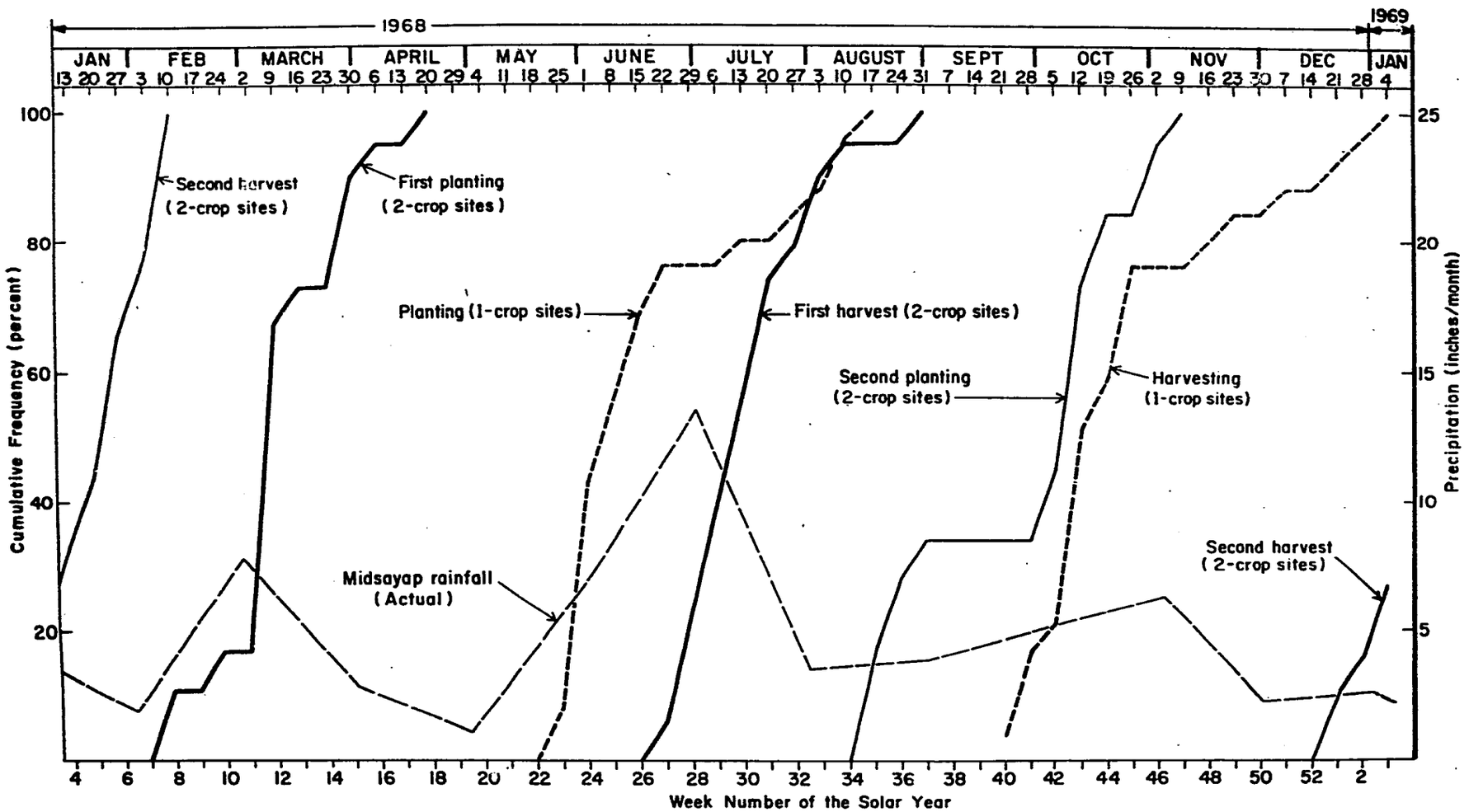


Fig. 41. Planting and harvesting cycles, 18 two-crop sites and 24 one-crop sites, Midsayap, Cotabato, 1968-1969.

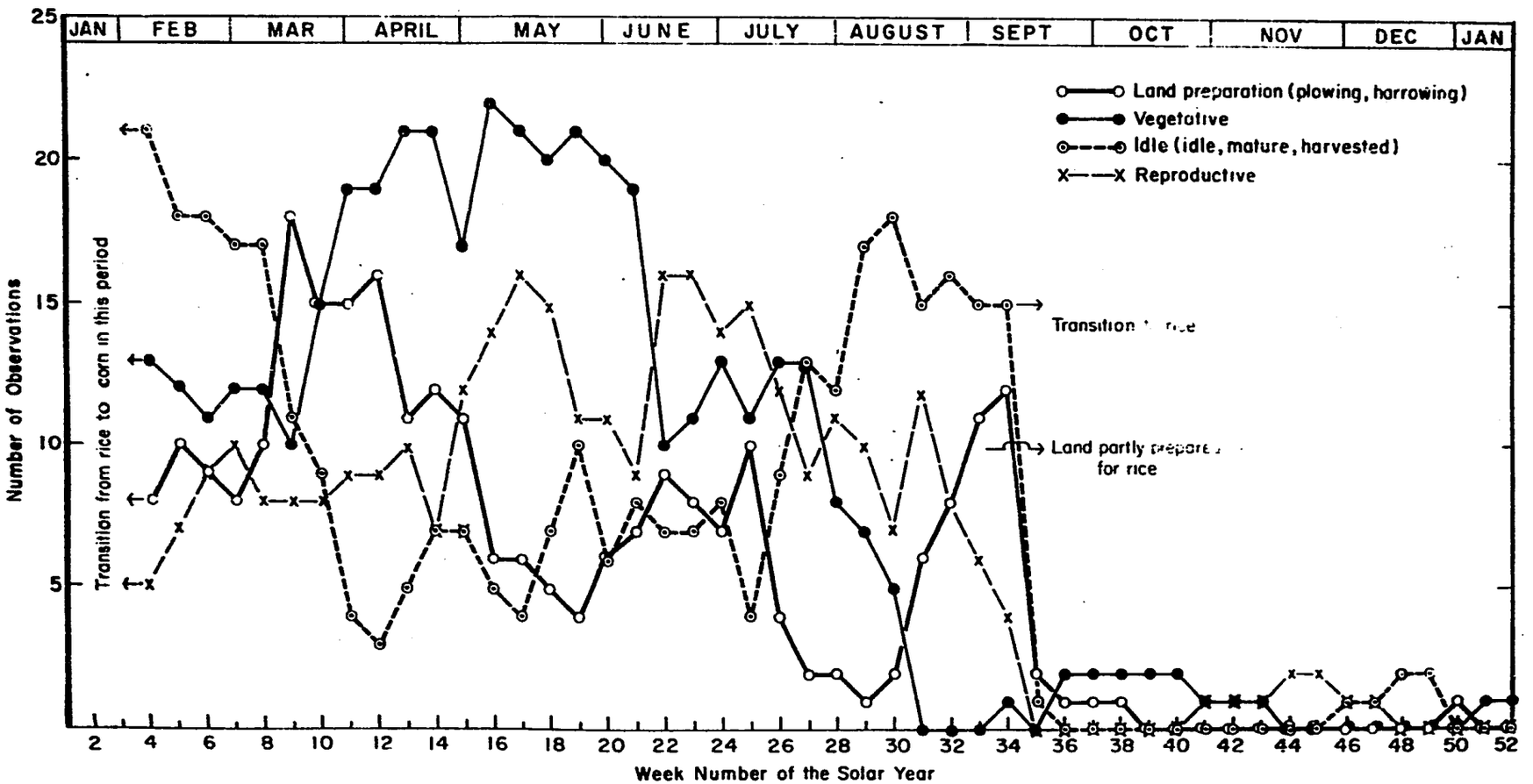


Fig. 42. Sequence of farm operations, Tacurong, Cotabato, 1968-1969 (cont).

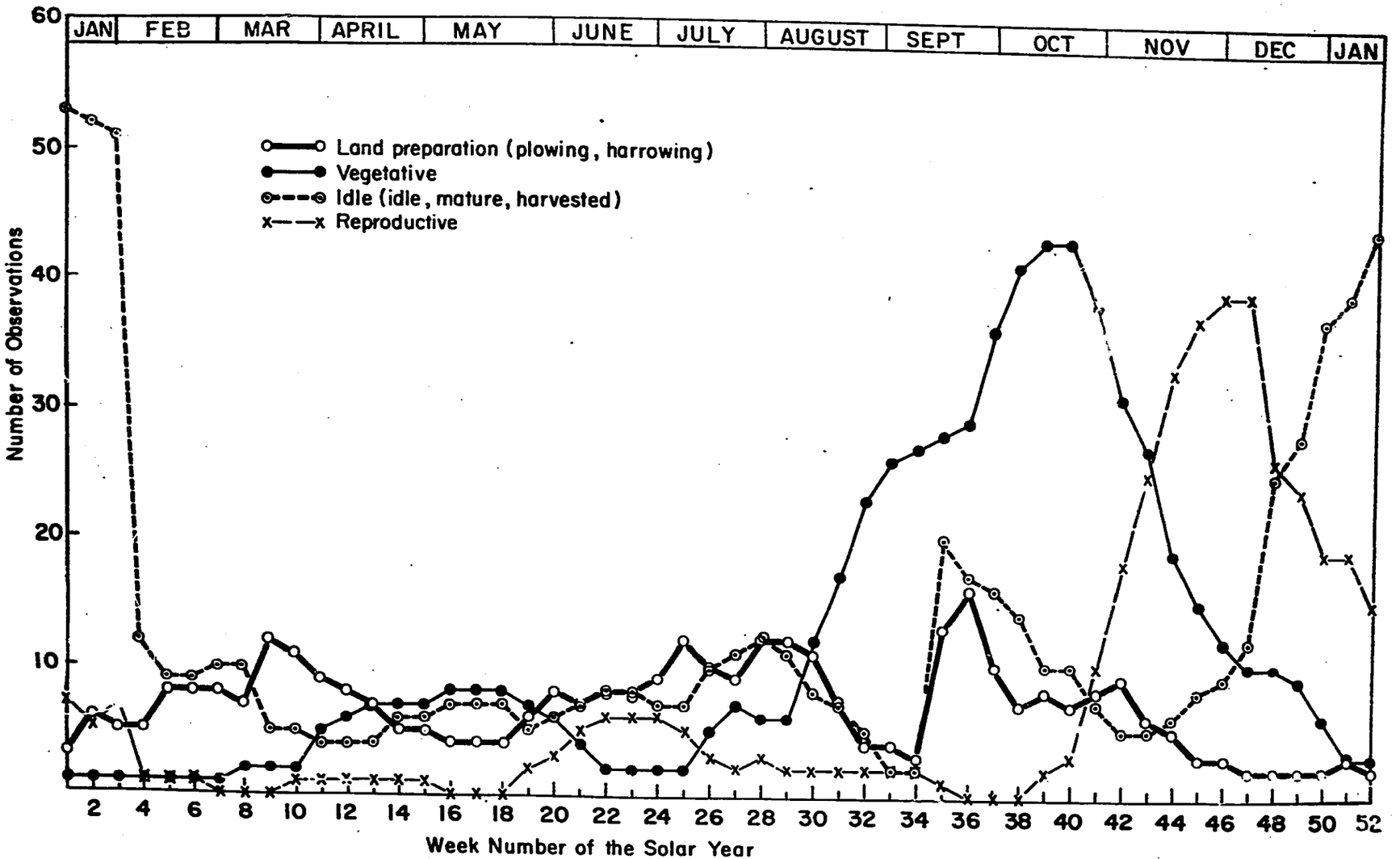


Fig. 43. Sequence of farm operations, Tacurong, Cotabato, 1968-1969 (rice).

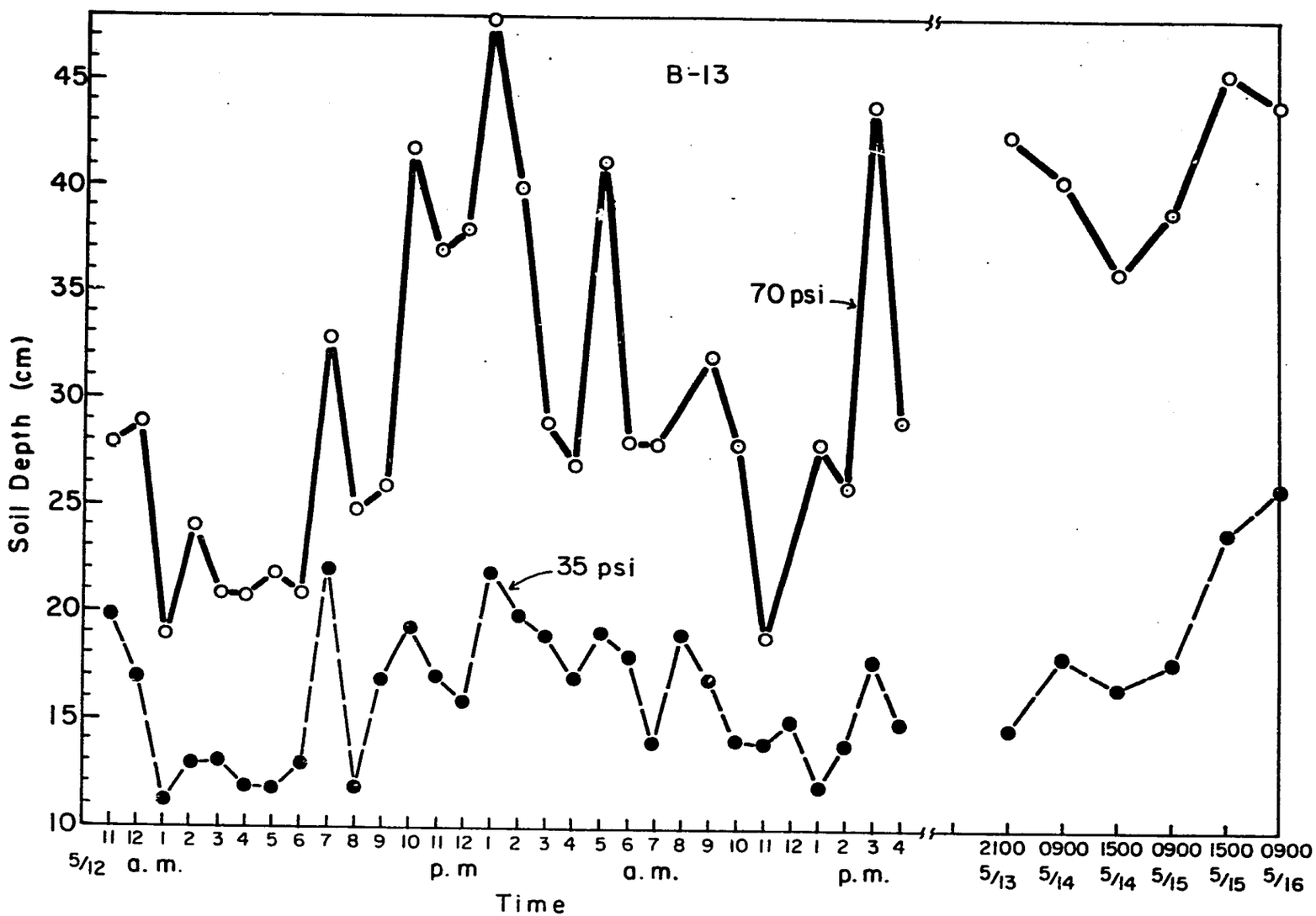


Fig. 44. WES Cone Penetrometer Measurements of Changes in Soil Penetrating Resistance from a dry to Flooded State (Field B-13, IRRI, 1969).

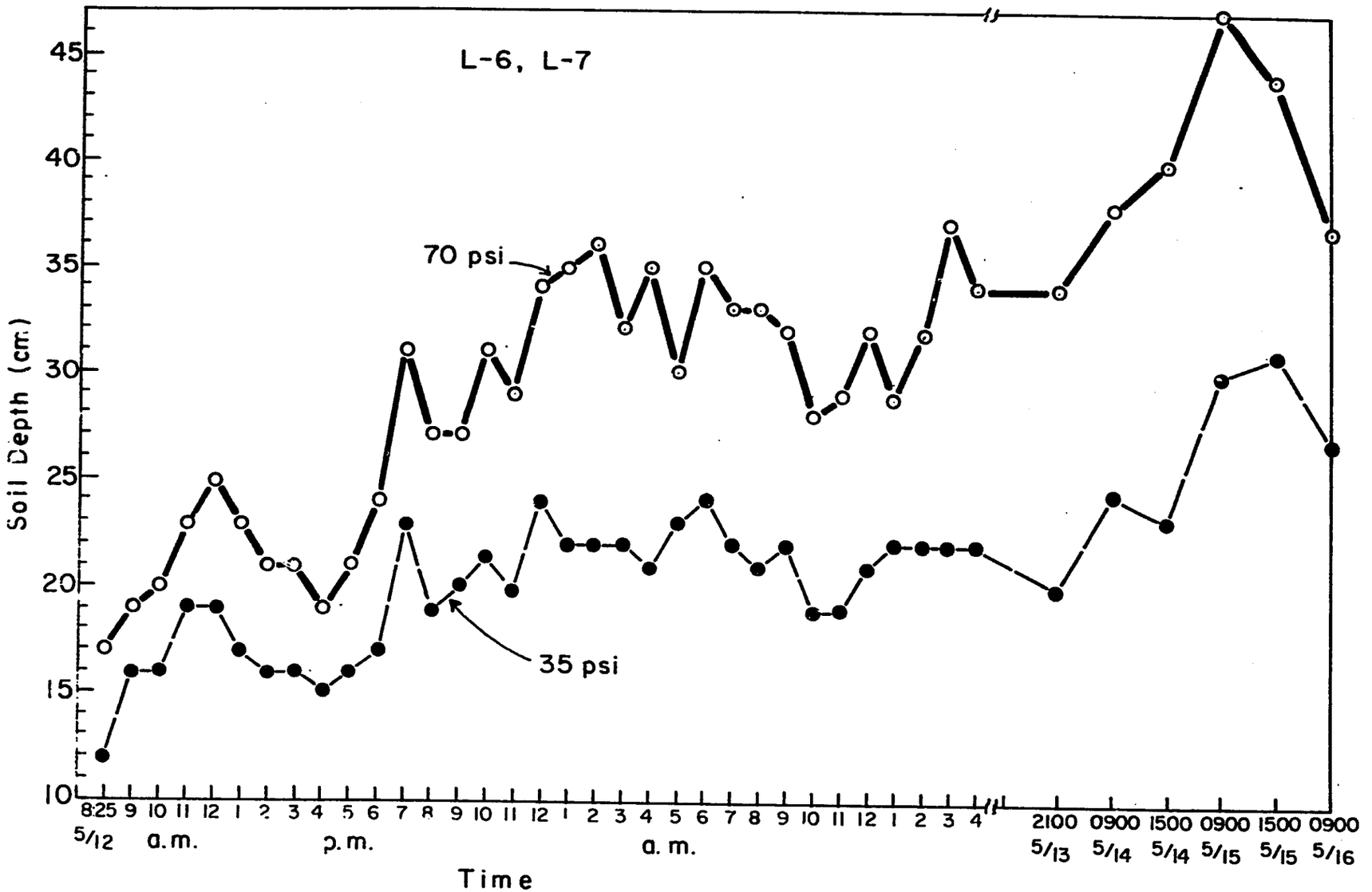


Fig. 45. WES Cone Penetrometer Measurements of Changes in Soil Penetrating Resistance From a Dry to Flooded State (Field L-6,7, IRRI, 1969).

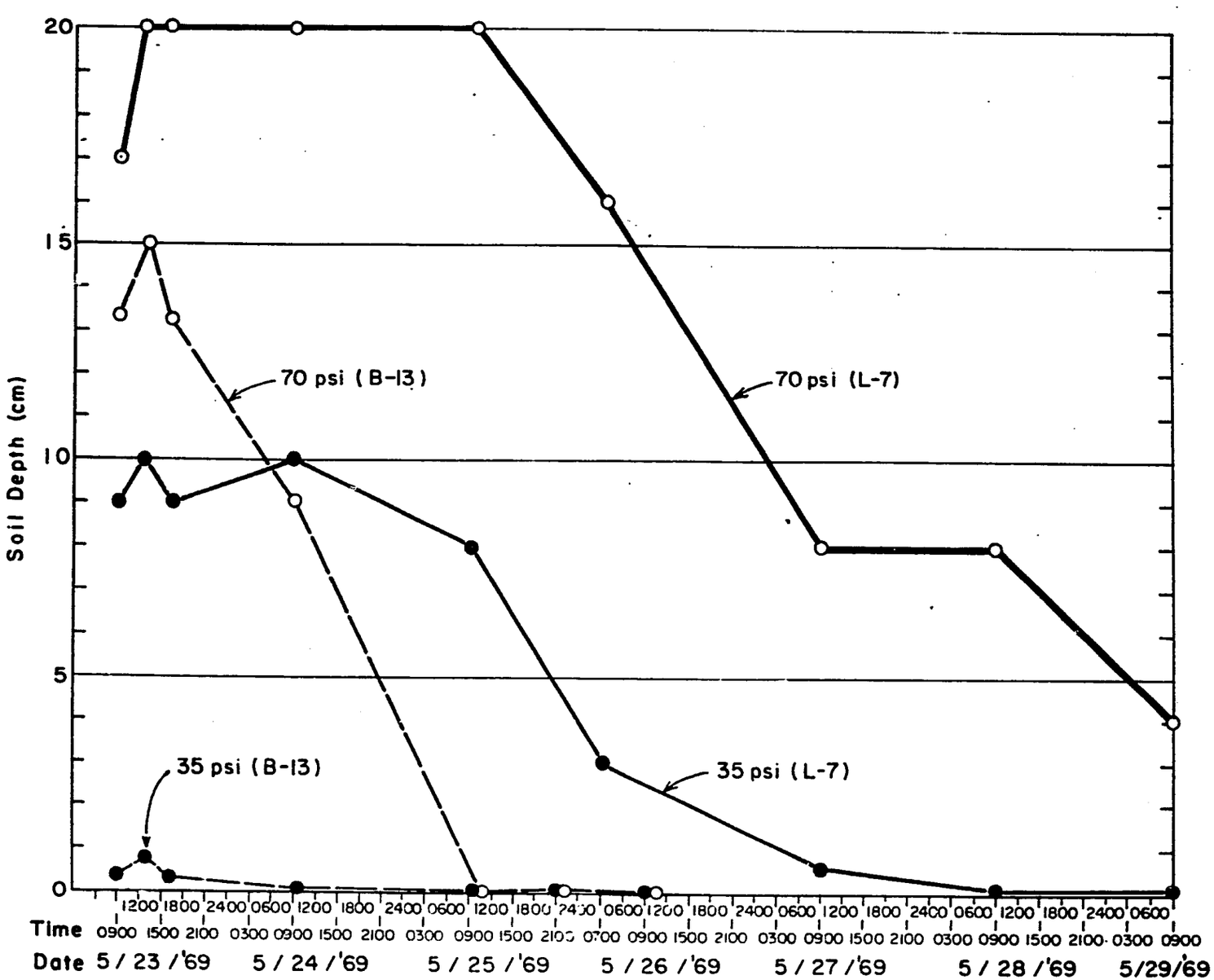


Fig. 46. WES Cone Penetrometer Measurements of Changes in Soil Penetrating Resistance From a Saturated to a Dry Condition (Fields B-13 & L-6,7, IRRI '69).

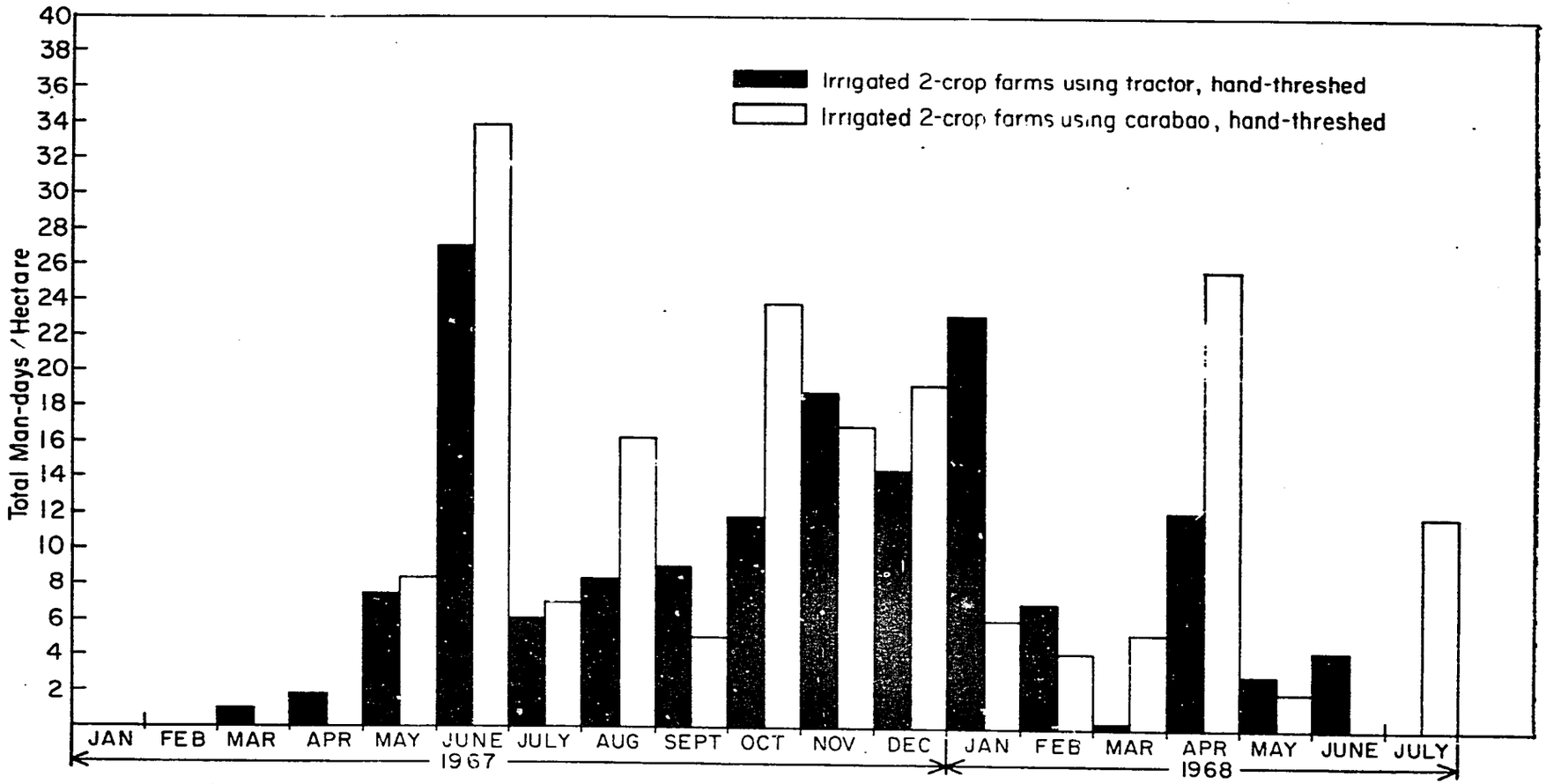


Fig. 47. Monthly Labor Distribution, 9 and 5 Irrigated 2-Crop Farms Using Tractor and Carabao, Respectively; Hand-Threshed Laguna, 1967-1968.

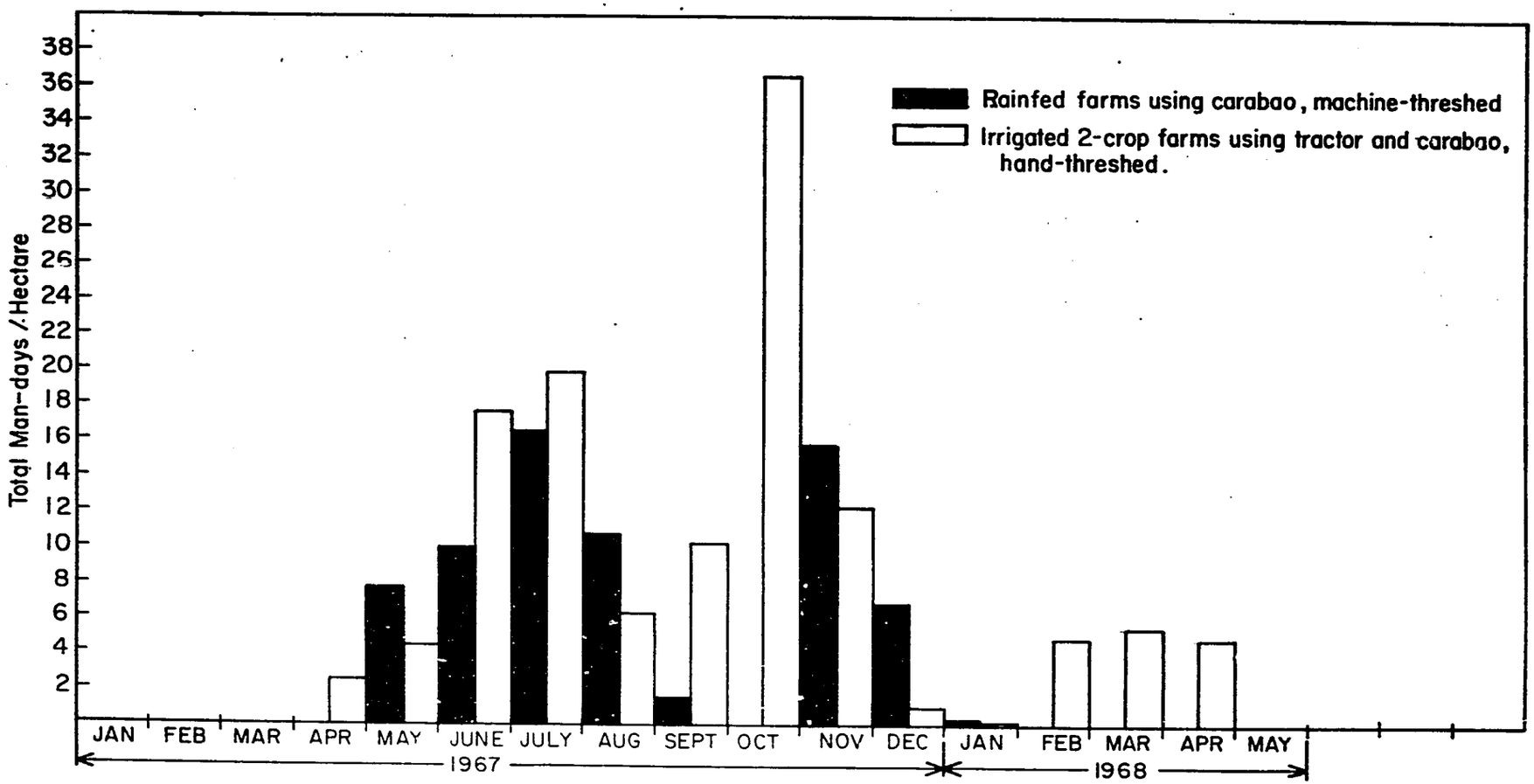


Fig. 48. Monthly Labor Use Per Hectare, 10 Irrigated 2-Crop Sites Using Tractor and Carabao, Hand-Threshed and Rainfed Farms Using Carabao, Machine-Threshed, Central Luzon, 1967-1968.