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GENERAL ENGINEERING AND ECONOMIC RESEARCH

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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

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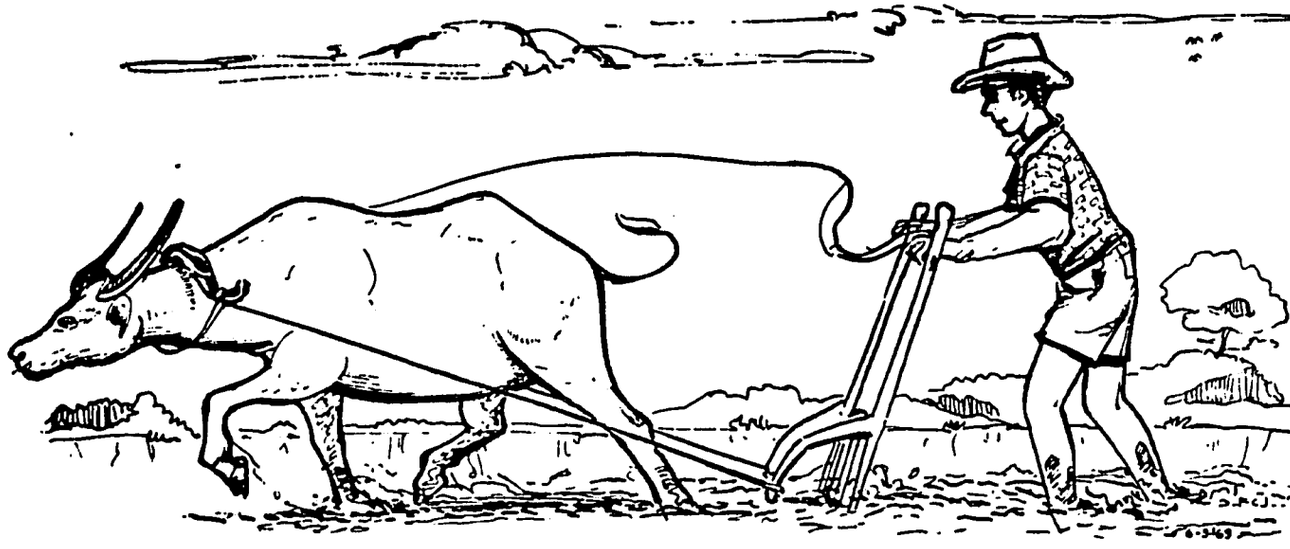

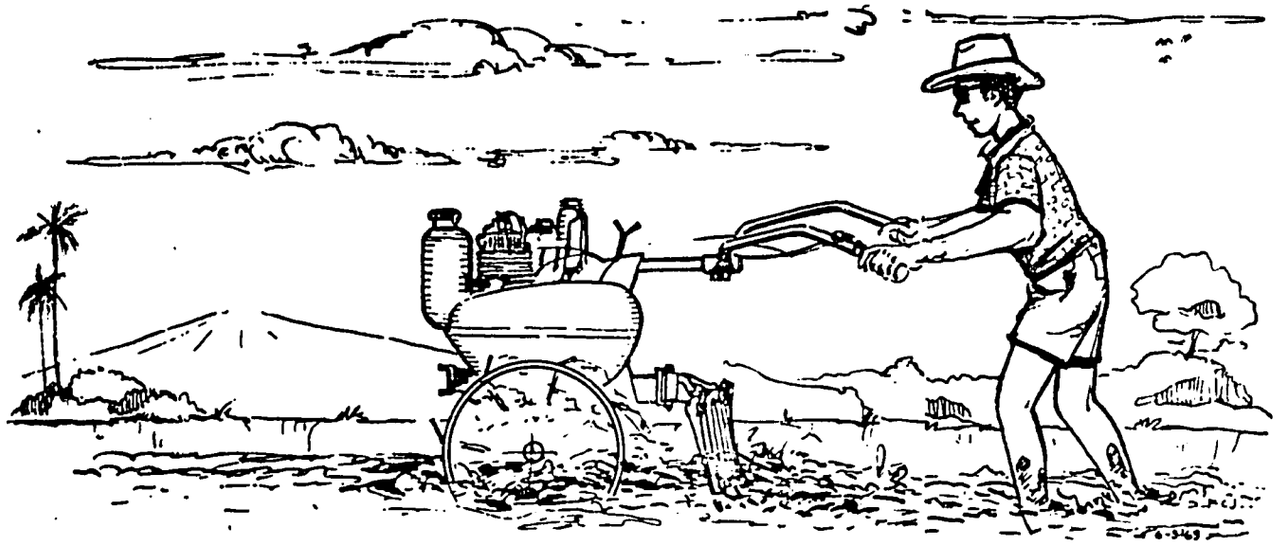

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INTRODUCTION

This is the terminal report of the general engineering and economics portion of Contract No. USAID/csd-834, signed on June 28, 1965. The contract was originally scheduled to terminate in June 1968 but was extended for another year. This report, therefore, presents in a condensed form the studies undertaken from July 1965 to June 30, 1969.

The contract was aimed at, among others, obtaining agronomic, general engineering, and economic data for tropical rice farmers. It called for the establishment of tentative limits for basic rice farm operations and evaluation of the power requirements and field capacity of power equipment for producing rice. It was along this general guideline that studies on this portion of the project were conducted.

The general objective of the economic and engineering studies has been of an applied nature, to provide a general background on the present state of rice cultivation in South East Asia, to assess the extent of and attitudes toward mechanization, and to analyze the performance and economics of use of the various machines either being used or of potential application to tropical rice farming situations. The approach to mechanization has been neutral with respect to advocacy of large or small equipment; the object is to introduce equipment suited to the local environment, and beneficial to farmers individually and collectively.

With this objective in mind, the research effort was as follows: a general survey of three of the major rice-growing areas in the Philippines was undertaken to provide agronomic, engineering and economic field data; performance tests were conducted on machinery available for land preparation, weeding and harvesting-threshing; and a general analysis of mechanization was made based on the foregoing observations, other published materials, and personal observations from travel to South East Asian countries.

It is difficult to acknowledge individually all the persons who have contributed towards this project. However, mention is made of Mr. Loyd Johnson for assisting in laying out the general program of work; Mr. Eliseo Ruiz who carried out the weekly surveys and tractor tests; Mr. Nestor Navasero who did the weeding experiments; and Messrs. Ben Hur Aguila, Norberto Orcino and Abdul Amilhussin for their work on performance tests of threshers and general economics studies.

A. SURVEY OF CENTRAL LUZON, ISABELA AND COTABATO PROVINCES

The purpose of the surveys was to gather data by weekly observations on agronomic and engineering factors involved in the current practices in growing rice. Additionally, some economic data were derived from these weekly observations, and an interview was conducted with the farm operator of the survey site. In the weekly surveys, the major observation made was on the condition and stage of operation of the crop; that is, the sequence of operation, water control, lodging and the presence of disease, weeds, or important external factors. A second observation made, especially in the original survey, was to take soil penetrating resistance measurements.

The type of data obtained is helpful in assessing the impact of newer varieties as well as in determining the actual practices of farmers in the major rice-growing areas of the Philippines. Thus, one wants to know not only the current practice, but even more importantly, how farmers are changing with respect to new technology. Information on change cannot be obtained by the weekly observations alone, or perhaps not in a single year. Thus, interview data were needed to obtain information on both present and changing practices.

The three largest rice-growing areas of the Philippines were studied, Central Luzon, Isabela Province in northeast Luzon, and Cotabato Province of Mindanao (Fig. 1). The scope and time duration of the surveys were as follows. The initial survey for the crop 1966-1967 included 145 survey sites, and was a broad sweep encompassing Laguna Province and northward up the east side and down the west side of Central Luzon. After the first crop year of this survey, the emphasis was changed somewhat to include more irrigated farming situations. More observations were taken in Laguna Province and the survey proceeded up the east side of Central Luzon only as far as Cabanatuan City. No further observations were taken in the northern and western part of Central Luzon. At the same time, a survey route was established in the Cagayan Valley in Isabela Province, on a circular route from Cauayan to Santiago. This area has a large percentage of surface irrigation and there is a great potential for a much increased use of irrigation. Another important rice-growing area is in Cotabato Province of Mindanao. Two survey areas were chosen in Mindanao so as to include both an irrigation district (at Midsayap) and a rainfed rice-corn area (Tacurong).

Because of lack of time, only the three major rice-growing areas were studied, so that not all rainfall situations were studied. There are some major differences, however, between the three study areas. The Central Luzon and Isabela Province rainfall distribution present an interesting contrast (Fig. 2). The average annual rainfall in the survey area of Central Luzon is 75 inches, and in Isabela Province, 75 inches. The monsoon rainfall pattern is very pronounced in Central Luzon with the rains starting in June coming to a very high peak in July and August, and slackening in October and November. Thus, for those dependent on rainfall, there are about four months for growing the rice crop, considering that the month of June is used for land preparation by carabao. On the other hand, in Isabela Province, the rain typically starts at the same time of the year as in Central Luzon, but there is a bi-modal dis-

tribution of rainfall. The rain comes to a peak in July and August as in Central Luzon, slackens off, and then reaches another peak several months later, with the later rainfall being the heaviest. Several observations can be made about this rainfall contrast. One is that in Isabela, with good early rain, farmers may be able to put in two rainfed crops, with the first crop coming off under perhaps very rainy conditions. And secondly, with the main harvest coming later than the main harvest in Central Luzon, there is an opportunity to bring in the machinery and labor from the harvesting-threshing season from Central Luzon to Isabela. This is currently being done with the large McCormick thresher, the typical threshing device in both Central Luzon and Isabela.

The rainfall pattern in Cotabato Province differs considerably from that of Luzon in that the rainfall is more evenly spread throughout the year (Fig. 2). However, even here the greatest amount of rainfall and hence, the typical rainfed planting date coincides with that of Central Luzon. In the off-season there is usually moisture for a crop of corn. Two areas in Cotabato Province were studied: one, the Midsayap area, is irrigated for two rice crops, and the other, Tacurong, not irrigated, is the rice-corn area.

Sampling Methods

Methods of sampling were much the same in all areas. The original survey sites in Central Luzon were chosen in the following manner. To define the sample, a preliminary observatin trip was made to six Luzon provinces, Laguna, Bulacan, Nueva Ecija, Pangasinan, Tarlac, and Pampanga. Following this preliminary inspection, the sampling sites were located 25 meters from the road edge at the kilometer posts along the major highways (Figs. 3 and 4). A survey route of 800 kilometers was planned, enabling observation of a maximum number of sites by two men travelling five days per week. A final survey list of 145 sites located in rice land was determined. Where practicable, sites were selected on alternate sides of the road at successive sites.

Two men left each Monday morning on the route shown on the map (Fig. 5) and collected the data shown on the form (Fig. 6). This particular form was completed for sites 1 to 30 for the 30th week of the year, July 11-17, 1966. Some of the sites were idle, some plowed, etc., though at that particular date all sites had surface water. The surface water and soil depth were measured. A notation was made if the site needed weeding, nirtrogen, or insecticide, if there were particular diseases, and other pertinent comments were noted. A brief description of each of the items noted in this form appears on the back of Fig. 6. Figure 7 shows a summary for one particular site, No 4, for all the weeks from Week No. 23 (May 24, 1966) to Week No. 23, 1967. Site No. 4 was first planted in Week No. 25; the first harvest was in Week No. 44. The second crop was transplanted in Week No. 52 (December 13, 1966) and harvested in Week No. 19 (April 26, 1967). The land was in crop about 40 weeks out of the year, idle 4 weeks, and in land preparation 8 weeks. However, most two-crop sites were only in crops about 30 weeks as shorter season varieties were grown.

Sequence of Operations: Initial Survey of Central Luzon and Laguna Province (1966-1967 Crop Year)

The planting and harvesting sequence for the sampled one- and two-crop rice fields during the period mid-1966 to mid-1967 is shown in Fig. 8. It plots time on the x-axis and a cumulative frequency for 109 one-crop fields and for 31 two-crop fields on the y-axis. Superimposed are the rainfall data for the Manila area and run-off data of the Pampanga River. For the one-crop or rainfall-dependent farms, planting took place in July and August, considerably after the start of the monsoon rains. Land preparation on these farms was delayed until the ground was soft enough to be prepared by animal power. The two-crop farms used supplemental irrigation to soak the fields in advance. These farms were planted 6 weeks before those dependent on rainfall. The maximum rate of planting or harvesting was about 15 percent per week. The steep slopes of the lines for the first planting indicate that a majority of farmers in the valley perform cultural operations simultaneously. The seasonality of rainfall thus creates conditions of high labor and power use for short time periods.

The two-crop farms were planted to shorter season varieties that required about 14 weeks from transplanting to harvest, while the one-crop sites were planted to varieties requiring about 17 weeks from planting to maturity. The first crop from the two-crop sites, and a major portion of the one-crop sites, were harvested during the rainy season. This timing was necessary so that adequate water would be available for growing the single non-irrigated crop and the residual run-off water may be used for irrigating the second crop.

A summary of observations from the sites collected to date has been made. Special attention was given to time in land preparation. Cumulative tables and figures of the different stages of growth of the rice farms were prepared separately for one-crop and two-crop farms (Figs. 9 and 10). One is struck by the symmetry of the cycles of land preparation and crop growth for the one-crop farms (Fig. 9). At the onset of the monsoon season, the farmers prepare the land; then they transplant the seedlings; the rice grows through the vegetative stage and, with flowering, into the reproductive and mature stage; finally the crop is harvested and the land is again left in an idle state. The two-crop rice farms (Fig. 10) show a somewhat different pattern. As in the one-crop sites, most of the farms were still dependent on the first monsoon rain for the "wet" season land preparation. However, a comparison of Figs. 9 and 10 shows that land preparation was considerably more timely for the two-crop farms.

If one assumes a similar period of crop growth for both one- and two-crop cycles, mechanization can affect land preparation, and, to some extent, the harvest sequences. By compressing the time involved in these operations, the farmer has more time to add a second crop, whether it is rice or another crop.

Figure 11 presents in a 360°circle the data on farm operations for all rice farms in order to illustrate the cyclical pattern of the operations.

Since the Central Luzon area lies to a large extent in the Pampanga River drainage area, the flow of the Pampanga River as measured in millimeters per day was plotted in the circle. The cropping pattern of the area conforms with the rainfall and run-off pattern.

Two other figures have been prepared to aid in illustrating the sequence of farm operations. Figures 12 and 13 picture the 112 non-irrigated and 29 irrigated sites, respectively. These figures present the different farming operations in cumulative totals for a particular time of the year. The figure for the non-irrigated sites shows that most of the sites were in an idle state at the start of the survey, May 23, 1966. Quickly, as the monsoon rains started, the majority of farmers began land preparation. After the seedlings were transplanted and until flowering, the rice was categorized as being in the vegetative stage. After flowering and through harvesting, the rice was termed in the reproductive stage. Over 50 percent of the farmers had started land preparation by June 13, and 50 percent had harvested their rice by December 17, a period of five months. Allowing for a growing season of 120-130 days, the remaining 20-30 days were spent in land preparation and harvesting.

The figure for the 29 irrigated sites provides further emphasis of the large percentage of the two-crop farmers who waited for the monsoon rains to start before preparing their land. The time for the second crop, however, varies considerably, since rainfall is not the only consideration at that time of the year.

The sequence of farm operations for Central Luzon and Laguna Province is contained in Figs. 14 and 15, Laguna and Central Luzon, respectively. Actual rainfall incurred is presented in monthly totals for each area. Note that the rainfall was earlier and heavier for Central Luzon than for Laguna Province. Thus, with the heavy rainfall in June in Central Luzon, the planting of the rainfed sites began in July. On the other hand, with the rainfall slower and more sporadic in Laguna Province, the planting of rainfed sites started in late August. Again, one can see the dependence on sufficient rain to soften the soil before land can be prepared by animals.

The first planting of the irrigated sites came earlier than the rainfed sites by two months in Laguna, and two weeks in Central Luzon. The dates of transplanting for both Central Luzon and Laguna two-crop sites are approximately the same. However, the Central Luzon rice was harvested earlier than in Laguna, and the second planting of the Central Luzon sites was a month earlier.

The sequence of farm operations for Isabela Province in northeast Luzon is contained in Fig. 16. Actual rainfall is plotted for Isabela Province. And note that the arrangement of dates at the top of the figure are different from the preceding figures, so that these dates and those of the succeeding figures will coincide with the actual dates of the survey.

In Isabela Province, the first crop is transplanted in the major rainfall period in September and October. The steepness of the slope of transplanting of the one-crop sites indicates that the majority of the farms were transplanted within a very short time. This again illustrates the high seasonal labor requirements. The second planting was from April through June, somewhat approximating the onset of the monsoon in Central Luzon.

The sequence of operations of the fields in Cotabato Province are presented in Figs. 17 through 20. Figure 17 presents for the Midsayap area a cumulative sequence of farm operations: land preparation, vegetative through reproductive stages and fields in idle state. The fields in Midsayap are largely irrigated. Figure 18 presents the planting and harvesting cycles for Midsayap, along with monthly averages of rainfall. Note that whereas there was rainfall throughout the year, the largest amount fell in June and July. At this time the one-crop farmers planted their rice. Again note the steepness of the slope. Those having water for two crops planted their first crop in March and their second crop in September and October.

One can contrast this with a rainfed rice and corn area for the Tacurong area of Cotabato Province, in Figs. 19 and 20. Figure 19 presents the sequence of operations for the corn crop. Part of the land preparation for the corn crop was contained in observations on rice farms, since it is difficult to determine whether the farmer will put in rice or corn in advance. However, one can note the timing of the corn crop by the increase of the number of observations in the vegetative stage. By February, one is able to note the large increase in corn in the vegetative stage, followed by a further increase in April and May. The corn crop reached the highest point in the reproductive stage in May, June and July, with the harvesting period in July and August. Figure 20 presents the data on the rice crop with again the information on land preparation partly obscured because the observers could not tell whether the farmers will pant rice or corn. But note the vegetative stage rising in number of observations in August, September and October, followed by the rise in the reproductive stage in November and December. The harvest then would be in December and January.

A further comparison of rainfed and two-crop irrigated fields may be made by examining Figs. 21 and 11. Figure 11 presented the rainfall-dependent areas of Central Luzon, demonstrating the conformity of farmers to the rain. On the other hand, the data plotted in Fig. 21 are for the two-crop areas of Laguna Province, illustrating the much larger use of land throughout the year.

3. ANALYSIS OF SOIL PENETRATING RESISTANCE

A further major problem in mechanization is that of trafficability: both in traction and flotation. Many soils are deep and will not provide traction for nor sustain the weight of heavy equipment. The major purpose of the study of soil resistance and trafficability was to obtain quantitative data on soil characteristics. What percent of the lowland rice-growing areas have soils too soft to support power equipment? What rough guides can be adopted for tractor mobility indices for specific fields?

Research on soil trafficability was conducted in two major rice areas in the Philippines, Central Luzon and Cagayan Valley in northeastern Luzon. Rice soils in these areas are generally clayey, varying from sandy clay loam to heavy clay soils. The randomly selected fields were either non-irrigated (one-crop) or irrigated (two or more crops per year).

Two instruments were used: the U.S. Army Corps of Engineers WES Cone Penetrometer [1/] and the self-recording Japanese-made penetro-shear graph called Soil Values Meter TN-4 [2/]. Both consist of a 30-degree circular cone having a surface area equal to one-half square inch (3.2 sq cm). A schematic drawing of the WES cone penetrometer is presented in Fig. 22, showing the following parts: (1) circular handle, (2) dial indicator, (3) dial support stud, (4) machine bolts, (5) proving ring, (6) mounting block, (7) extension graduated rod, and (8) cone.

This cone penetrometer can measure the cone index of the soil, which refers to the pounds of force that must be applied to the handle of the instrument per square inch of end area of its cone tip in order to push it into the ground. The cone is pushed slowly downward into the soil and readings at the pressure gage are read at desired vertical increments which are shown by graduations in centimeters on the instrument's shaft. A schematic drawing of the soil values meter TN-4 is shown in Fig. 23, with numbered parts as follows: (1) handle bar, (2) rotatable recording cylinder, (3) coil spring, (4) cylinder rotating mechanism, (5) terminal for attaching the measuring rod, (6) penetration cone and its holding rod, and (7) vane for shear test.

When the cone is used, the TN-4 meter prints a cone diagram which shows the relationship between the cone penetrating resistance and soil depth. It is done in the following manner. First, the cone with the penetrating rod is attached to the measuring device and a millimeter-graphing paper is wound around the recording cylinder and fastened with cellophane tape. The pen is fixed in a recording position. Next, the cone is placed on a hard plane and the recording cylinder is allowed to rotate by pulling the end of the wire down to the plane parallel to the rod. This operation will allow the pen to draw a line which indicates the spring load zero. The spring load zero means that the dead weight of the handle alone (about 800 grams) is acting on the upper end of the wire. At this position, the handle is pressed so the pen moves up and down, indicating the "zero" depth. The instrument is now ready

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[1/] See Knight, S. Johnson and Freitag, D.R. 1962. Measurement of Soil Trafficability Characteristics. Transactions of the American Society of Agricultural Engineers. 5(2):121-124 and 132.

[2/] Tanaka, T. Prediction of the Trafficability of the Tractor on the Soft Paddy Field. III Measuring Device of the Soil Penetrometers, TN-4. Japan Society of Agricultural Machinery, Japan 27(3):150-154, 1965. (In Japanese).

for the test. Testing is done by pressing the handle which causes the cone to penetrate into the ground while the cylinder rotates as the wire is tightened. The contraction of the spring corresponding to the hardness of the ground surface is recorded as the cone diagram. By repeating this operation, similar cone diagrams can be drawn on the same paper, from which an average value can be obtained.

The penetrating resistance is recorded on graduated paper so that 20 mm of the graph paper shows a depth of 10 cm. The soil cone index is calculated from the penetrating resistance and is expressed in kg/sq cm.

Measurements taken weekly with only the WES cone penetrometer were made on 145 rice fields in Central Luzon during 1966-1967. Two pressures, 35 psi and 70 psi, representing soft and firm soil conditions were chosen. The cone penetration before reaching the two pressures was recorded in centimeters. One-crop sites were found to be firmer than two-crop sites (Fig. 24), which is expected since the longer saturation softens the soil. The softest soil conditions occurred during harrowing when the soil was completely puddled. However, soil conditions did not change much between harrowing and harvest. An arbitrary "go" and "no-go" criterion for a 50-hp tractor with cage wheels is about a 70 psi cone index at 30 cm (12-inch) depth. With this criterion for Central Luzon, about 90 percent of the one-crop sites would be suitable for heavy equipment compared to about 60 percent of the two-crop sites. As irrigation becomes available for the second crop, soil trafficability problems will increase.

Trafficability, too, can vary according to soil type. On closer examination, a division of the Central Luzon data was necessary, separating those soils of Central Luzon from those of the province to the south of Manila, Laguna. Problems of traction exist in Laguna Province that do not seem to be present in Central Luzon.

Figures 25 and 26 present mean data on soil depth for each site, for two operations, plowing and harrowing, divided into fields in Laguna Province and the Central Luzon area, and for one-crop and two-crop farms. As previously analyzed, the soils of the one-crop sites were firmer than those of the two-crop sites. But furthermore, on the average, the soils of Laguna were softer than those of Central Luzon.

The high percentage of soft soils in Laguna is one of the major reasons why a higher proportion of the land is prepared by hand tractors as compared to standard-sized tractors.

Measurements with the soil values meter TN-4 were taken recently in the Central Luzon area at three stages of operation: immediately before land preparation, during final harrowing, and just after harvest. Similarly, these measurements demonstrated that the irrigated two-crop fields and the Laguna soils are softer than those in Central Luzon (Figs. 27, 28 and 29).

In Isabela Province, measurements with the TN-4 meter at different stages of the cropping season (Fig. 30) show that, on the average, the two-crop

rice soils are softest during the harrowing stage and firmest at harvest. Furthermore, the graph confirms the result of the test with the WES cone penetrometer that the soils in the area apparently offer no bogging problems to large equipment (Fig. 31).

And what of fields continuously under flood during the year? A test was conducted on some continuously cropped fields (three crops per year) at The International Rice Research Institute, Los Baños, Laguna. The results (Fig. 32) showed that at a penetrating resistance of 35 psi (2.464 kg/sq cm) and 70 psi (4.928 kg/sq cm), the average soil depths were 39 and 57 cm, respectively. Under these conditions, the standard tractor is not workable. The soil resistance of a water-logged area in Isabela Province was measured and the results are presented in Fig. 33. Average soil depths at 35 psi and 70 psi were 44 cm and 48 cm, respectively.

Two tests on cone index measurements with respect to time were done using the TN-4 meter. The first case (Fig. 34) was to measure the change in soil resistance from a dry state to a condition after it has been continuously flooded for a time. This was done to establish the optimum time for land preparation and to avoid work in excessively softened flooded soils. In this experiment the change in penetrometer reading was abrupt after the first five hours, and then decreased until it became insignificant with respect to time. This particular field, one of IRRI's maximum production plots, will not be workable by a standard tractor after it has been flooded for five hours. The cone index at the time was 70 psi at a depth of 30 cm. However, further tests are needed, as the TN-4 meter indicated the sub-soil was already moist, although dry on top.

The second case (Fig. 35) was a change from the harvesting stage to a dry state. The change in soil resistances was more or less gradual with respect to time. This field, also a maximum production plot but in another location, could be prepared for the next crop with a standard tractor about three days (70 hours) after harvesting. The soil at the time had a unit resistance of 70 psi at 30 cm depth.

Two further tests were undertaken measuring the two situations, changing from a dry to a wet condition, and from wet to dry condition. Two locations were used at IRRI, one an enclosed small field, and the other a large field away from other irrigated fields so that subsurface moisture would be at a minimum. However, some moisture was noted at depths below 1 meter in both fields.

The results of the two tests are presented in Figs. 36 and 37, showing the results of the WES cone penetrometer measurements. These figures list hourly measurements in the two fields from the time water was introduced to the field. The fields remained at continuous flood throughout the tests. Each measurement represents an average of 5 to 8 readings in each field. It took 10 hours for the first average reading at a pressure of 70 psi to reach a depth of 30 cm and another 16 hours in which the field averaged about 30 cm. After the conclusion of the flooding test, the fields were drained and measurements were again taken to record the drying time (Fig. 38). In both cases the

fields became firm very quickly. These data may represent measurements under drier conditions than those measurements above using the TN-4 meter.

All of these tests indicate that the farmer has relatively little time in which he can expect fields to remain firm under continuous flooding, if these fields are very soft under normal flooding conditions. One of the criteria he must draw on is the subsurface moisture present in the field at the time of flooding. Another is the amount of moisture needed to soften the soil just sufficiently to operate in the field.

C. FIELD OBSERVATIONS FROM SURVEY SITES

Data were obtained on a number of factors considered as affecting yield. These factors are the ones listed on the weekly survey sheets in Fig. 6. A number of these variables have not yet been summarized, and will be included in a later report.

Rice yields were obtained from as many of the sites as possible. The yields were estimated by harvesting a 4 sq m area at each site at or just before the regular harvest. Additional estimates of yield were obtained through interviews. As an example, the yields of the rice sites from the earlier survey of Central Luzon during the crop year 1966-1967 are presented in Fig. 39. The figure shows a frequency distribution of yields in metric tons per hectare for both the one-crop and the two-crop sites. The median yield for the one-crop sites was 2080 kg/ha as compared to the median yield of 3040 kg/ha for the two-crop sites. Few of the fields used an improved variety.

Correlation of Yield and Observed Field Conditions: Central Luzon, 1966-1967.

In order to relate the observed conditions on the rice crop to the yeild of the crop, a number of regressions were computed for several of the rice areas surveyed. The first regression was run for the 1966-1967 survey of Central Luzon. Although under actual farming conditions many other factors condition yield response, regression analysis was used to determine the relative effect on yield of the measured variables. Two regression equations are listed below. The numbers in parentheses below the regression coefficients are the standard erros of the regression coefficients*.

$$Y_1 = 1861 + \underset{(45.7)}{83.3X_1} - \underset{(26.7)}{55.6X^*} + \underset{(21.7)}{10.0X_3} - \underset{(20.9)}{15.7X_4}$$

$$- \underset{(62.1)}{39.0X_5} - \underset{(102.0)}{145.6X_6} + \underset{(3.70)}{3.10X_7} + \underset{(5.81)}{19.3X_8^*} - \underset{(0.396)}{0.297X_9}$$

$R^2 = .37$, D. F. = 81.

*Significant at 5% level or better.

$$Y_2 = 1860 + \underset{(114.3)}{202.5X_1} - \underset{(57.1)}{89.2X_2} - \underset{(76.9)}{140.2X_3} - \underset{(78.9)}{83.9X_4}$$

$$+ \underset{(149.1)}{299.1X_5} - \underset{(104.2)}{113.4X_6} - \underset{(8.34)}{4.30X_7} + \underset{(10.7)}{19.2X_8} + \underset{(0.997)}{0.815X_9}$$

$R^2 = 68$, D. F. = 19.

where:

Y_1 = Yield (in kg) of rough rice (local name: palay) per hectare, one-crop sites
Y_2 = Yield (in kg) of rough rice per hectare, two-crop sites
X_1 = Number of weeks in a rice crop
X_2 = Number of weeks that rice crop needed weeding
X_3 = Number of weeks that rice crop needed nitrogen
X_4 = Number of weeks that rice crop needed insecticide
X_5 = Number of weeks that rice crop showed dead heart
X_6 = Number of weeks that rice crop showed white head
X_7 = Percent of reproductive weeks that rice crop was dry
X_8 = Percent of reproductive weeks that rice crop was lodged
X_9 = Average soil depth in centimeters to a cone index of 70 psi

The regression coefficients compared with the standard errors obtained demonstrate that the data indicating weeks in rice, percent lodged, weeding need, nutrient need, and white head were more highly correlated with yields.

Many of the rice varieties in the survey were susceptible to lodging. For the improved short-statured varieties, early lodging is expected to result in reduced yield. However, most of the varieties planted with surveyed fields were of the tall type that lodge easily. Thus, the sign of the regression coefficient is positive as the higher yielding, tall varieties lodged earlier. In the future, as higher yields are obtained from improved lodging-resistant varieties, the sign of the regression coefficient should become negative for the higher yields.

An example of the lodging of the rice crop in the 1966-1967 survey is presented in Fig. 40. This figure presents the frequency of the percentage of the time that the rice crop lodged during the reproductive stage. Roughly 25 percent of the fields did not lodge. But on the other hand, 50 percent of the fields had a lodging percentage of 30 or more during the reproductive stage. Given that the typical variety during the survey was of the taller indica type, one would expect this heavy lodging percentage.

The results of the two regressions above indicate that there is little correlation between factors considered relevant to yield in rainfall-dependent fields. The irrigated fields evidently had more control over the environment

so that certain factors could be attributed to or correlated with yield changes.

Correlation of Yield and Observed Field Conditions, 1967-1968: Central Luzon, Laguna Province, Isabela Province.

A number of further regressions were run using data from the 1967-1968 surveys. The factors considered and the regression coefficients and related data are presented in Table 1. Instead of using all data for rainfed and irrigated fields, the fields were further categorized into those using improved varieties, and the crops were separated according to the wet and dry season. Unfortunately, problems occur because of the limited number of observations and the large number of variables. However, all the data are included, to demonstrate what has been tried, and to indicate the variation between effects of variables on yields.

The results of these regressions can be used only as rough indications. Actual field conditions need to be studied, and these factors are now being summarized. When these data are listed, then the variations between areas can be more likely understood.

For instance, water control. It was known that there was a lack of water at the end of the dry season in Laguna Province. But at the end of the dry season in 1966-1967, although far much fewer observations taken, there was little indication of a severely dry condition. Yet, after examining the 1967-1968 data more closely, it was found that of 53 fields observed, 31 were excessively dry, 5 had some likelihood of stress, 2 did not plant, and 15 had adequate moisture. Thus the data need to be better known prior to interpretation of the regression coefficients, for of the two years, the earlier year had little or no dry situations, and in the latter period, maybe not as many wet situations as desired.

However, with these conditions in mind, what do the 1967-1968 regressions show? They showed that a higher R^2, and hence a better correlation of variables to yield, was obtained for the irrigated fields, as far as Laguna and the irrigated areas of Central Luzon and Isabela. Water control did show up as a significant variable in Laguna.

How can one interpret the consistent plus sign on lodging? Again the varieties need to be studied. Tall higher-yielding indica varities are more likely to lodge than some of the older traditional varieties. And then, if all varieties are short-statured and do not lodge, then the coefficient should not be significant.

Varieties Planted

Varieties planted are indicative of the change taking place in a region. A change in cultural practices may well indicate a propensity to change toward mechanization. Tables 2 and 3 list the varieties planted in Central Luzon and in the Laguna and Isabela Provinces. For Central Luzon and Laguna one-crop farms, which are usually rainfall-dependent, no sampled farm grew an improved variety. For the two-crop farms, 26 of 41 farms in Laguna grew an im-

proved variety in the wet season, and 13 of 27 farms in the dry season. For Central Luzon two-crop farms, 6 of 24 in the wet season and 4 of 4 in the dry season grew improved varieties. This indicates that changes are taking place in the irrigated farms, but not in the rainfall-dependent farms. For Isabela Province, 24 of 104 farms, or about 20 percent, indicated that they were growing an improved variety.

Rice Yields

Rice yields were obtained by harvesting 4 sq m plots. The yields for Central Luzon are summarized in Table 4. Data on factors affecting these yields have also been collected and will be presented in a later report. These data, however, do not accurately reflect the yield realized by the farmer as several factors are left out. One is the usual field loss during harvesting and threshing. Another is an upward bias in the yield estimate due to the sampling method. Also, the levees and unproductive areas were not included in the samples.

The estimated yields obtained from interview data averaged 25 percent less than the harvested samples. Considering this reduction, the yields are not high. It is interesting to note that the improved varieties had distinctly higher over-all yields than the more traditional varieties.

D. INTERVIEWS WITH RICE FARMERS IN THREE RICE-GROWING AREAS, PHILIPPINES

In addition to the survey of the rice fields, interviews were taken with the operators of the field surveyed. The type of question asked is indicated in Table 5[3].

Interviews of Central Luzon Farmers: 1966-1967 Crop Year

Farm operators of the fields sampled were located and interviewed. The results are presented below.

Description of the area. The Central Luzon farmers are largely share-tenants. The 1960 census of agriculture indicates that Pampanga and Nueva Ecija Provinces are 85 percent tenant-operated, and Laguna, 72 percent. The average farm size is about 3 ha. Of 114 farmers interviewed, 63 reported a farm size of between 1.6 and 3.5 ha.

Outside sources indicate that about 9 percent of Central Luzon is irrigated for a second rice crop. In Laguna Province, 8 farms out of 13 reporting were irrigated, while in Central Luzon, 22 out of 108.

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[3] Because the surveys have only recently been completed, not all of the interview data have been compiled yet.

Farm equipment and animals owned. The cultural practices are centered on the use of carabao (water buffalo) and manual labor. Table 6 contains a summary of farm equipment and animals owned. For farms below 1.5 ha in size, the typical equipment was 1 plow, 1 harrow and 1 carabao. For farms between 1.6 and 3.5 ha, the equipment in average terms was 1.4 plows, 1.5 harrows and 1.5 work animals. For farms above 3.6 ha, the equipment was 2 plows, 2 harrows, and 2 carabaos. Of the 114 farms reporting, while several indicated tractor use, only 1 farm owned a tractor. Furthermore, the use of tractors and carabaos was limited to land preparation.

Labor shortage? When asked about labor shortages during peak periods of labor need, the farmers stated that they had little difficulty in obtaining transplanting and harvesting labor, jobs for which women and children were available. Farmers noted some difficulty in obtaining labor for plowing and harrowing. The labor shortage may be aggravated by the practice in local communities of performing particular farm operations simultaneously.

Intensity of land preparation and weeding. The intensity of land preparation varies considerably between farms. The frequency of land preparation operations among the farms interviewed is as follows (each harrowing contains two "passes" of the field):

Operation	Frequency
one plow, three harrow	61
two plow, three harrow	10
one plow, two harrow	9
two plow, two harrow	8
one plow, five harrow	6
one plow, four harrow	5
one plow, six harrow	5
others	17
Total farmers responding	121

The farmers did not view weeding labor as a problem. Weeding practices among the 121 farmers were as follows:

no weeding	30
one hand or rotary weeding	66
two or more weedings	22
no data	3
Total farmers responding	121

Hence, on one-fourth of the farms there was no weeding; on over three-fourths there was one weeding or less. However, this situation is likely to change towards a greater demand for weeding labor since the improved varieties need to be weeded well to produce better yields.

In brief, only in one farm operation, land preparation, was there any comment regarding labor shortage. This situation is created by the practice of the entire community (barrio) of performing this particular farm operation simultaneously. There will be little change in this practice for rainfall-dependent operations. However, in the irrigated two-crop areas (15 percent of the total area, or less) the practice is less common. Thus, mechanizing land preparation may have the least undesirable effect on employment.

Interviews, 1967-1968: Farm Size and Tenancy

Past reports have indicated a high degree of share tenancy and an average farm size of less than 3 ha in the Central Luzon Valley. However, national statistics indicate larger average farm sizes and more owner-operators in the more recently developed areas. Table 7 presents data on the surveyed rice fields of Isabela and Cotabato Provinces. In Isabela, the median farm size was 3.0 ha, with only three out of the 115 farms being over 15.0 ha in size. Of these 115 farms, slightly less than half were operated by full or part owners. The median farm size for full owners and share-tenants was about 3 ha, and for part-owners, 5.0 ha. In the Tacurong area of Cotabato (corn-rice), roughly two-thirds of the farms were owner-operated. Median farm size for the owners was 5 ha, and for the tenants, 3 ha.

Four farm sizes were between 50 and 89 ha. On the other hand, in the Midsayap area of Cotabato, only one-fourth of the farms were operated by full or part owners, and median farm sizes ranged from about 1 ha for tenants and 3 ha for owners. Thus, between areas in the same province, there exists a large difference in tenure and farm size.

Farm equipment. Interviews were taken in the three areas for the crop year 1967-1968. A summary of farm equipment and animals owned, by size of farm, is listed in Table 8. The data are presented in percentages of the number of farms reporting. One may compare this with the farm equipment for Central Luzon listed in Table 6.

One would expect the Tacurong area to have relatively more farm equipment because of its larger farms and the fact that corn is more readily adaptable to mechanization. In the Isabela area, of 124 farms reporting, 5 owned tractors. At Midsayap, 2 out of 45 farmers owned tractors. At Tacurong, 16 out of 63 farms had tractors.

In all three areas, the majority of farmers relied on animals for farm power. At Tacurong, the average number of carabaos for farms less than 5.5 ha was 1.5, and 3.0 for farms larger than 5.5 ha in size. At Midsayap, the average number of carabaos was 1.5 for farm sizes less than 2.5 ha, and 2.5 for farms of larger size. The number of carabaos per farm in Isabela was 1.0 head for farms less than 2.5 ha, 1.5 for farms of 2.5-4.5 ha, and 2.5 for farms larger than 4.5 ha.

Thus, in contrast to the results obtained from sample areas in Central Luzon, the outlying areas of Isabela and Cotabato are using tractors for land

preparation to a much greater extent. The rice areas with a high proportion of share tenants and small operating units are slower to adopt farm machinery. However, Laguna Province may be an exception - while farm sizes in this province are larger than in Central Luzon, tenancy is high; however, hand tractors are being used to a great extent in this area.

Further indications of labor shortage? Tables 9 and 9a indicate the response of farmers in the survey areas to queries about labor shortages. The Tacurong and Midsayap, Cotabato farmers indicated no serious labor-hiring difficulties. However, in Isabela, 50 percent of the farmers encountered difficulty in hiring labor for land preparation. Further, there was some labor shortage in each farm operation. Of the three major rice areas, Isabela may suffer a serious labor shortage.

Interviews, 1967-1968: Use of Farm Labor

In order to understand the possibility of mechanization, one has to know the demand and supply parameters for labor.

As we have seen, there are seasonal peaks of farm operations. Farmers, however, have not indicated a general shortage of labor in any category except, perhaps, land preparation.

A reliance on hired labor, which is a cash cost, can indicate that farmers may be in a position to shift from hand to machine methods if costs are lower. Do farmers rely to any extent on hired labor? Tables 10 and 11 present data on labor inputs for Laguna Province wet and dry seasons. Since these are averages for all farms, there is some overlapping of months, since not all farms coincide in timing of the farm operations. Average total 8-hour man-days for wet and dry seasons are 79 and 72 man-days, respectively.

In Table 10, wet season, operator and family labor comprise 15 of the 79 man-days. The remaining labor is hired (and exchange). For the dry season, Table 11, operator and family labor contributions totalled 15 man-days of 72 total man-days. Thus there is a great reliance on hired labor in Laguna Province.

Operations requiring the greatest amounts of hired labor are harvesting and threshing (largely by hand in this province), weeding (crop care), transplanting, and to some extent, land preparation. In most operations there is a reliance on hired labor.

Contrast Laguna Province with Tacurong in Mindanao. Table 12 presents the seasonal labor distribution by category of farm workers for tractor-prepared and machine-threshed wet season rice farms. Of a total of 56 man-days, 13 were by operator and family labor. Transplanting and harvesting labor were the two operations using the largest amount of hired labor. But look at Table 13, using carabao and hand threshing; 44 of 63 man-days were by operator and family labor.

These data illustrate a reliance on hired labor, especially for the operations of transplanting, harvesting and threshing.

The seasonal distribution of labor use can be seen for types of farms in the foregoing Tables 10 to 13. One can see graphically in Fig. 41 the contrast in distribution of labor for two-crop farms using carabao and tractor. Table 14 summarizes the labor use in the two-crop farms for both Laguna Province and Central Luzon. Labor use is spread throughout the year, but still with seasonal peaks in May-July and October-December. And finally, Fig. 42 contrasts an irrigated two-crop farm use of labor with that of a single rainfed crop.

Interviews, 1967-1968: Field Size

An indication of field size is given in Fig. 43. The areas of the surveyed fields in Central Luzon and Laguna Province are presented in a frequency distribution by the size in square meters. The median field area was between 601-900 sq m, or of a size between 25x25 and 30x30 m. Most of the fields were below 1800 sq m in size, or less than 42x42 m. The largest recorded field was below 7500 sq m, or 85x85 m as a square.

Cost of Production of Survey Farms

Average costs have been assembled for the survey areas and are presented in Tables 15 through 18. Allowance should be made for the owner-operator, or part-owner, as these data are for share rental farms, at the rate of 50-50, after the obligations of each party are settled. And many of the payments shown herein are on the basis of a percentage of the yield. Hence, these costs reflect the current yield situation in each area.

Costs may be classified into two major 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 pocket" costs and are generally lacking, especially before planting. Non-cash costs, on the other hand, represent payments inkind for services rendered and are usually paid after harvest. A classic example of non-cash costs are the harvesters' and threshers' share: they get a certain percentage of the product. 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 cash and in kind 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 cost, the greater the potential profit - or loss, in the advent of crop failure. Because of this risk involved, it is expected that farmers with bigger farms are more receptive to yield-increasing inputs than those with smaller farms because the consequences of a loss will be less severe. Running parallel with this, farmers with irrigated holdings are likely to invest more money (and are able to borrow more money)

than those farmers with rainfall-dependent farms because they have water throughout the growing season, and thus assurance of a second crop.

The data shown in Tables 15 and 16 seem to confirm this. In Laguna and Central Luzon, for example, cash costs on irrigated two-crop farms amounted to P214.34 per hectare; compared to P178.35 and P137.13 per hectare for irrigated one-crop farms and rainfed farms, respectively. Expenditures on fertilizer in irrigated two-crop farms were also greater than that of the other two farm types. This trend in cash expenditures holds true for the other areas.

Returns to the operator and to family labor were entered at the rate of P3.50 per man-day under non-cash costs. Another way of looking at it is by subtracting it from the total cost, thereby treating it as additional return to the farmer.

E. WEEDING

A power weeder operating from the back pack was designed in this department and tests were performed other than tests of design characteristics. Our primary consideration was to check the performance and cost of the machine in the field, and to compare its characteristics with other methods of weeding.

Several tests were conducted utilizing the mechanical weeder, and two of the major tests are reported here.

But what is the possible role that a mechanical weeder can play in mechanization? What is the current state of weeding practices? Data on weeding were assembled from several sources, primarily the survey data from the three major rice-growing areas of the Philippines. We know that the new varieties take more care. The plant type is shorter, there is more capital invested, and increased management is needed. We need to answer the following questions: (1) what is the present state of weeding: the number of times farmers weed, the use of family or hired labor, the availability of labor when needed; (2) what is the adequacy of weed control by hand labor, the crop response to weeding, the economic returns to different types of weeding, the quantity of weeds that can be present without lowering the yield; (3) what is the need for a mechanical weeder or large cultivator; (4) what are the strong and weak points of different weeding methods, such as hand, mechanical, herbicidal, or some combination of the above; (5) what is the effect of alternative weeding methods on input expenditures and economic returns to farmers, and (6) what effect have the different weeding alternatives on labor use. We have tried to answer a few of the questions below.

Present State of Weeding

On the initial survey in 1966-1967 of Central Luzon farmers, certain questions were asked concerning weeding. In terms of number of weedings for 121 farmers interviewed, the response was as follows: no weeding, 30; 1 hand

or rotary weeding, 66; 2 or more weedings, 22; no data, 3. Hence, on one-fourth of the farms there was no weeding; on over three-fourths there was 1 weeding or less. However, the time of the survey (1966-1967) was such that few improved varieties had been introduced. We assume that farmers when introducing new varieties will also use the necessary inputs for higher yields. To what extent is this true?

Table 19 presents a summary of weeding practices for surveys in the 1967-1968 crop year. The data indicate that most of the farms interviewed did weed; only in Central Luzon did a significant number do no weeding. And there was a rather large number of farmers using the hand rotary weeder. This is especially true in Isabela Province where labor is shortest. And 134 of the 312 farms indicated that they sprayed their weeds. Perhaps some of the Central Luzon farms sprayed instead of weeding.

There is some indication that the improved varieties were weeded more, especially in Laguna Province.

Crop REsponse to Weeding

One would like to know the particular response of the yield of rice to weeding. From the IRRI Annual Reports of 1967 and 1968, we know (1) that rice is a competitive crop, and that given initial growth over weeds, can shade them out and yield well against them. Thus the early weed growth is important to overcome; and, (2) that of the three types of weeds, namely, grasses, sedges and broad-leafed weeds, that the grasses offer rice the most competition for sun. Thus timeliness with respect to weed establishment is important. These concepts need to be kept in mind when evaluating weed control methods.

The Need for a Mechanical Weeder

How can one judge whether a mechanical weeder is needed? Our approach was to ask the farmers if there appeared to be a labor bottleneck at weeding time. The answer was usually no, but there are location differences in labor supply. Secondly, what is the customary practice with respect to the people weeding; are they family members, relatives, people from the nearby area, or people from far away? Are the weeders hired, that is, do they have to be paid in cash or in kind for the weeding? And the typical practice is to hire weeders. And then, we need to ask if there is some technical or economic advantage of using a mechanical weeder over hand methods or over chemical methods. For this answer, we conducted some field tests.

Alternative Weeding Methods

The three alternative weeding methods that we have analyzed are hand weeding, mechanical weeding, and herbicide treatments, as well as certain combinations of these three. From previous experience, we know that hand weeding requires 130 to 160 man-hours per hectare. Two of the common methods used at the IRRI farm are to have the weeders bend over and actually bury the weeds using their hands. The second method is to stamp the weeds under with the

feet, a less preferred method. There are two mechanical methods: one, the single-row hand rotary weeder, and the IRRI-developed three- to five-row back pack power weeder. A further weeder was available but was not included in the studies, which was a commercial Japanese three-row weeder. Power is supplied to a large center wheel, and the other two rows are actuated on contact with the soil. The two defects noted were that the machine needed considerable head room to turn, and one could not use any back and forth motion to get the weeds under. The third method, herbicides, is a method commonly used in labor-short countries.

An Initial Test of Weeding Methods

A test was run comparing the times of the experimental three-row power weeder with the hand single-row rotary weeder and with hand weeding. Two sub-plots were chosen randomly out of six adjacent sub-plots for each type of treatment. The rice had been transplanted 22 days earlier, in square rows of 25x25 cm. The power and hand rotary weeders made two passes, one in each direction. Later, larger fields were utilized to determine performance rates over longer time periods. The results of the test are as follows, in man-hours per hectare:

	First plot	Second plot	Average of 2 plots	Endurance trial
Power weeder	16.4	26.0	21.2	20.2
Rotary weeder	56.4	48.7	52.6	66.6
Hand weeding	107.7	153.5	130.6	137.6

Two men were used alternately on the power weeder, so the time per hectare can be doubled so as to include the time of two men. The endurance trial was to compute the time for the various operations as they continued through the day. The data do not include rest time which was considerable for the rotary hand weeders as the day progressed.

IRRI Power Weeder Test, 1968 Dry Season

During the 1968 dry season, the portable three-row IRRI power weeder (Fig. 44) was tested on rice at different stages of growth. This was done to determine whether the 5 inches rotor axle clearance was sufficient for the plants to bend and pass under the axle without any significant damage.

Table 20 lists the plant height, rate of weeding, fuel consumption, and the number of hills damaged during one weeding operation. The test indicated that the machine required an average of 15.84 man-hours to weed a hectare and a fuel consumption of 0.70 liter per hour (11.09 liters/ha). The ideal plant age to avoid physical damage during weeding ranges from 22 to 38 days after transplanting.

Comparative Evaluation of the IRRI Power Weeder, 1968 Wet Season

An experiment was conducted during the 1968 wet season to compare the IRRI power weeder performance with the commonly practiced and recommended

weeding methods under the lowland conditions. The experimental design and treatments are presented in Table 21. The experiment evaluated the rice yields, weed growth, and the plant damage caused by the weeders. Two varieties, Chianung 242 and IR8-68, were transplanted in a field which was subdivided into plots with a one-meter strip in between for the mechanical weeder application. Plots with herbicide treatments were enclosed with levees to avoid diffusion of chemical to adjacent plots. The field was fertilized during the last harrowing operation with 70 kg of ammonium sulfate. Grass was seeded two days after the fertilizer application. Standard water management and optimum pest control were practiced during the test. However, considerable damage was incurred due to rice stem borer and tungro virus.

Observations of control plots indicated that only a few grass seeds germinated. It seems that the broadleaf Monochoria Vaginalis (L) Presl. outgrew in competition with grass due to its early stand.

Figures 45 and 46 show a comparative evaluation of different weeding methods on tiller and weed count at 45 days after transplanting. Highly significant difference of weed population was observed between the control and treated plots. The experiment indicated that the mechanical treatments (1 to 8) had more weeds than the herbicide treatments. Among the mechanical methods of weeding, namely, manual, manual rotary weeding, and power weeding, no significant difference was observed. There was a fairly uniform number of tillers per square meter. This indicates that the number of tillers damaged during weeding was minimal.

Rice yields, weed weights at harvest, and other data are shown in Table 22. Two yield means are presented: those for both varieties combined, and those for IR-8. There was considerable rice stem borer damage, about 20 percent for the Chianung 242 and 10 percent for IR-8. Thus, IR-8 with the less damage was analyzed separately.

Note that the control is decidedly lower, and the other means are not so significantly different from each other. Evidently, the yield response to different weeding treatments is not so great if enough weeding is done to give the rice tillers a headstart on the weeds.

The economic evaluation of weeding returns is based on the average returns of both varieties, and on the actual labor time involved, which is a little extreme in the hand weeding operations.

F. PERFORMANCE AND ECONOMICS OF POWER TILLERS

In Philippine agriculture, which includes the cultivation of 2 million hectares of lowland paddy, a total of 3.5 million carabaos plus several thousand tractors are used. A rough estimate indicates the presence of about 7,500-10,000 standard-sized tractors, and over 5,000 units of hand tractors. Sales of hand tractors are localized, especially to small farmers who have irrigated two-crop farms, i.e., those with repayment capacity.

The size of the moldboard plow and comb harrow of the carabao and the tractor are about the same. Therefore, the replacement of the carabao is almost 1:1. However, the tractor gains advantage in speed, endurance, and by the additional tillage effect of the cage wheels. Land preparation with the small tiller typically involves one plowing followed by 3-5 harrowings. The final harrowing may follow a week after the others to bury germinating weed seeds. For the power tillers, the rotovation may be done twice, followed a week later by 2-3 harrowings.

Hand Tractor Studies

Towards the end of 1966 and in 1967 studies were conducted on the engineering and economic aspects of hand tractors for tillage operations on lowland rice farms in Laguna. A survey of all the tractor owners in the province revealed the presence of 434 units of which 9 were reported to have been purchased before 1960 (Table 23).

These hand tractors are largely the tractive type tillers of 4 to 6 hp, designed to pull plows, comb harrows, and small trailers. They are usually sold with both plow and comb harrow, but the comb harrow is most widely used. A typical cash price for a 6-hp tractive type tiller with cage wheels, plow and comb harrow is ₱3,700. The larger horsepower (6-13 hp) rotary tiller types are also being sold and are gaining in popularity. These machines use rototillers to replace plowing and some of the harrowings.

During the survey, observations and timed tests of harrowing operations under farm conditions were made. The tests indicate that about 540 to 740 square meters may be harrowed in a single pass per rated horsepower-hour of the tiller. Since 3 to 5 passes of the harrow were required for complete land preparation on soft soils, a 6-rhp tiller could not be expected to complete all harrowing of more than one hectare per day. Fuel consumption was about 4 to 6 liters of gasoline to a hectare for complete harrowing. A few tests were also made on the rotary tilling of flooded fields. Data gathered indicate a fuel consumption of 10 to 16 liters of diesel, and 10 to 27 liters of gasoline per hectare. For plowing, the average was about 33 liters of gasoline per hectare. Based on one liter of gasoline providing about 3.3 rhp-hrs of machine power, the following are estimates of power requirements for preparing lowland rice fields in Laguna Province:

Method A (Plow and Harrow)

Plowing	33 x 3.3	=	110 rhp-hr
Harrowing, 3 passes	5 x 3 x 3.3	=	50 rhp-hr
Total			160 rhp-hr/ha

Method B (Rotary Tiller and Harrow)

Rotary tiller	20 x 3.3	=	66 rhp-hr
Harrowing, 3 passes	5 x 3 x 3.3	=	50 rhp-hr
Total			116 rhp-hr/ha

Additional Tests

Time studies were made on IRRI experimental fields where closer observations could be made. The fields had already produced one crop during the monsoon season and were still very soft as shown by the U.S. Army WES cone penetrometer readings of a depth of 27 to 38 cm at a pressure of 70 psi. From 1 to 5 tons/hectare of weeds and stubble were incorporated and the land was prepared ready for transplanting. Six of the fields were so soft that the comb harrow was used instead of the plow, and in several fields the tillers often bogged down. The total fuel consumption averaged 39.9 liters/hectare. Plowing averaged 15.3 liters/ha; harrowing, 5.11 liters/pass, and 5.5 passes for a total of 27.5 liters/ha; leveling, 2.21 liters/ha, on the average. For harrowing, the fuel consumption of 5.11 liters/ha per pass is comparable with the results of the field survey in 1966 of 4.87 liters/ha while the fuel requirement for plowing IRRI fields (15.3 liters/ha) is much less than the 33.7 liters/ha obtained in the survey. The apparent explanation is that the farmers' fields were firmer in the first season and the farmers plowed a narrower furrow slice.

Hand Tractor Cost of Operation

Installment plans could usually be obtained for two-crop farmers by extending the payments over 7 crops or three and one-half years. In addition to the ₱3,700 base price, a service charge of ₱1,200 is made, making each of the seven payments ₱700. The two most quoted range of prices were between ₱2,500-₱2,900 and ₱4,500-₱4,900.

The annual fixed cost of owning a tractor is presented below under three assumptions:

(1) Straight-line depreciation for the cash price yields the following, considering a 7-year life:

$$\frac{₱3,700}{7} = ₱530.00 \text{ per year}$$

(2) For the tractor cash price plus interest, at a more pessimistic 5-year life:

$$\frac{₱4,900}{5} = ₱980.00 \text{ per year}$$

(3) For the farmer to meet his payment of ₱700 per crop, he needs to earn:

$$₱700 \times 2 = ₱1,400.00 \text{ per year}$$

One can then estimate the farmer's break-even (B/E) work load to meet his payments or to compare with computed depreciation. The simplest form of the break-even formula is to compute a ratio of the amount of money needed to be paid or earned to the variable profit per unit of measurement. The ratio is:

$$B/E = \frac{\text{Fixed Cost}}{\text{Total Revenue} - \text{Variable Cost}}$$

The variable costs of tractor operation are the wages of the tractor operators, fuel, oil, and repair costs. Two men combine to operate a tractor at a daily wage of ₱5.00 plus meals and snacks. The cost may add up to ₱15.00 per day. Fuel cost per day is roughly ₱4.00. Not enough years of data and repairs have been collected to adequately estimate repair costs. Therefore, a repair cost of ₱100.00 per year, or for 100 days of operation, ₱1.00 per day.

Hand tractor contract rates vary from ₱25.00 to ₱35.00 per day. The latter amount is typical of rates in which meals are included.

Using these operating costs, the break-even point in terms of 8-hour work days is, for the three assumptions:

(1) Cash cost, 7-year life:

$$B/E = \frac{₱530.00}{₱35.00 - ₱15.00 - ₱4.00 - ₱1.00}$$

$$= \frac{₱530.00}{₱15.00}$$

$$= 35.3 \text{ days}$$

(2) Installment cost, 5-year life:

$$B/E = \frac{₱980.00}{₱15.00}$$

$$= 65.3 \text{ days}$$

(3) To meet yearly payment of ₱1,400.00:

$$B/E = \frac{₱1,400.00}{₱15.00}$$

$$= 93.3 \text{ days}$$

These requirements could be reduced by one-third if the owner is the operator of the machine.

From Table 24, the mean time to prepare one hectare of land by tractor is 27 hours, or 3.4 days. Then the number of hectares of land to be worked in order to cover the annual fixed cost is, for the low estimate, 35 ÷ 3.4 = 10.4 hectares; for the high estimate, 65.3 ÷ 3.4 = 19.4 hectares. Thus, if the contract rate is the appropriate measure, the farmer needs to prepare between 10 and 20 hectares of land per year in order to cover the yearly depreciation costs, and roughly 30 hectares to meet the semi-annual tractor payment.

Comparison of Hand Tractors and Animals

A series of trials were conducted in 1967 on four adjacent quarter-hectare plots at the IRRI experimental farm to compare the two power units. The plots were level, with clay soil and with about 150 grams of vegetative cover per square meter. Four 4- to 6-hp tractive type hand tractors with two operators each, and eight carabaos with their individual owners were used in the trials.

One hectare was subdivided into 16 plots in a Latin square. Individual plots measured approximately 25 m x 26 m. The area was flooded five days before the test. Soil depth was found to be approximately 18 cm, 28 cm, and 35 cm at a pressure of 20 psi, 35 psi, and 70 psi, respectively (Table 25). Hand tractors and carabaos started simultaneously in adjacent plots. Two plots were each plowed once and harrowed a few times by two hand tractors. The degree of puddling and incorporation of vegetation after each pass of the comb harrow was observed. Harrowing was stopped when the operators considered the plots comparable to outside farmers' fields ready for planting. Having completed one plowing, the two carabaos were then required to pass the comb harrow as many times as necessary to approximate the quality of work done by the hand tractors. The same procedure was followed in the other plots. As each pass with the plow was timed, and the number of passes and rounds noted, the effective field capacity was computed using the formula:

$$\text{EFC (sq m/hr)} = \frac{60 \times 2 \times N \times L \times W}{t}$$

where

60 = number of minutes in one hour
2 = number of trips per round
N = number of rounds
L = length of trip, meters
W - width of implement, meters
t = time used during operation, minutes

The plowing or harrowing time is arrived at by substituting values in the formula:

$$\text{Plowing or harrowing time per single pass (hrs/ha)} = \frac{10000}{A} \times T \times P$$

where

10,000 = number of square meters in a hectare
A = area of plot, sq m
T = time used during operation, hours
P = number of passes of the implement, usually one for plowing and several for harrowing

Table 26 shows that hand tractors with 18 cm moldboard plows have a mean effective field capacity of 311 sq m per hour. This would require 32.2 hours of plowing time per hectare. However, actual mean time used was only

12.90 hrs/ha. This indicates that the plows were cutting furrows 18 cm wide and covering unplowed strips about 27 cm wide. The mean depth of plowing was 18 cm. The plows, therefore, were working practically through soft soil with cone index of about 20 psi.

With the 137 cm comb harrows, the same hand tractors had to make 3 to 4 passes through the test plots to complete preparation of the land. These took 13.90 hrs/ha. However, with their mean effective field capacity of 2381 sq m/hr, 14.7 hours would be needed to harrow a hectare. This indicates that 6 percent of the area, at one time or another, was not harrowed. Adding up the time used for plowing and harrowing gives 26.80 ± 3.11 hours, or roughly 4.5 days to a hectare.

Table 27 gives data on the performance of the carabaos. With the 12 cm moldboard plows, the mean effective field capacity was 138 sq m/hr or 72.5 hrs/ha. The actual time, however, was only 36.34 hours, indicating 12 cm wide unplowed strips. The mean plowing depth was 16 cm.

With the 137 cm comb harrow, the carabaos had to traverse the test plots 9 to 13 times to achieve a finish comparable to that prepared by means of the hand tractors. These 9 to 13 passes took 83.41 hours to finish a hectare. Based on the mean effective field capacity of 1554 sq m/hr, 73.3 hours are needed to harrow a hectare, showing an overlapping of about 20 cm in the operation, or about 14 percent of the area was harrowed twice on each pass. Some 119.75 ± 29.54 hours (about 20 days) are needed to prepare a hectare for planting.

To determine the capacity of each during the crop year, we can start with an assumption of a 60-day period for land preparation for each crop. Remember that the crop requires 110-120 days or about 4 months to mature; for 2 crops, 8 months. When we add 60 days to each, we have the entire year.

For the carabao, with 20 to 25 days per hectare, the maximum is 2.5 to 3.0 hectares per season. For the hand tractor, with 3.5 to 6 days per hectare, the maximum hectarage per 60 days is 10 to 17 hectares. The interview data on hand tractors indicate a median of 4.0 hectares own land and 30 days of contract work. By our figures, this is roughly 10 hectares, and compares favorably with our assumptions.

Relative Cost of Operation of Hand Tractor and Carabao Power

Comparisons of the tractive type hand tractor and the carabao in land preapration can be made by using the current hire rates of each (Table 24). At a contract rate of ₱35.00 per day for the hand tractor and ₱8.00 per day for the man and the carabao, the cost of operation per hectare is:

	Plow	Harrow
Carabao	₱48.33	₱110.94
Tractor	₱ 56.50	₱ 60.88

Thus, the plowing cost is similar, while the big cost difference is in harrowing. One must remember, however, that most farmers own their carabaos. Since the opportunity cost of family labor may be zero, the ownership cost of the carabao is low.

Large Tractor Tests

Several large and medium-sized tractors were tested in Isabela Province where soils are firmer than at IRRI. The data are contained in Table 28.

Three large tractors of 55-70 hp, three medium-sized tractors of 11-14 hp, and one power tiller of 8.5 hp were tested during rotovation. One of the 55-70 hp tractors in second gear (high speed) had the highest effective field capacity. It rototilled 1.07 hectares in one hour with a fuel consumption of about 6.38 liters of diesel. However, the engine overheated at this high speed so that the operation was impractical. The other two large tractors registered an almost identical efc of about 0.71 ha/hr with a fuel consumption of 11.34 liters/ha for one and 8.45 liters/ha for the other. Wheel slippages were 24.38, 12.19, and 3.36 percent.

The medium-sized tractors had an efc of about 0.22, 0.19, and 0.12 ha/hr. The least fuel consumption was about 9.24 liters of diesel per hectare. Others: 14.65 liters (diesel) and 50.76 liters (gasoline). It can be noted in the table that the depths of cut for the medium-sized tractors were slightly deeper than that of the large tractors; this is because the areas where the former had worked were previously plowed while the areas for the latter were not.

Four makes of large tractors were tested for harrowing. One tractor with a 2.90 m wide comb harrow which allowed about 19 percent slippage on its cage wheels harrowed 1.03 hectares in one hour using 5.71 liters of fuel. Another harrowed a hectare of dry clay loam soil with a 2.04 m peg-tooth harrow in one hour and consumed 5.14 liters of diesel. In another field which was flooded and which had a silt loam texture, the same kind of tractor trailing a 2.50 m comb harrow had an efc of about 0.82 ha/hr. A 15-year-old tractor was also tested. It harrowed only 0.65 hectare in one hour and had a high fuel consumption of 9.37 liters/ha. Another tractor had an efc of about 0.62 ha/hr and 6.32 liters/ha of fuel consumption. It had a very high slippage of 25.34 percent.

Tests on plowing were conducted using five different kinds of large tractors. One had the highest efc of about 0.61 ha/hr, followed by 0.50 ha/hr, 0.42 ha/hr, 0.30 ha/hr, and 0.21 ha/hr. The fuel consumption was in this order: 17.09 liters, 14.76 liters, 9.63 liters, 8.01 liters, and 6.53 liters per hectare. All the tractors were fitted with pneumatic tires during the operations on dry fields. The least slippage was about 13.42 percent, followed by 14.03 percent, and the others had an almost identical 16 percent.

Ara-wheeling is a type of land preparation using only cage wheels. The tractor uses no attachment and pulverizes with its cage wheels the area which had been previously plowed. With a 55-70 hp tractor, an efc of 0.57 ha/hr was obtained, consuming 8.23 liters/ha. Traction on the wheels was fairly good and allowed only 2.49 percent slippage during the operation. The operator goes around and ends at the center of the field. This operation requires that he make three complete rounds before starting on a new pass.

Methods of Land Preparation in Isabela Province :

		Unit cost/ha	Total cost/ha
First method:	1 pass rotovator	₱ 65.00	₱ 65.00
	2 passes harrow drawn by tractor w/ leveling board	80.00	160.00
	Final harrowing + leveling w/ carabao	-	-
Second method:	Dry plowing	₱ 40.00	₱ 40.00
	2 passes harrow drawn by tractor w/ leveling board	80.00	160.00
	Final harrowing + leveling w/ carabao	-	-

Note: After plowing, the area is idle for 2-4 weeks before the next operation is made. (Given that the operator has the time).

Third method:	Dry plowing	₱ 40.00	₱ 40.00
	1 pass rotovator	45.00	45.00
	4 passes harrow drawn by carabao	-	-

Note: All operations are done on flooded conditions except when stated otherwise. All charges are on a contract basis.

Tractor operators are paid ₱5 to ₱6 per hectare and there are usually two operators for one tractor.

G. HARVESTING AND THRESHING

Harvesting is still typically done by hand in most areas of the Philippines. There have been some demonstrations of reapers, binders, and small and large combines, and a few machines in each category have been purchased. However, the large use of machinery is in stationary threshing.

With the development of the IRRI drum-type paddy thresher, a testing program has been underway to make tests on the IRRI threshers, and on the performance of other threshers in the Philippines.

Hand Threshing

Threshing by hand is still common in most areas of the country. One of the most popular threshing methods is to cut the straw long, and, holding the rice by the trundle, strike the panicles against a rock, log, or a wooden threshing frame called a hampas. The output of the hampas method has been studied, but the rate of output is extremely variable. However, the following data are presented as "typical".

Hand harvesting with sickles for the hampas means that the stalks are cut long enough so that the thresher will be able to swing the handle overhead and beat off the grain. On several timed tests, the average work rate was 137 man-hrs/ha.

Hand threshing on the hampas was timed at IRRI fields by local farm workers. Output will depend on the amount of grain per bundle (yield), the ease of shattering the rice, performance of the operator, and moisture content of the rice and stalks (especially in winnowing).

For two tests, with the rice at 18 percent moisture content, and a yield of 4500 kg/ha, the performance rate was, for each of both tests, 18 and 22 kg/man-hr, or 220 and 235 man-hrs/ha. Threshing loss was estimated to be 1-2 kg/hr, or from 5.8 to 8.6 percent of the output. (Part of the loss might be recoverable.) The timed operation included winnowing and cleaning.

McCormick Threshers

The large rice-growing areas currently rely on the large McCormick stationary threshers for threshing the major part of the crop. In Isabela Province, northeastern Luzon, data were obtained from farmers about their reaction to the machines. The procedure is to harvest the rice by hand, bundle the rice, and place these in small stacks (called mandalas) to dry, later to be restacked in large mandalas for threshing. The threshers operate on a contract basis; 5 percent of the threshed crops is usually sufficient for paying for their own crew and the large-hp tractor that drags the thresher through the paddies. Farmers interviewed in Isabela Province indicated that they were able to get their crop threshed within one to four weeks after harvest, subject to the availability of a threshing machine. Only a few indicated an unduly long wait before threshing. They did indicate that they thought the threshing charge was too high. The harvesting and threshing was not paid for together. The operator contracted and paid for the harvesters separately. A common practice is to pay a specific price per head per day. The most commonly mentioned price was ₱2.50 per day.

Thus, where the threshing was mechanized, the harvesting and threshing crews were separate. In contrast, in Laguna Province, harvesting and threshing are still done by hand, and the practice is to pay a crew for both operations.

Performance of the McCormick threshers. The tests were conducted in the provinces of Nueva Ecija, Bulacan, Tarlac, Pampanga and Pangasinan in Central Luzon and in Isabela Province of northeastern Luzon. Data on output, time used, fuel consumption, etc. were obtained by going with the men operating the threshers. In Isabela Province, for example, observations were made on only one thresher per day; thus the test crew had to follow the thresher wherever it went. This gives some insight on the output of a machine for a whole day's operation.

Data presented in Table 29 shows that the threshers observed could normally thresh an average of 60-70 cavans/hr of continuous threshing, depending on the yield and condition of the rice straw during threshing. It was observed that the separating loss was greater when threshing relatively moist paddy. Thus, farmers were reluctant to have their crop threshed early in the morning, not starting to thresh until about 0900.

Measurements were taken in such a manner that the threshing operation was not disrupted. Fuel consumption, for example, was not measured until after one "mandala" (a large stack) had been threshed. Separating and threshing losses were obtained by swinging the spout to another place for one minute or so and collecting the straw by laying a canvas on the ground. It was observed that these losses amounted to 40.98 kg/hr on the average.

The threshers observed used large tractors (both tractive and crawler types) of about 55-70 hp as prime movers. These tractors consumed an average of 4.34 liters of diesel per hour although one of the tractors, a crawler type, had a high fuel consumption of 6.16 liters to the hour. Since data on the amount of grease and oil used could not be measured directly during the tests, this information was obtained through personal interviews with the owners and/or operators of the machines. They indicated that they used an average of ₱6.50 of grease and ₱5.20 of oil per week.

All the threshers observed operated on a contract basis. The usual charge was 5 percent of the output although it ranged from a low 3.5 percent in Pangasinan, and a high 7 percent in Cagayan. This threshing fee was enough to pay for the expenses incurred and the wages of the threshing crew which numbered 12, on the average. Wages of workers are typically a certain percentage of output. These 12 persons and their corresponding wages are as follows:

1 tractor operator	-	₱3.45/100 cavans threshed
1 machinist	-	₱3.00/100 cavans threshed
6 thresher hands	-	₱6.33/100 cavans threshed (divided equally among them)
1 checker	-	₱2.00/100 cavans threshed
1 cook	-	₱2.16/day
1 agent	-	₱7.00/100 cavans threshed
1 sack collector	-	₱1.60/100 sacks collected

In addition to the expenses already mentioned, the owner of the threshers also give food to the threshing team. Furthermore, he has to secure a

municipalicense, mayor's permit, etc. One-half cavan from the 5 percent threshing fee goes to the barrio (village) government as fee.

Thresher Testing

In areas of high rainfall, an important element in choice of threshing machines is the capability of the various threshers to thresh and separate wet straw and grain. Handling wet palay is a feature of the newly introduced IRRI drum paddy thresher. As part of the development of this thresher, a number of other small threshing machines were tested, especially with relevance to wet grain and straw separation.

In general, it was found that not all threshers can thresh wet rough rice without grinding and milling the kernels, and that common dry straw separating techniques are not satisfactory when the straw is wet. And there seems to be a point (somewhere beyond 30 percent moisture content) at which no machine tested could perform.

The threshing practices in the Philippines are commonly of two kinds: one, where there are large areas of rice and where the rice matures at the end of the rainy season, the large tractor-drawn McCormick type threshing machine is used; two, threshing otherwise is accomplished by hand methods.

The sequence of operations with threshing machines ordinarily involves some delay for drying between harvesting and threshing. For wet conditions, a machine is needed that can thresh the rice immediately after harvesting so as to avoid large losses caused by the subsequent poor condition of the grain.

And in these areas where capital is short and labor relatively plentiful and low-cost, the requirements for a machine are economy of cost, simplicity of design, adaptability to local conditions, and, perhaps, local fabrication, and at least a medium output per man-hour.

The following threshers were tested:

1. IRRI drum-type paddy thresher powered by a 4.2-hp gasoline engine
2. IRRI table-type paddy thresher powered by a 4.2-hp gasoline engine
3. Japanese automatic thresher powered by a 4.2-hp gasoline engine
4. Locally made thresher Make A powered by a 10-hp diesel engine
5. Locally made thresher Make B powered by a 4.0-hp gasoline engine
6. Turner "Economy" thresher powered by a 10-hp gasoline engine
7. Vogel thresher powered by a 10-hp gasoline engine
8. Garvie Type DA thresher powered by a 12-hp diesel engine
9. Pedal thresher, manually operated

The detailed specifications of the threshers are listed in Table 30. The IRRI drum thresher was simultaneously tested with the other makes of threshers in the same field and with the same paddy variety. The paddy used in the tests were freshly harvested with a grain moisture content varying from 18 percent to above 30 percent. The method of feeding differed in each machine.

In the case of the IRRI drum-type paddy thresher, the 4-men pick-thresh method was employed. As in the earlier tests with this machine, good results were obtained by this method. The method of feeding for each machine is shown in Table 31.

The tests were conducted around Laguna and Isabela Provinces located in the southern and the northern parts of Luzon Island in the Philippines. The duration of the tests ranged from 15 minutes to 1 hour for every trial. The data were analyzed in three categories: (1) low output when threshing very wet grain; (2) average output; and (3) high output when feeding was at the maximum possible rate. The data shown in Table 31, particularly thresher output, grain m.c., and fuel consumption, are the average results of 5 to 10 tests. The thresher output (kg/hr) is adjusted to 14 percent m.c. level.

The data in Table 31 present some preliminary results. These data refer to the more conventional statistics on output, but moisture conditions (as a percentage figure) accompany the output figures. These figures are not necessarily indicative of output of the machines in very dry conditions, unless the moisture content is indicated as such. Company names have not been included. The criterion was to obtain as much field test data as possible under varying local conditions with emphasis on wet rice.

Table 32 lists the machine, power, labor and economic performance efficiency of the different threshers tested at IRRI. Both the IRRI drum-type and table-type threshers indicated satisfactory performance in almost all categories. The test showed that the IRRI drum and table threshers could thresh an average of 216.04 and 228.80 kg of palay per hour, respectively.

The Japanese thresher could not perform well at moisture levels of above 20 percent m.c. However, both the IRRI drum and table threshers did not indicate any moisture level limitations in threshing. The locally made thresher Make I performed without clogging when threshing wet rice but output was considerably reduced. All the other makes of threshers encountered severe clogging problem with paddy of above 20 percent m.c. level.

Economics of Use of Different Threshers

Mechanically powered threshers are gaining popularity in the tropical rice-growing regions. Because their cost is an important item in producing farm products, farmers are often faced with the choice between buying or hiring a threshing machine. While the shortage of labor during the harvest season may induce some farmers to purchase power threshers, most farmers would be interested in the relative cost of threshing by alternate methods (like hand threshing, using pedal thresher, trampling by animals, etc.) before purchasing a thresher. They would like to know the number of hectares or hours of use needed to make the machine pay. The various types of threshers available in the market and the availability of custom threshing make it increasingly difficult to pick the best machine and method of threshing.

This study was undertaken to derive the average costs of owning and operating some of the threshers currently available in the Philippines. Such information would be helpful to farmers in thresher selection and to thresher designers in developing new machines. The following analysis is primarily based on the data gathered at IRRI from performance tests conducted on a number of threshers. The following output for the threshers was found in the tests at IRRI:

Make of thresher	Output/hour	
	cavans	kilograms
1. IRRI drum-type paddy thresher		
Feeding method:		
(a) 4-man method (2 men pick-transfer and 2 men thresh)	4.02	176.88
(b) 5-man method (2 men pick-transfer and 3 men thresh)	5.70	250.80
(c) 6-man method (2 men pick-transfer and 4 men thresh)	7.15	314.60

Thresher Costs

There are two groups of factors that affect the cost of using a thresher: (1) factors related to machine ownership, and (2) factors related to machine operation. Costs associated with the first group of factors are referred to as fixed costs and costs associated with the latter are called variable costs.

Fixed costs result from mere ownership and will be incurred whether the thresher is used or not. In determining the fixed cost associated with the thresher ownership, only the depreciation and interest on investment were considered.

Depreciation is a typical cost item. It consists of: (1) depreciation due to use, i.e., loss of service capacity due to wear and (2) time depreciation, which is independent of use and is usually due to obsolescence, rust, decay, and other factors. Depreciation can be due to time and due to use. The common practice is to handle all depreciation as a fixed cost. In our analyses the straight-line method of computing depreciation was used. In this method, the service life of the machine is assumed, thus the yearly depreciation is:

$$\text{Depreciation} = \frac{\text{Original cost - Trade-in value}}{\text{Expected life}}$$

Annual interest costs were computed on average investment at the rate of 12 percent per annum. Average investment is half the sum of the purchase price and the resale value. Thus, the interest cost for any year is:

$$\text{Interest cost} = \frac{(\text{Value of machine for the year in question}) + (\text{Trade-in value})}{2} \times 0.12$$

As stated earlier, the fixed ownership costs are based on the investment in the machine and would vary with its price.

Variable cost is directly related to machine use and includes maintenance, repairs, fuel, lubricants, and labor. No wage data for threshing operations are available because the common practice in the Philippines is to pay for threshing in kind on the basis of the weight of the paddy threshed during the day. Therefore, the institutional agricultural wage rate of ₱3.50 per man-day was used in estimating labor cost. It was found that the labor cost for the IRRI drum-type paddy thresher for the four-man, five-man, and the six-man method of feeding would be ₱1.75, ₱2.19, and ₱2.62 per hour, respectively (Table 33). Table 33 also shows the hourly operating cost of the other threshers.

Total costs were calculated for the assumed number of hours of use over the estimated life of the machines. The fixed, variable, and total costs for the threshers are shown in Table 34. The hourly operating costs are shown in Table 35 for a wide range of hours of use.

To establish the economic feasibility of use of each machine, the break-even point for the number of hours of operation was calculated by the following formula:

$$B/E = \frac{FC}{TR-TVC}$$

where

B/E = number of hours of operation to break even with current threshing practices
FC = fixed cost
TR = total returns ("custom rate" which is 5% of output times price per cavan)
TVC = total variable cost (hourly operating cost)

The results are given below:

Machine	Break-even (hours)
A. IRRI paddy thresher	
(1) 4-man method	2062
(2) 5-man method	1612
(3) 6-man method	1104
B. Japanese automatic thresher	3445

The break-even point computations show that on the average, the choice of thresher will greatly depend upon utilization. To elucidate this point, let us turn to the IRRI drum-type paddy thresher. The average total cost per hour curves on the IRRI drum thresher are shown in Fig. 47. On the assumption that the custom rate for threshing is 5 percent of the threshing output (which is a typical threshing rate in the Philippines), the break-even point for the four-man, five-man, and six-man method would be about 2062, 1612, and 1104 hours, respectively. This is based on a ₱17/cavan (44 kg) price of paddy (rough rice). The price of paddy would have a marked influence on the break-even point and it may be attained earlier or later depending upon the direction of change in the price of paddy. Although the cost per hour increases considerably with the number of men used for feeding, the increase is sufficiently justified by the higher returns.

A wage rate of ₱3.50/man-day has been assumed, however, wages may be lower in some areas than others. Figure 47 illustrates this possibility. With a custom threshing rate of ₱4.84/hr, the break-even point for the five-man method is about 1612 hours. In other words, at this number of hours of use the threshing cost is the same by either method - owning the paddy thresher or custom threshing. Thus, with the five-man method, the least cost alternative is custom threshing up to 1612 hours. To generalize the analysis, various wage rates were substituted into the equation

$$C = F/A + V + L$$

where

C = custom rate per hour
F = fixed cost
A = break-even point in hours
V = operating costs per hour
L = labor cost per hour

Figure 48 shows the various combinations of labor wage and hours of use for the five-man feeding method. The curve separates the zones for which it costs less to custom hire or to own the paddy thresher. For all combinations of labor cost and hours of use to the right and below the line, it costs less to own the paddy thresher. The competitive position of custom hiring is, therefore, greater at higher wage rates and more hours of use are required to justify ownership of the machine.

TABLE 1. 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	-9.481	-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	96.83	173.9	-1333.0*	-2871.0	-1109.0*	-657.2**	38.38	-331.8	-74.35	-107.3	-140.0	-669.9*	399.9	-210.1	858.6	-296.2	-275.8	-333.3**
x_5 = number of weeks of leaf blight	-622.0	-715.2*	-630.3	-1058.0	-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	44.78	-731.1	-8.627	-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	-	167.8	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**	-148.2	157.2	421.6	503.9	104.2	296.4	673.7*	531.8**	165.0	309.7*	-532.1	201.8	165.3	-1.7.1	159.0	124.5	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	-4.850	-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	0.18
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 2. Rice varieties planted in Laguna and Central Luzon, 1967-1968 cropping season*

Variety	One-crop farm		Two-crop farm				Total
	Laguna	C. Luzon	1st crop Laguna	1st crop C. Luzon	2nd crop Laguna	2nd crop C. Luzon	
	Number of farms						
Tjeremas		15		1			16
Intan		13	1	1	12		27
Ramajah		7					7
BE-3		5					5
BPI-121		3					3
Raminad		2					2
Peta		1	1				2
Binato		1		14			15
Darrah		1					1
Piling Baybay	1		1				2
Not listed	3	3					6
IR-5**			2				2
IR-8**			22	6	13	4	45
Glutinous			9		1		10
BPI-76**			1				1
C4-63*			1				1
Wagwag			1		1		2
Thailand			1	1			2
Milagrosa				1			1
Cotabato			1				1
TOTAL	4	51	41	24	27	4	151

*Sample of farms.

**Improved varieties.

TABLE 3. Rice varieties planted in Isabela Province, 1967 wet season crop.

Variety	Number of farms grown
Intan	19
IR-8*	17
Raminad	12
Wagwag	8
Ramadja (Ramajah)	6
BPI-76*	5
Los Baños	4
Magsaysay	3
Ketchel (Seraup Ketchel)	4
Glutinous	2
Besar	2
Magralia	2
Peta	2
Milfor	2
Buenketan	2
IR-5*	1
BPI-121	1
F-76	1
Milagrosa	1
Binato	1
Tjeremas	1
C-4*	1
Bicol Selection	1
Magrasia	1
Miniranda	1
Zero	1
Londion	1
Binuldozer	1
Squad	1
TOTAL	104

*Improved varieties.

TABLE 4. Central Luzon: Mean yields from sampled 4 sq m plots, 1967-1968 crop year.*

Variety	No. of fields sampled	First crop
		- - - kg/ha of rough rice - - -
IR-8	28	4882.04
IR-5	2	4865.50
C4	1	4619.00
BPI-76	1	4548.00
Glutinous (Malagkit)	9	4132.67
Piling Baybay	1	3706.00
Darrah	1	3698.00
Thailand	2	3336.50
Binato	15	3148.93
BE-3	5	3136.60
Ramajah	7	3126.57
Raminad	2	3115.50
Cotabato	1	3055.00
Tjeremas	16	2987.81
Intan	14	2972.93
Peta	2	2827.00
Wagwag	1	2326.00
BPI-121 (Macapagal)	3	2142.00
Milagrosa	1	1758.00

*Sample of field.

TABLE 5. Materials in IRRI interview schedule for Central Luzon, 1966.

1. Name - address - household members
2. Field workers in the family
3. Tenure of operator
4. Land use
5. 1st and 2nd crop varieties and quantity of seeds
6. Cultural practices including equipment used
7. Calendar of operations, which includes:
   (a) field operation
   (b) date started and finished
   (c) total days elapsed for each operation (8-hour days)
   (d) number of men, animals and equipment listed by categories of:operator, family, hired and exchange labor
   (e) cost of cultural operations either in pesos or cavans of palay, and other remarks
8. Inventory of tools and equipment and work animals. (This includes the value of the item and the rental cost.)
9. Information on when the sample area was prepared relative to the other fields
10. Irrigation information: rainfed, gravity irrigated, pump irrigated, availability of water during growing season both in the rainy and dry seasons:
    (a) cost of irrigations
    (b) Note: There is no question on the type of pumps or depth of well
11. Landlord's name and address
12. Harvesting and milling operation and cost

TABLE 6. Farm equipment and animals owned, by area of farm (in percent), 1966-1967 Central Luzon survey.

Hectarage	No. of farms reporting	Tractor	Plow	Harrow*	Weeder	Sprayer	Carabao	Cattle
		- - - - - - - - - - - - -			-percent-	- - - - - - - - - - - - -		
Below 1.5	17**	(11)***	111	123	17	11	94	5
1.6 - 2.5	30	(16)	140	140	10	3	143	0
2.6 - 3.5	33	3(36)	142	163	18	12	163	15
3.6 - 5.5	16	(6)	212	218	12	18	231	0
5.6 - above	18	(11)	250	238	22	38	244	0
All farms	114	(16)a/	164	171	15	14	170	5

*Includes upland harrows used in lowland paddies, specifically in Pangasinan.
**Two farmers reported no equipment owned.
***Tractor hired.
a/Less than 1%.

Farm equipment and animals owned, actual numbers.

Hectarage	No. of farms reporting	Tractor	Plow	Harrow*	Weeder	Sprayer	Carabao	Cattle
Below 1.5	17	(2)*	19	21	3	2	16	1
1.6 - 2.5	30	(5)	42	42	3	1	43	0
2.6 - 3.5	33	1(12)	47	54	6	4	54	5
3.6 - 5.5	16	(1)	34	35	2	3	37	0
5.6 - above	18	(2)	45	43	4	7	44	0
All farms	114	1(22)	187	195	18	17	194	6

*Includes upland harrow used in lowland paddies, specifically in Pangasinan.
**Two farmers reported no equipment owned.
***Numbers enclosed are hired tractors.

TABLE 7. Number of farms, by size and tenure, Tacurong and Midsayap, Cotabato and Isabela, 1968*.

Size of farm (hectare)	Tenure: Full owner	Tenure: Part owner	Tenure: Tenant	All tenure groups
	Number of farms			
TACURONG, COTABATO				
0.1 - 1.9	1	-	3	4
2.0 - 3.9	11	-	14	25
4.0 - 4.9	19	-	6	25
6.0 - 7.9	2	-	-	2
8.0 - 9.9	1	-	-	1
10.0 - 11.9	1	-	-	1
12.0 - 13.9	-	1	-	1
46.0 & above**	4	-	-	4
All farms	39	1	23	63

*Sample of farms. **Sizes are 89, 65, 50 and 75.

MIDSAYAP, COTABATO				
0.1 - 1.9	2	-	20	22
2.0 - 3.9	3	2	14	19
4.0 - 5.9	-	-	-	-
6.0 - 7.9	2	1	1	4
All farms	7	3	35	45
ISABELA PROVINCE				
0.1 - 1.9	6	2	18	26
2.0 - 3.9	7	8	28	43
4.0 - 5.9	7	9	10	26
6.0 - 7.9	0	6	5	11
8.0 - 9.9	0	0	3	3
10.0 - 11.9	1	1	0	2
12.0 - 13.9	0	0	0	0
14.0 - 15.9	0	0	1	1
16.0 - 17.9	0	1	0	1
26.0 - 27.9	1	0	0	1
44.0 - 45.9	1	0	0	1
All farms	23	27	65	115

TABLE 8. Farm equipment and animals owned, by size of farm, 1967-1968, Cotabato and Isabela*.

Size of farm	No. of farms reporting	Tractor		Plow	Harrow	Weeder	Sprayer	Cart	Others**	Carabao					Cattle	Horse
		Owned	Rented							Owned		Worked		Total		
						(percent)				M***	F***	M***	F***			
TACURONG, COTABATO																
< 1.6	3	-	-	200	233	-	67	33	-	133	33	133	33	166	-	-
1.6 - 2.5	15	-	-	160	180	-	53	47	20	93	13	73	13	86	127	-
2.6 - 3.5	11	-	-	145	200	9	73	64	9	118	109	118	91	209	9	9
3.6 - 4.5	11	-	-	136	154	-	64	54	36	73	91	73	91	164	36	-
4.6 - 5.5	13	38	-	161	185	-	62	46	23	138	46	123	46	169	-	-
5.6 & above	10	110	-	270	280	10	590	210	140	270	30	260	30	290	130	10
All farms	63	25	-	173	198	3	146	76	40	133	54	124	51	175	59	3
MIDSAYAP, COTABATO																
< 1.6	21	-	5	167	100/5/	-	28	14	114	100	43	100	43	143	14	-
1.6 - 2.5	13	15	-	138	131	8	69	15	231	92	54	92(8)	54	146(8)	-	-
2.6 - 3.5	6	-	-	183	250	-	50	167	67	100	167	100	167	267	-	-
3.6 - 4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.6 - 5.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.6 & above	5	-	-	260	160	60	60	20	180	200	40	200	40	240	-	-
All farms	45	4	2	171	135/2/	9	47	35	149	109	62	109(2)	62	171(2)	7	-
ISABELA																
< 1.6	20	-	-	100	95	15	5	30	70	65	35	60	35	95	15	-
1.6 - 2.5	21	-	-	148	105	71	24	43	81	110	28	105	24	129	76	5
2.6 - 3.5	29	3	-	141	128	21	28	45	93	117	45	110	41	151	21	-
3.6 - 4.5	14	-	-	150	164	64	21	71	114	136	50	128	43	171	7	-
4.6 - 5.5	18	-	-	189	172	39	33	78	106	144	89	144	78	222	11	-
5.6 & above	22	18	-	204	204	45	59	73	132	204	82	191	68	259	23	5
All farms	124	4	-	155	143	40	29	56	98	129	54	122	48	170	27	1

*Sample of farm.
/ /Borrowed.
( )Rented.
**Includes sleds, calesa, harvest tools, etc.
***Male, female carabaos.

TABLE 9. Indications of a labor shortage, taken from interview data, 1968*.

Operation	Yes				No				No answer
	All hired labor	Some hired labor	No hired labor	Total	All hired labor	Some hired labor	No hired labor	Total	
TACURONG, COTABATO - 63 farms									
Plowing - harrowing		8	2	10	5	40	6	51	2
Pulling seedling & transplanting/planting	12	1		13	17	9	22	48	2
Weeding/cultivation	3		5	8	5	6	42	53	2
Hiring more weeders				7				54	2
Harvesting & threshing	2		1	3	16	22	20	58	2
MIDSAYAP, COTABATO - 45 farms									
Plowing-harrowing	1		3	4	1	13	27	41	
Pulling seedling & transplanting/planting	2	2	1	5	12	22	6	40	
Weeding/cultivation			4	4	2	3	36	41	
Hiring more weeders				6				36	3
Harvesting & threshing			1	1	17	17	10	44	
ISABELA - 124 farms									
Plowing-harrowing	3	22	37	62	1	30	31	62	
Pulling seedlings & transplanting/planting	22	14	4	40	36	42	6	84	
Weeding/cultivation	1		25	26	3	16	79	98	
Hiring more weeders				24				59	41
Harvesting & threshing	6	23	4	33	15	72	4	91	

*Farmer responses are listed under the category of whether the farmer used hired labor for that operation, some, or no hired labor.

TABLE 9(a). Difficulty in hiring labor, by area and operation, 1966-1967 survey.

Central Luzon

Province	No. of farms surveyed	No. of farmers indicating difficulty in hiring labor			
		Plowing & harrowing	Pulling seedling & transplanting	Weeding	Harvesting
Laguna	11	2	0	0	0
Bulacan	24	9	3	2	2
Nueva Ecija	53	12	7	6	6
Pangasinan	17	10	1	0	0
Tarlac	5	3	2	0	1
Pampanga	6	3	0	0	0
TOTAL	116	39	13	8	9

TABLE 10. 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	-	-	-	-	-	-	.18
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 11. 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.[illegible]	-	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 12. 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 13. 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 14. 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 15. Cost of producing rice per hectare, Laguna and Central Luzon, 1967-1968.

Items	Irrigated 2 crops	Irrigated 1 crop	Rainfed	All farms
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 P3.50/man-day.
*** Shares in kind for services like harvesting and threshing.

TABLE 16. 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			
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 P3.50/man-day.
**Shares in kind for services like harvesting and threshing.

TABLE 17. 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:				
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	-	1.07	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
	[illegible]	[illegible]	[illegible]	[illegible]

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

**Labor entered at the rate of P3.50 per man-day.

TABLE 18. Average farm expenses per hectare, Tacurong, Cotabato, 1967-1968.

Item	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:						
Hired labor including food	91.94	46.29	146.70	37.85	99.92	40.46
Fertilizer	1.74	-	5.98	-	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 P3.50/man-day.
**Shares in kind for services like harvesting and threshing.

TABLE 19. 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

TABLE 20. Performance test of IRRI power weeder on different plant height.*

Plot	Plant age (DAT)**	Plant height (cm)	Rate of machine (man-hr/ha)	Fuel consumption (lit/hr)	Hills damaged per hectare	Remarks
1	18	10-20	18.5	0.72	666	Hills buried in soft mud which did not recorver as inspected 10 days after weeding.
	18	10-20	20.8	0.71	832	
2	22	20-25	16.4	0.74	0	Fairly good performance: damaged hills were mostly thos not in a straight row.
	22	20-25	13.9	0.75	56	
3	24	25-30	13.8	0.70	83	"
	24	25-30	12.4	0.66	50	
4	26	30-35	16.7	0.69	33	"
5	38	41-50	12.0	0.66	0	Plants that had been bent during weeding were found to have recovered, as inspected 10 days after weeding.
	38	41-50	13.9	0.62	0	
6	50	60+	20.0	0.75	400	Bent and broken tillers; sprouts seen growing as inspected 10 days after weeding.
		Average	15.84	0.70		

*Data taken from results of 30-minute trials.
**Days after transplanting.

TABLE 21. Comprehensive evaluation of weeding methods in flooded rice, 1968 wet season at IRRI (date of transplanting, August 31) (21-day old seedling).

Treatment	Rate (kg ai/ha)	Time of Application
1. (RW) 2x		23 & 35 DAT
2. (HW) 2x		23 & 35 DAT
3. (PPW) 2x		23 & 35 DAT
4. (RW) fb (HW)		23 & 35 DAT
5. (PPW) fb (HW)		23 & 35 DAT
6. (RW) 1x		25 DAT
7. (HW) 1x		25 DAT
8. (PPW) 1x		25 DAT
9. MCPA fb (RW)	.8	25 & 35 DAT
10. MCPA fb (HW)	.8	25 & 35 DAT
11. MCPA fb (PPW)	.8	25 & 35 DAT
12. Trifluralin + MCPA (G)	.7 + .4	4 DAT
13. Nitrofen + 2 4D IPE (G)	2.0 + .8	4 DAT
14. EPTC + MCPA	1.75 + .7	4 DAT
15. No (HW)		

Plot size: (2 varieties) 4.5 x 6m = 54 m + 1 m space between plots for turning.
Design: Split block of 3 replications (with systematic arrangement of whole plot)
Varieties: IR8-68 and Chianung 242

(RW) = push type rotary weeding
1x, 2x = one time, two times
(PPW) = IRRI portable power weeder (experimental)
fb = followed by
(HW) = hand weeding

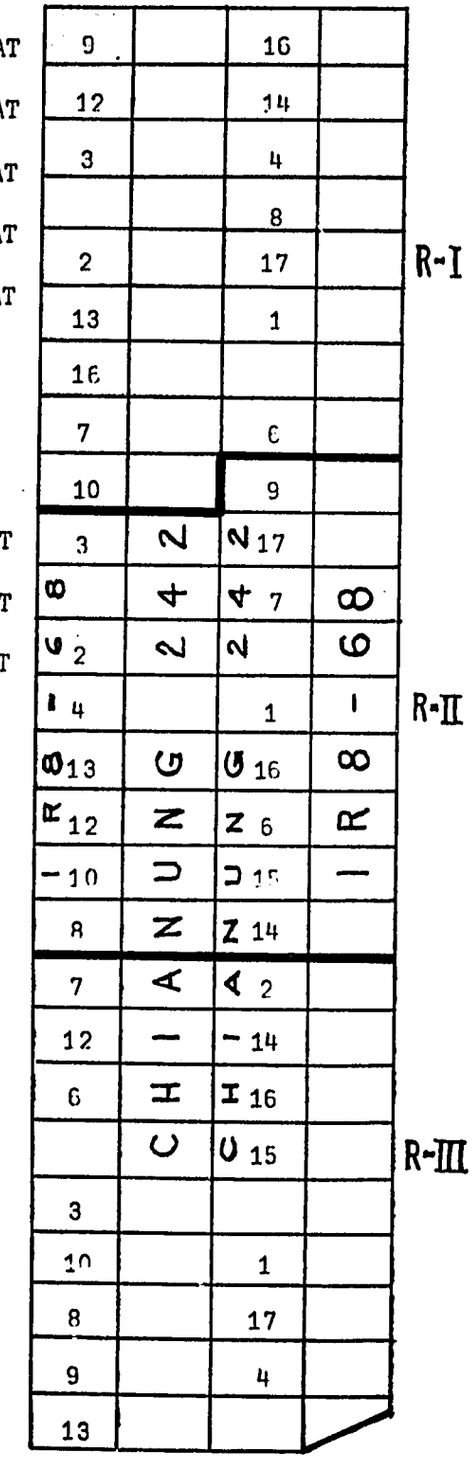


TABLE 22. A comparative evaluation of weeding methods in flooded rice, IRRI, 1968 wet season.

Method	IR8		Chianung 242		Yield means[2] for both varieties (kg/ha)	Yield means[2] for IR8 (kg/ha)	Labor (man-hours per hectare)	Evaluation of weeding returns (kg rough rice/ha)			
	Weeds at 45 DAT[1] per m^2	Weed weight at harvest (gm/m^2)	Weeds at 45 DAT per m^2	Weed weight at harvest (gm/m^2)				Rice earned per man-hour	Cost of labor[3]	Cost of chemical and gasoline[4]	Yield increase (net of weeding cost)
1 Rotary weeding 2x	84	56.33	196	320.00	2416[b]	3112[b]	200	6	350	0	862
2 Hand weeding 2x	58	24.67	122	110.00	2966[ab]	3952[ab]	500	4	875	0	887
3 IRRI power weeder 2x	106	23.33	177	133.67	2939[ab]	4022[ab]	50	35	88	85	1562
4 Rotary weeding fb hand weeding	149	13.33	120	35.33	2827[ab]	3520[ab]	310	5	542	0	1081
5 IRRI power weeder fb hand weeding	93	7.33	133	150.67	2779[ab]	3640[ab]	320	5	560	37	978
6 Rotary weeding 1x	96	139.33	214	242.33	2426[b]	3266[b]	90	14	158	0	1064
7 Hand weeding 1x	44	26.33	117	202.00	3604[a]	4904[a]	240	10	420	0	1980
8 IRRI power weeder 1x	94	129.00	145	340.67	2328[b]	3228[b]	25	45	44	42	1038
9 MCPA fb rotary weeding	18	20.33	57	32.33	3180[ab]	4032[ab]	104	19	182	35	2193
10 MCPA fb hand weeding	2	2.67	9	25.00	3084[ab]	3688[ab]	260	7	455	35	1390
11 MCPA fb IRRI power weeder	9	0	10	38.33	3657[a]	4696[a]	36	68	63	73	2317
12 Trifluralin + MCPA (G)	6	7.67	8	16.33	3546[a]	4656[a]	8	293	14	256	2072
13 Nitrofen + 2,4D IPE (G)	0	0	0	8.67	3285[ab]	4176[ab]	11	189	19	266	1796
14 EPTC + MCPA (G)	0	0	1	12.33	2777[ab]	3872[ab]	8	197	14	266	1293
15 No weeding (control)	385	214.67	339	550.00	1204[c]	1914[c]	CV(b) = 24.6% for all means CV(b) = 18.8% for IR8 means				

[1] Days after transplanting.

[2] Any 2 means followed by the same letter are not significantly different at 5% level by the Duncan multiple range test.

[3] Cost of labor - ₱0.50/man-hr = 1.75 kg rough rice.

[4] Cost of (a) chemical: Trifluralin + MCPA (.7 + .4 kg active ingredient/ha) = ₱73.
Nitrofen + 2,4D IPE (G) (2.0 + .8 kg active ingredient/ha) = ₱76.
EPTC + MCPA (1.75 + .7 kg active ingredient/ha) = ₱76.
MCPA (0.8 kg active ingredient/ha) = ₱10.

(b) gasoline consumption/ha = ₱12.

TABLE 23. Hand tractor survey data: Laguna, 1967.

AGE OF ALL MACHINES:

Total no. of machines	Months			Years													
	1	2-5	6-12	1	2	3	4	5	6	7	8	10	12	13	14	No data	New
434	11	54	34	93	88	55	35	33	12	4	4	1	1	1	2	3	3

HIRING FEE OF ALL MACHINES: (pesos/day)

Total no. of machines	₱7	₱25	₱30	₱35	₱40	₱45	₱50	₱55	₱60	₱65	₱70	₱75	₱80	₱90	₱120	No data	No idea	Machine not hired
434	1	69	191	13	10	1	2	1	6	1	5	1	5	9	5	28	51	35

AREA WORKED ON OWN FARM BY ALL MACHINES (ha/tractor)

Total no. of machines	0.7	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	8.5	9.0	10	11	12	13	14	18	19	19.5	20	21	24	No data	No idea
434	1	10	16	54	22	55	28	75	11	37	3	23	2	12	13	3	4	16	4	5	2	3	3	1	3	2	1	2	19	4

NO. OF DAYS THE MACHINES WERE HIRED OUT PER YEAR

Total no. of machines	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	76-80	81-85	86-90	91-120	121-160	No data	No idea
434	4	22	41	48	8	55	11	33	26	13	2	15	3	2	1	5	2	1	89	62

TABLE 24. Plowing and harrowing: carabao and hand tractor (6 hp).*

Item	Mean time		Actual range
	efc**	Actual	
	- - - - - - - hours per hectare - - - - - -		
Plowing:			
Carabao	72.5	36.3	28.8 - 41.2
Tractor	32.2	12.9	11.2 - 14.6
Harrowing:			
Carabao	73.3	83.4	55.5 - 109.5
Tractor	14.7	13.9	11.3 - 16.6
Cost comparisons (₱/ha):			
Plowing:			
Carabao	96.67	48.33	
Tractor	141.04	56.50	
Harrowing:			
Carabao	97.70	110.94	
Tractor	64.39	60.88	
Total cost of land preparation:			
Carabao	194.37	159.27	
Tractor	205.43	117.38	

*Tests conducted on IRRI soils. Plowing - one pass. Harrowing-judged to be "adequate" at 9-13 passes of the carabao and 3-4 passes of the tractor.

**The efc times are computed to provide a relative indication of the time to prepare a field fully. During actual land preparation, considerable undertilling was noted.

Contract rates: tractor - ₱35.00 per 8-hour day, or ₱4.38 per hour.
carabao - ₱8.00 per 6-hour day, or ₱1.33 per hour.

TABLE 25. Gasoline used for preparing flooded IRRI ricefields from stubble to final puddle using 4- to 6-rated horsepower two-wheel tractive type tillers (field condition: stubble - soft).

Weed weight gm/m²	Soil depth cm* 20-35-70	Area m²	Number of passes and liters of fuel used per hectare: Plowing	Harrowing	Leveling	Total
No record	15 20 29	2623	0 - -	4 -23.01 (5.75)	1 -1.91	24.9
No record	17 22 27	2624	0 - -	5 -27.05 (5.41)	1 -2.47	29.5
No record	16 25 31	2667	1 -12.13	6 -28.61 (4.77)	1 -1.99	42.7
156	15 25 33	2675	0 - -	7 -32.97 (4.71)	1 -2.19	35.2
116	15 24 31	2667	1 - 10.55	5 -23.47 (4.70)	1 -2.96	37.0
125	15 22 30	1320	0 - -	4 -24.24 (6.06)	1 -2.93	27.2
169	14 24 34	2656	1 -11.60	5 -24.72 (4.94)	1 -2.90	39.2
134	17 23 34	2642	1 -11.79	5 -22.14 (4.43)	1 -2.23	36.2
480	21 25 35	647	0 - -	7 -40.42 (5.77)	1 -2.05	42.5
480	21 25 35	647	0 - -	7 -35.70 (5.10)	1 -2.05	37.7
98	16 21 29	667	1 -15.59	5 -19.41 (3.88)	1 -2.29	37.2
98	16 21 29	667	1 -14.54	7 -27.96 (3.99)	1 -2.29	44.7
170	14 26 36	673	1 -14.26	7 -30.01 (4.29)	1 -2.64	46.9
170	14 26 36	673	1 -11.89	5 -32.24 (6.44)	1 -2.64	46.8
135	24 34 38	669	1 -20.60	4 -25.19 (6.30)	1 -1.37	47.2
135	24 34 38	669	1 -16.22	4 -24.29 (6.07)	1 -1.37	41.9
203	17 29 37	668	1 -21.86	5 -31.51 (6.30)	1 -1.78	55.1
203	17 29 37	668	1 -22.45	7 -21.78 (3.11)	1 -1.78	46.0
Average per pass			1.0-15.3	5.5-27.5 (5.11)	1.0-2.21	39.9

*Depth in centimeters before the soil resistance is 20, 35, and 70 psi on a standard U.S. Army Corps of Engineers WES Cone Penetrometer.

TABLE 26. Performance of the 4- to 6-hp tractive type hand tractor in wetland preparation.

Plowing with 18 cm moldboard plow			Harrowing with 137 cm comb harrow			
Number of passes	Effective field capacity	Plowing time	Number of passes	Mean effective field capacity	Total harrowing time	Total tillage time
	m^2/hr	hr/ha		m^2/hr	hr/ha	
1	341	13.00	3	2524	11.31	24.31
1	264	13.10	4	2625	15.32	28.42
1	255	12.82	4	2423	15.17	27.99
1	250	14.60	3	1739	13.31	27.92
1	363	11.22	4	2271	16.62	27.85
1	279	11.58	3	2698	13.39	24.98
1	325	14.43	3	2427	11.44	25.87
1	415	12.47	4	2344	14.61	27.08
ΣX	2492	103.24	28	19051	111.17	214.41
$\bar{X}$	311	12.90	3.5	2381	13.90	26.80
2 s	119	2.39	1.1	590	3.77	3.11

TABLE 27. Performance of the carabao in wetland preparation.

Plowing with 12 cm moldboard plow			Harrowing with 137 cm comb harrow			
Number of passes	Effective field capacity	Plowing time	Number of passes	Mean effective field capacity	Total harrowing time	Total tillage time
	m^2/hr	hr/ha		m^2/hr	hr/ha	
1	137	40.84	12	1950	69.32	110.16
1	146	41.24	10	1668	55.45	96.70
1	149	35.99	12	1822	76.16	112.15
1	158	39.06	13	1606	91.01	130.07
1	119	33.27	9	1085	91.16	124.43
1	139	35.75	12	1331	109.45	145.21
1	131	35.82	13	1555	89.54	125.36
1	125	28.76	10	1412	85.18	113.93
ΣX	1104	290.73	91	12429	667.27	958.01
$\bar{X}$	138	36.34	11.4	1554	83.41	119.75
2 s	26	8.26	2.0	552	32.68	29.54

TABLE 28. PERFORMANCE OF LARGE AND MEDIUM-SIZED TRACTORS: LAND PREPARATION IN THE RICE FIELDS OF ISABELA PROVINCE, CAGAYAN VALLEY, PHILIPPINES, 1968

CODE	BHP	AGE OF TRACTOR/ ATTACHMENT	SPEED COMBINATION USED DURING OPERATION	TYPE OF TRACTIVE DEVICE, CM (W x DIA.)	SLIPPAGE %	WIDTH OF ATTACHMENT M	EFFEC. FIELD CAPA. M^2/HR	EFFEC. FIELD CAPA. M^2/BHP-HR	FUEL CONSUMP. LIT/HA	UNROTOTILLED/ UNPLOWED/NOT HARROWED, M^2	OVERLAP M^2	DEPTH OF TILLAGE CM	SOIL TYPE	SOIL DEPTH AT RESISTANCE OF 35 psi BEFORE THE OPERATION IN	SOIL DEPTH AT RESISTANCE OF 70 psi BEFORE THE OPERATION CM	SOIL COND. ON DAY OF OPERATION	DURATION OF FLOODING, DAYS BEFORE OPERATION	DEPTH OF WATER CM	NO. OF YEARS EXPER. OF OPERATOR
1. ROTAVATION																			
I-A	55-70	T - 8 mo R - 1 yr	Engine - 2nd (H) Rotor - (L)	Paddy Wheel (51 x 141)	12.19	1.66	10705.75	194.65	6.38		684.48	14.5	Sandy cl-loam	12	18	Flooded	7.0	14.8	3.0
I-B	55-70	T - 3 yr R - 1 yr	Engine - 1st (H) Rotor - (H)	Paddy Wheel (51 x 141)	24.38	1.52	7116.96	121.66	11.34	11.45		10.3	-do-	12	17	-do-	4.0	9.4	2.0
I-C	55-70	T - 8 mo R - 1 yr	Engine - 2nd (H) Rotor - (L)	Paddy Wheel (51 x 142)	3.36	1.52	7095.30	113.52	8.45	1779.40		14.8	-do-	12	15	-do-	1.0	7.8	2.0
I-D*	14.0	T & R-7 mo	Engine - 2nd (L) Rotor - 1st (L)	Paddy Wheel (17 x 84)	20.58	1.00	2178.43	115.60	9.24		64.80	14.0	Silt loam	5	22	Saturated	0	0	2.0
I-E*	11.0	T & R-3 yr	Engine - 2nd (L) Rotor - 2nd (L)	Paddy Wheel (20.5 x 74.5)	10.54	0.94	1229.42	111.77	14.65	75.22		16.4	-do-	21	24	Flooded	1.0	1.0	2.0
I-F*	12.0	T & R-2 yr	Engine - 2nd (L) Rotor - (H)	Paddy Wheel (36 x 69)	7.38	1.03	1928.12	160.68	50.76		7.66	17.0	-do-	21	24	Saturated	0	0	1.0
2. HARROWING																			
II-G	55-70	T & H - 2.5 yr	Engine- 4th (L)	Ara Wheels (61 x 145)	3.36	Home-made comb 2.51	8243.89	122.13	5.10	17.58		15.4	-do-	16	20	Flooded	0	11.7	5.0
II-C	35-45	T & H - 1.25 "	Engine- 3rd (L)	Cage Wheels (61 x 126)	25.34	Home-made comb 2.97	6166.99	158.13	6.32		546.12	13.5	-do-	13	15	-do-	1.0	13.2	5.0
II-G	35-45	T & H - 15 yr	Engine- 2nd (L)	Ara Wheels (61 x 149.5)		Two-way disc 2.00	6523.76	144.97	9.37		4132.80	9.0	-do-	2	4	-do-	3.0	10.3	2.0
II-G	55-70	T & H < 1 yr	Engine- 1st (H)	Pneumatic tires (33 x 155)	13.21	Pegtooth 2.04	10054.28	148.95	5.14		86.14	12.0	-do-	4	6	dry		-	4.0
II-C	55-70	T & H 2 yr	Engine- 2nd (L)	Cage Wheels (61 x 140)	19.02	Home-made 2.90	10308.37	187.42	5.71		545.95	12.1	-do-	14	17	Flooded	0	3.0	4.0
3. ARA-WHEELING																			
III-G	55-70	T - 2.5 yr	Engine- 4th (L)	Ara Wheels (61 x 145)	2.49		5676.39	84.09	8.23	45.30		16.1	-do-	18	23	Flooded	0	9.6	5.0
6. PLOWING																			
IV-A*	28 BHp	T & P-1.5 yr	Engine- 3rd (L)	Pneumatic tires (28 x 140)	16.15	2 - disc 0.80	2074.84	74.10	14.76	124.95		18.0	-do-	2	4	dry		- 09	5.0
IV-B*	55-70	T & P-1.66 "	Engine- 3rd (L)	Ditto(40 x 140)	13.42	4 - disc 1.40	6075.30	110.46	9.63		551.88	18.0	-do-	2	3	dry		- 10	5.0
IV-G*	55-70	T & P < 1 yr	Engine- 4th (L)	Ditto(33 x 155)	16.56	4 - disc 1.22	4152.50	61.52	17.89		79.24	20.7	-do-	3	5	dry		- 09	10.0
IV-C	35-45	T & P 3 yr	Engine- 2nd (L)	Ditto(28 x 140)	16.83	3 - disc 1.07	3036.01	84.33	6.53	1097.36		15.0	-do-	2	4	dry		- 05	< 1
IV-B	55-70	T & P 3 yr		Ditto(33 x 158)	14.04	4 - disc 1.40	5003.34	85.53	8.01		82.19	14.8	-do-	1	3	dry		- 05	4.0

* Tractor demonstration at San Mateo, Isabela.
ARA-WHEELING: Land preparation by cage wheels only.

TABLE 29. Performance of large stationary threshers, 1968-1969.

Item	Case				All cases
	1	2	3	4	
Time consumed (hrs)	4.08	1.20	4.28	4.55	3.53
Quantity of fuel used (liters)	14.50	4.65	26.35	20.45	16.48
Fuel consumption (liters/hr)	3.56	3.87	6.16	4.50	4.66
Threshed grain (cavans)	204.06	66.44	329.89	385.04	246.36
Threshing rate (cavans/hr)	50.00	55.37	77.07	84.62	69.79
Threshing loss (kg/hr)	3.00	3.51	2.98	60.14	17.40
Separating loss (kg/hr)	28.20	22.27	25.05	54.83	32.58
Total grain loss (kg/hr)	31.20	25.78	28.03	117.97	49.98
Total grain loss as percentage of output	1.42	1.06	a/	3.17	1.62
Threshing crew	11	12	10	12	11
Threshing fee (percentage of of output)	5	5	5	5	5

a/ Less than 1%.

TABLE 30. Specifications of different threshers.

Thresher model	Dimensions			Cylinder		Type of threshing cylinder	Engine		Weight of machine including engine (kg)
	Length (mm)	Width (mm)	Height (mm)	Width x dia (mm)	Rpm		Make	Hp	
IRRI drum-type	3570	830	870	500 x 2270	300	U-shaped wire loop	Honda	4.2	500
IRRI table-type	1550	1550	1080	1117*	130	U-shaped wire loop	Honda	4.2	175
Japanese Automatic Model D2L	1100	530	1020	500 x 460	450	U-shaped wire loop	Honda	4.2	150
Locally made thresher I	-	-	-	560 x 485	750	U-shaped wire loop	Diter	10.0**	975
Locally made thresher II	-	-	-	925 x 400	500	U-shaped wire loop	Kawasaki	4.0	-
Turner "Economy"	3400	765	1560	705 x 330	680	Rasp bar	Wisconsin	10.0	820
Garvie Type DA	3962	1575	2083	470 x 508	1450	Rasp bar	Hosch	12.0**	545
Vogel	1820	754	1830	504 x 300	800	Spike tooth	Wisconsin	10.0	-

*Diameter of thresher.
**Diesel engine.

TABLE 31. Comparative output of different threshers.

Thresher model	Thresher output, 14% moisture content						Fuel (gas) consumption (liter/hr)	Method** of feeding	Grain yield (kg/hr)	Variety
	Low (kg/hr)	M.C.* %	Average (kg/hr)	M.C.* %	High (kg/hr)	M.C.* %				
IRRI drum-type	46.48	32.0	127.53	24.9	326.16	18.0	1.09	1	2640	Mixed
IRRI drum-type (Clinton)	80.76	25.4	147.0	21.80	249.80	26.0	1.47	1	3300	Mixed
IRRI drum-type (GAMI)	160.76	18.20	212.68	18.20	252.16	18.6	1.39	1	2772	Mixed
IRRI table-type	181.78	32.0	228.86	24.38	267.0	19.3	0.67	1	5280	IR5
Japanese Automatic D2L	86.64	31.0	89.73	30.37	95.28	30.0	0.87	4	3300	IR8
Japanese Automatic TF50	123.92	26.0	195.52	21.80	261.60	19.6	1.81	4	5280	IR5
Locally-made thresher I	27.56	24.0	117.13	20.77	186.28	19.5	1.67***	3	2200	C-4
Locally-made thresher II	131.54	18.50	158.50	18.0	181.65	17.0	2.45	2	Unknown	Mixed
Turner "Economy"	163.68	32.0	171.14	31.30	180.72	30.0	1.74	3	3080	C-4
Garvie Type DA	143.92	32.0	163.28	32.0	204.0	32.0	1.43***	3	5280	IR5
Vogel	103.0	32.0	118.76	32.0	130.0	32.0	1.93	4	Unknown	Mixed
Pedal	61.35	19.8	89.19	19.8	117.04	19.8	-	2	Unknown	IR5

*Grain moisture content during threshing.
**Method of feeding: (1) 4 men pick-thresh, (2) 2 men pick-thresh, (3) 2 men pick-transfer and 1 man thresh, and (4) 1 man pick-transfer and 1 man thresh.
***Diesel fuel.

TABLE 32. Comparative performance of selected rice threshers*.

Thresher model	Performance								
	Machine		Power		Labor			Economic	
	Kg/hr	Ha/hr**	Engine hp	Hp-hr per 44 kg	Number of men***	Man-hr per ha**	Grain output per man-hr (kg)	Machine cost (₱)	Threshing cost per 44 kg (₱)
IRRI drum-type:									
Low feed	160.60	0.0365	4.2	1.095	5	136.98	32.12	2500	1.392
Average feed	216.04	0.0491	4.2	0.855	5	101.83	43.21	2500	1.035
High feed	252.12	0.05373	4.2	0.695	5	87.26	50.42	2500	0.887
IRRI table-type	228.80	0.0520	4.2	0.807	5	96.17	45.76	1800	0.657
Japanese automatic	195.36	0.0444	4.2	0.946	3	67.56	65.12	3500	0.765
Locally-made thresher I	117.04	0.026	12.5	4.700	4	172.94	29.26	6750	1.512
Locally-made thresher II	158.40	0.0360	4.0	1.333	3	83.33	52.80	2464	0.9308
Turner "Economy"	170.72	0.0388	10.0	2.577	4	120.00	39.60	-	-
Garvie Type DA	163.24	0.0371	17.5	4.717	4	107.85	40.79	-	-
Vogel Nursery	126.72	0.0288	10.0	3.473	4	138.81	31.68	-	-
Pedal	68.64	0.0156	-	-	2	128.20	34.32		

*These results are indicative of output under the conditions noted. The threshers may function differently under other environmental conditions. Especially to be considered are the moisture content of the grain and straw, and the type of harvesting to best facilitate economical and rapid threshing.

**Based on 4400 kg/ha yield.

***Number of men includes one man who collects and sacks the grain.

TABLE 33. Hourly operating cost of different threshers.

Item	IRRI paddy power thresher			Japanese automatic thresher	Locally made thresher	
	4 men	5 men	6 men	3 men	Make I 4 men	Make II 3 men
	pesos per hour					
Labor	1.75	2.19	2.62	1.31	1.75	1.31
Fuel	0.43	0.43	0.43	0.51	0.45	0.70
Oil	0.009	0.009	0.009	0.012	0.015	0.009
Repairs	0.47	0.47	0.47	0.66	0.63	0.46
Total	2.66	3.10	3.53	2.60	2.98	2.48

TABLE 34. Total cost of using different threshers.

Item	IRRI drum-type paddy thresher	Japanese automatic thresher	Locally made thresher Make I	Locally made thresher Make II
	in pesos			
Initial cost	2,500.00	3,500.00	6,750.00	2,464.00
Estimated service life*	3,200 hrs (5 yrs)	3,200 hrs (5 yrs)	6,400 hrs (10 yrs)	3,200 hrs (5 yrs)
Fixed Cost (Cost of ownership)				
Depreciation (assuming a trade-in value 10% of initial cost)	2,250.00	3,150.00	6,075.00	2,217.60
Interest (12% a year)	555.00	777	2,814.75	547.00
Total	2,805.00	3,927.00	8,889.75	2,764.60
Variable Cost (Cost of operation)				
Repairs (60% of initial cost)	1,500.00	2,100.00	4,050.00	1,478.40
Fuels (₱0.286/liter)	1,372.80	1,625.57	2,928.64	2,242.24
Oil (₱1.50/liter)	30.00	40.00	100.00	30.00
Labor (₱3.50/man-day)				
3 men		4,200.00		4,200.00
4 men	5,600.00		11,200.00	
5 men	7,000.00			
6 men	8,400.00			
Total				
3 men		7,965.57		7,950.64
4 men	8,502.80		18,278.64	
5 men	9,902.80			
6 men	11,302.80			
Total Cost				
3 men		11,892.57		10,715.24
4 men	11,307.80			
5 men	12,707.80			
6 men	14,107.80			

*Except for the locally made thresher (Make I) an estimated service life of 3200 hours (5 years) was assumed for all the threshers studied. This, therefore, becomes one of the limitations of the analysis because, certainly, the service capacity of the threshers are not the same; much less their make and the materials they are made of. Thus, caution should be exercised in using these data.

TABLE 35. Average cost of using different threshers.

Working hours	IRRI paddy power thresher			Japanese automatic thresher	Locally made thresher	
	4 men	5 men	6 men	3 men	Make I 4 men	Make II 3 men
	pesos per hour					
500	8.27	8.71	9.14	10.34		8.01
1000	5.46	5.90	6.33	6.42	11.73	5.24
1500	4.53	4.97	5.40	5.11		4.32
2000	4.06	4.50	4.93	4.46	7.29	3.86
2500	3.78	4.22	4.65	4.06		3.58
3000	3.59	4.03	4.46	3.80	5.81	3.40
3200	3.54	3.98	4.40	3.72	.	3.34
4000					5.07	
5000					4.62	
6000					4.33	

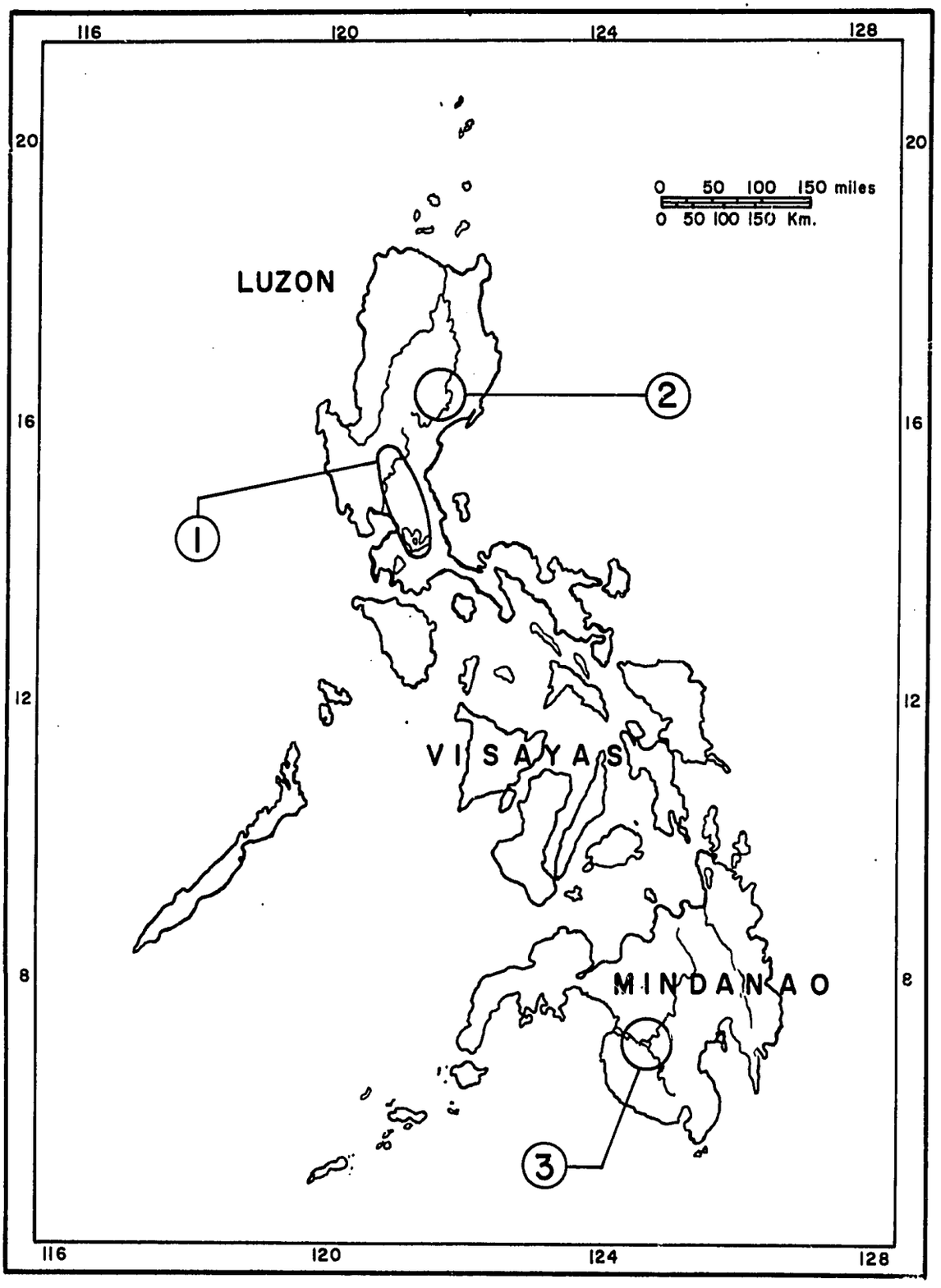
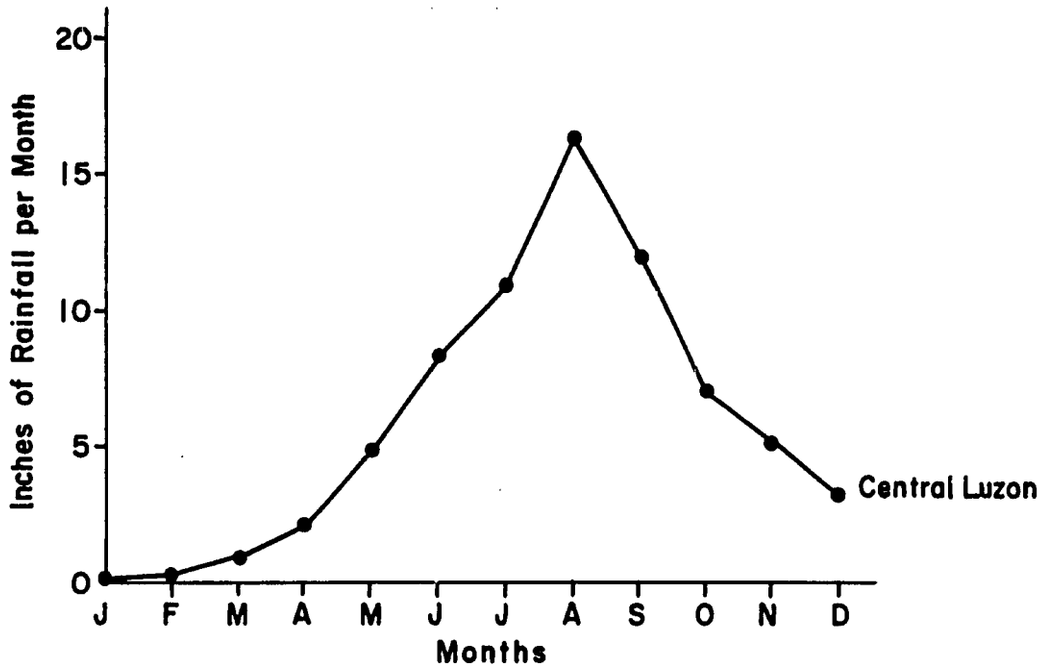


Fig. 1. Map of the Philippines. Three surveys undertaken in the Philippines: (1) Central Luzon; (2) Cagayan Valley (Isabela Province); and (3) Mindanao (Cotabato Province).



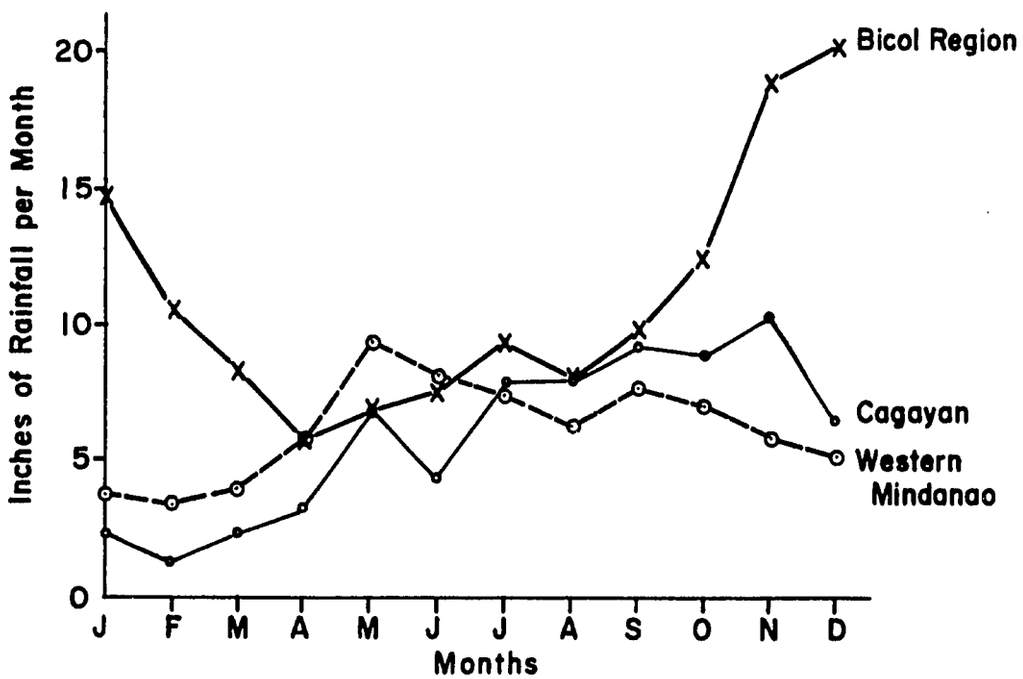


Fig. 2. Average annual rainfall for the following regions: Central Luzon (Cabanatuan City, Nueva Ecija); Cagayan Valley (Echague, Isabela Province); Bicol Region (Legaspi, Albay Province); Western Mindanao (Kabacan, Cotabato Province).

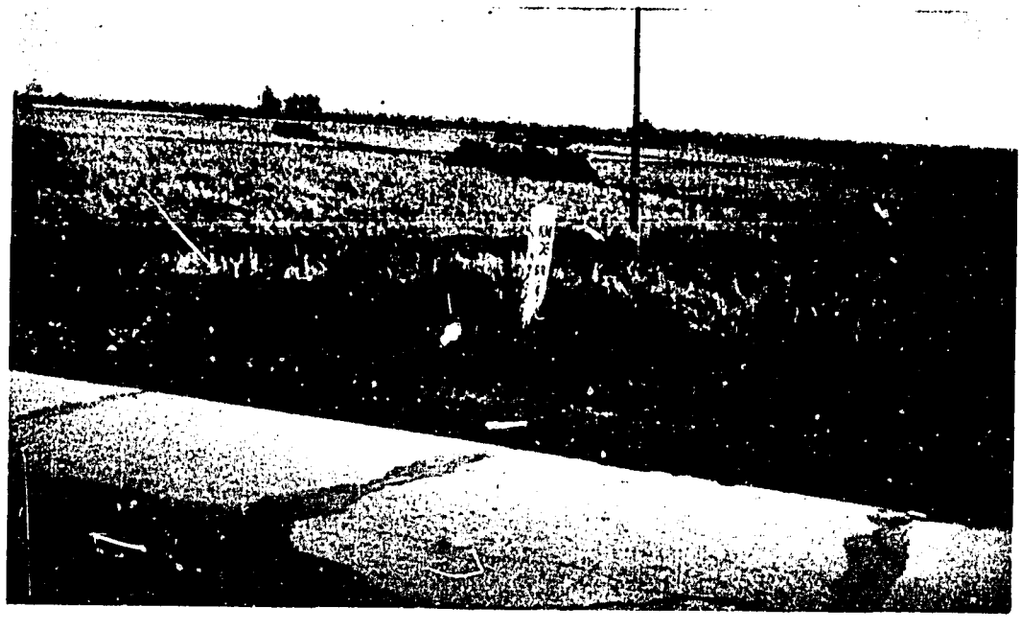


Fig. 3. A view of riceland in dry condition between crops. The sites were measured 25 meters out from the side of the road at the kilometer post. The kilometer post locates the site 106 km north of Manila and 2 km from Santa Rosa.

Fig. 4. A picture of the rice site #8 in the vegetative stage. The field is irrigated and lies in Laguna Province, south of Manila.

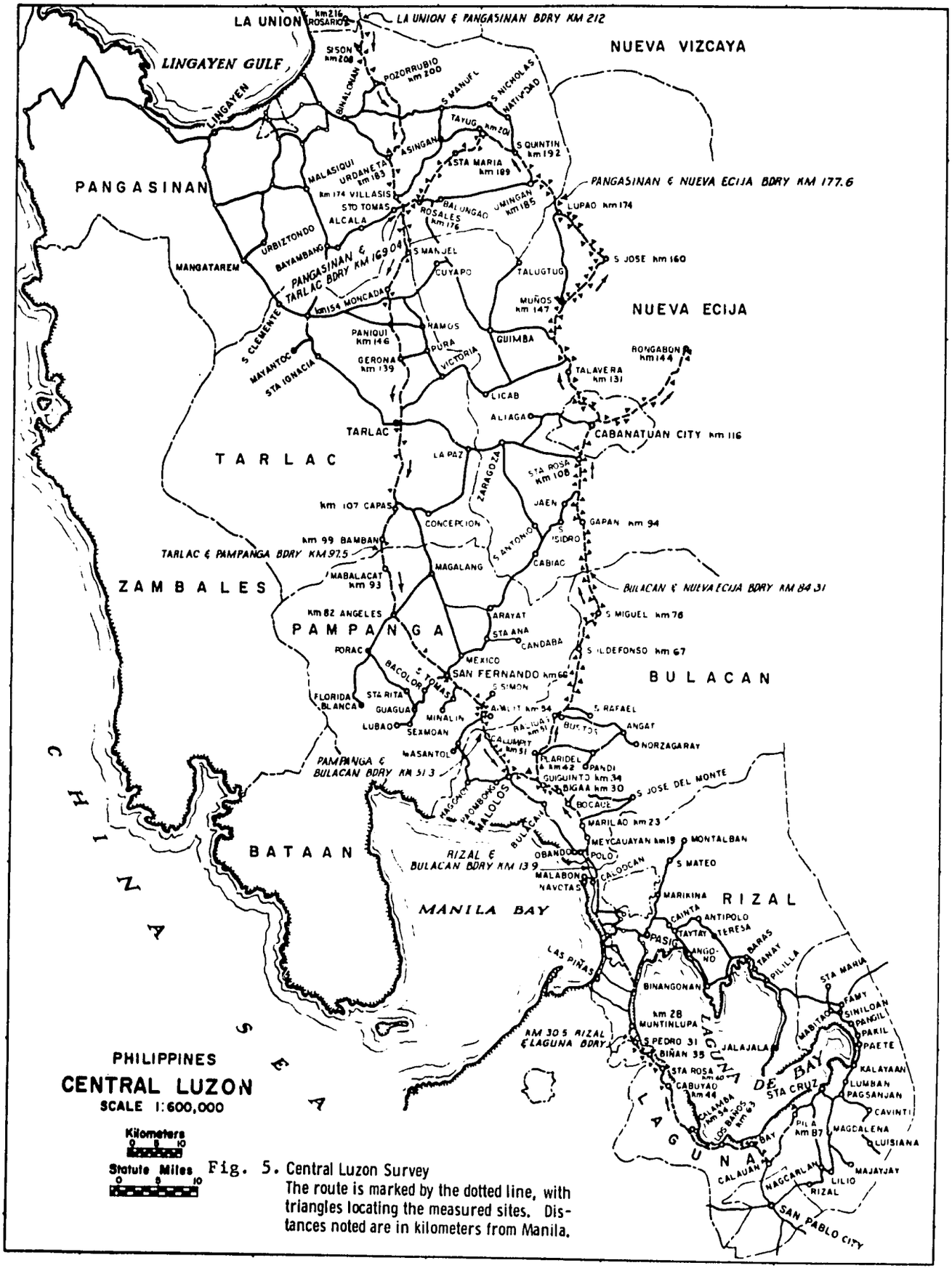


Fig. 5. Central Luzon Survey
The route is marked by the dotted line, with triangles locating the measured sites. Distances noted are in kilometers from Manila.

Fig. 6. Central Luzon Survey Sequence of Farm Operations: Measurements and Observations During the Week of July 11-17, 1966 for 145 Rice Locations.

APPLICATION
SEQUENCE OF FARM OPERATIONS

PREPARED BY
Emilio O. Casem

1-3 LOCATION SITE	4-6 WEEKS WK	9-10 IDLE WEEKS Z	11 PLOWED 1	HARROWED 2	PLANTED 3	VEGETATIVE 4	REPRODUCTIVE 5	MATURE 6	HARVESTED 7	THRESHED 8	SEEDBED 9	13-14 SOIL MOISTURE - DRY q	16-17 WATER DEPTH b	19-20 SOIL DEPTH 35 PSI-CM c	22-25 SOIL DEPTH 70 PSI-CM d	25 HAND WORK e	26 ANIMAL WORK f	27 MACHINE WORK g	28 DRY CONDITION h	29 WET CONDITION i	30 DIRECT SEED j	31 TRANSPLANT k	33 NEEDS WEEDING m	34 LEAF BLIGHT n	35 BLAST o	36 NEEDS NITROGEN p	37 VIRUS DISEASE q	38 NEEDS INSECTICIDE r	39 LODGED s	40 WHITE HEAD t	41 RAT DAMAGE u	42 DEAD HEART v	44 BIRD DAMAGE x	45 FLOODED y	46-47 TILLER NO. Φ	49 ROW PLANTING Δ	50 RANDOM M Ψ
001	30		1										01	34	39			9		i																		
002	30					4							12	30	39													r							17			
003	30					4							01	15	31																				06			
004	30					4							09	29	31																				22			
005	30					4							04	27	32													r							14			
006	30	04											24	35	44																							
007	30		1										08	10	17		f			i																		
008	30					4							04	38	45								m												17			
009	30			2									03	14	28		f			i																		
010	30						5						15	25	27								m			p		r										
011	30					4							10	23	25													r							05			
012	30	30											08	17	18																							
013	30	13											02	26	32																							
014	30		1										35	06	14		f			i																		
015	30		1										01	09	14		f			i																		
016	30		1										13	08	30		f			i																		
017	30					4							05	28	35																				12			
018	30	30											15	05	10																							
019	30					4							02	30	43																				19			
020	30				3								20	05	06	e				i		k	m														4	
021	30			2									07	18	28		f			i																		
022	30				3								05	10	12	e				i		k															4	
023	30		1										03	07	11		f			i																		
024	30				3								15	13	23	e				i		k															4	
025	30				3								10	18	43	e				i		k															4	
026	30				3								10	10	17	e				i		k	m														4	
027	30										9		06	09	10	e				i	j																	
028	30					4							10	30	34																				07			
029	30				3								08	20	50	e				i		k															4	
030	30					4							10	16	23																				15			

LOCATION (site)	- A point in the farmer's field, some 25 meters from the the edge of the road and one penetrometer length from the nearest levee.
WEEKS (WK)	- The number of weeks from December 21.
IDLE WEEKS (Z)	- The number of weeks the field is left as is after rice has been harvested or seedlings have been pulled out of the seedbed.
PLOWED (1)	- If plot is plowed and no subsequent operations in the field are performed.
HARROWED (2)	- If the plot is harrowed or rotary tilled and no subsequent operations in the field are performed.
PLANTED (3)	- If plot is planted to rice (direct or transplant) and is not a seedbed.
VEGETATIVE (4)	- If the previous week's observation is "planted", subsequent notations are vegetative until the plants reach the reproductive stage.
REPRODUCTIVE (5)	- The rice plant is at ear initiation up to a week before maturity.
MATURE (6)	- Grains start yellowing up.
HARVESTED (7)	- If mature rice has been harvested or cut with no signs of threshing in the field.
THRESHED (8)	- If harvested rice has been threshed in the field or signs of threshing in the plot are evident.
SEEDBED (9)	- If site is seeded as seedbed up to the time seedlings are pulled for transplanting.
SOIL MOISTURE - DRY (a)	- When the field is dry or to field capacity. Numbers 10 to 1 are used: 10 - when soil is dry and requires some 10 cm of water to bring it to field capacity; 1 - when soil is moist and at field capacity.
WATER DEPTH (b)	- This is the depth of water on the surface of the plot in cm.
SOIL DEPTH, 35 PSI-CM (c)	- The depth of penetration of the cone penetrometer when a pressure of 35 psi is applied.
SOIL DEPTH, 70 PSI-CM (d)	- The depth of penetration of the cone penetrometer when a pressure of 70 psi is applied.
HAND WORK (e)	- If farm operation is done with human hand or human power; ex: spading or transplanting.
ANIMAL WORK (f)	- If farm operation is done with animal power; ex: animal plowing.
MACHINE WORK (g)	- If farm operation is performed with machine power; ex: rotary tilling.
DRY CONDITION (h)	- When plot is without surface water, when farm operations are performed.
WET CONDITION (i)	- When plot is with surface water, when farm operations are performed.
DIRECT SEED (j)	- If seeds are sown directly to the field without coming from the seedbed.
TRANSPLANT (k)	- If seedlings are taken from the seedbed and planted to the site in rows or at random.
NEEDS WEEDING (m)	- If live weeds exist in the plot and are of the size and number to compete with the rice plant for nutrition, water, and solar radiation.
LEAF BLIGHT (n)	- If there are leaves with white spots along their margin up to the tip, with the upper portion appearing to be bleached.
BLAST (o)	- If there are reddish-brown or white oblong spots with streak of collapsed tissue of brownish color in the aerial portions of the rice plant.
NEEDS NITROGEN (p)	- If rice plants which are on vegetative or reproductive stage show signs of pale to yellowish leaves characteristic of nutrient deficiency.
VIRUS DISEASE (q)	- (1) Tungro, tillering slightly reduced; stunting; yellowing; rusty blotches; (2) Yellow dwarf, profuse tillering; severe stunting; general yellowing (3) Grassy stunt, profust tillering; severe stunting; narrow leaf blade chlorosis; rusty dots; (4) Orange leaf, reduced tillering; inconspicuous stunting; orange and rolled leaves; rapid death.
NEEDS INSECTICIDE (r)	- If insects and allied pests are present or near rice plants.
LODGED (s)	- If rice plants are inclined to side some 45 degrees or more to the horizontal.
WHITE HEAD (t)	- If there are emerging panicles that are white or dead.
RAT DAMAGE (u)	- If there are signs of rats eating up seeds or any portion of the rice plant.
DEAD HEART (v)	- If there are emerging shoots which are dead.
BIRD DAMAGE (x)	- If there are signs of birds eating seeds or rice grains.
FLOODED (y)	- If water level in plot is unusually deep or above top of surrounding levees.
TILLER NUMBER (θ)	- Average number of live tillers of 2 to 3 hills in plot. Counting starts a week after transplanting up to maximum tillering stage. Now revised to: average number of tillers of 2 to 3 hills in plot at reproductive (late) to harvest period.
ROW PLANTING (Δ)	- If seeds or seedlings are planted in rows.
RANDOM PLANTING (ψ)	- If seeds or seedlings are planted at random.

Fig. 7. Measurements and observations of Site No. 4 from May 23, 1966 to May 31, 1967.

SUMMARY SITE #4, 1966

APPLICATION: SEQUENCE OF FARM OPERATIONS

PREPARED BY:

1 2 3 LOCATION (SITE)	4 5 WEEKS ~ 1966 (WK)	9 10 IDLE WEEKS (Z)	11 PLOWED (1)	HARROWED (2)	PLANTED (3)	VEGETATIVE (4)	REPRODUCTIVE (5)	MATURE (6)	HARVESTED (7)	THRESHED (8)	SEEDBED (9)	13 14 SOIL MOISTURE - DRY (d)	16 17 WATER DEPTH (t)	19 20 SOIL DEPTH 35 PSI-CM (c)	22 23 SOIL DEPTH 70 PSI-CM (d)	25 HAND WORK (e)	26 ANIMAL WORK (f)	27 MACHINE WORK (g)	28 DRY CONDITION (h)	29 WET CONDITION (i)	30 DIRECT SEED (j)	31 TRANSPLANT (k)	33 NEEDS WEEDING (m)	34 LEAF BLIGHT (n)	35 BLAST (o)	36 NEEDS NITROGEN (p)	37 VIRUS DISEASE (q)	38 NEEDS INSECTICIDE (r)	39 LODGED (s)	40 WHITE HEAD (t)	41 RAT DAMAGE (u)	42 DEAD HEART (v)	44 BIRD DAMAGE (x)	45 FLOODED (y)	46 47 TILLER NO. (φ)	49 50 ROW PLANTING (Δ)	51 52 RANDOM (Ψ)
004	23		1										05	23	46		f	h																				
	24		1										05	16	39		f	h																				
	25				3								01	25	33	e				i		k															Δ	
	26					4							02	27	31																							
	27					4							01	27	29																							
	28					4							03	31	36																							
	29					4							02	24	28																							
	30					4							09	29	31																							
	31					4							01	27	29								m					r										
	32					4							04	26	30								m					r										
	33					4							04	29	31									n		p	q	r										
	34					4							01	29	30								m	n		p	q	r										
	35					4							02	30	34								m			p		r										
	36						5						01	33	36								m	n		p		r										
	37						5						02	32	33								m	n		p		r										
	38						5						01	28	31								m	n		p	q	r										
	39						5						02	28	30								m	n		p		r										
	40						5					01		27	29								m	n	0					t								
	41						5					03		29	31									n	0					t								
	42						5					03		25	27									n	0					t								
	43							6				03		24	27														s	t								
	44								7			03		25	27	e																						
	45	01										04		27	29																							
	46	02											01	29	30																							
	47		1										05	29	32			g	i															Roto	Tiller			
	48		1										01	35	36			g	i															Hand	Tractor			
	49			2									06	31	35			g	i															Hand	Tractor			
	50			2									07	27	32			g	i																			
	51			2									00	32	35			g	i															Hand	Tractor			
	52				3								00	30	34	e			i			k																

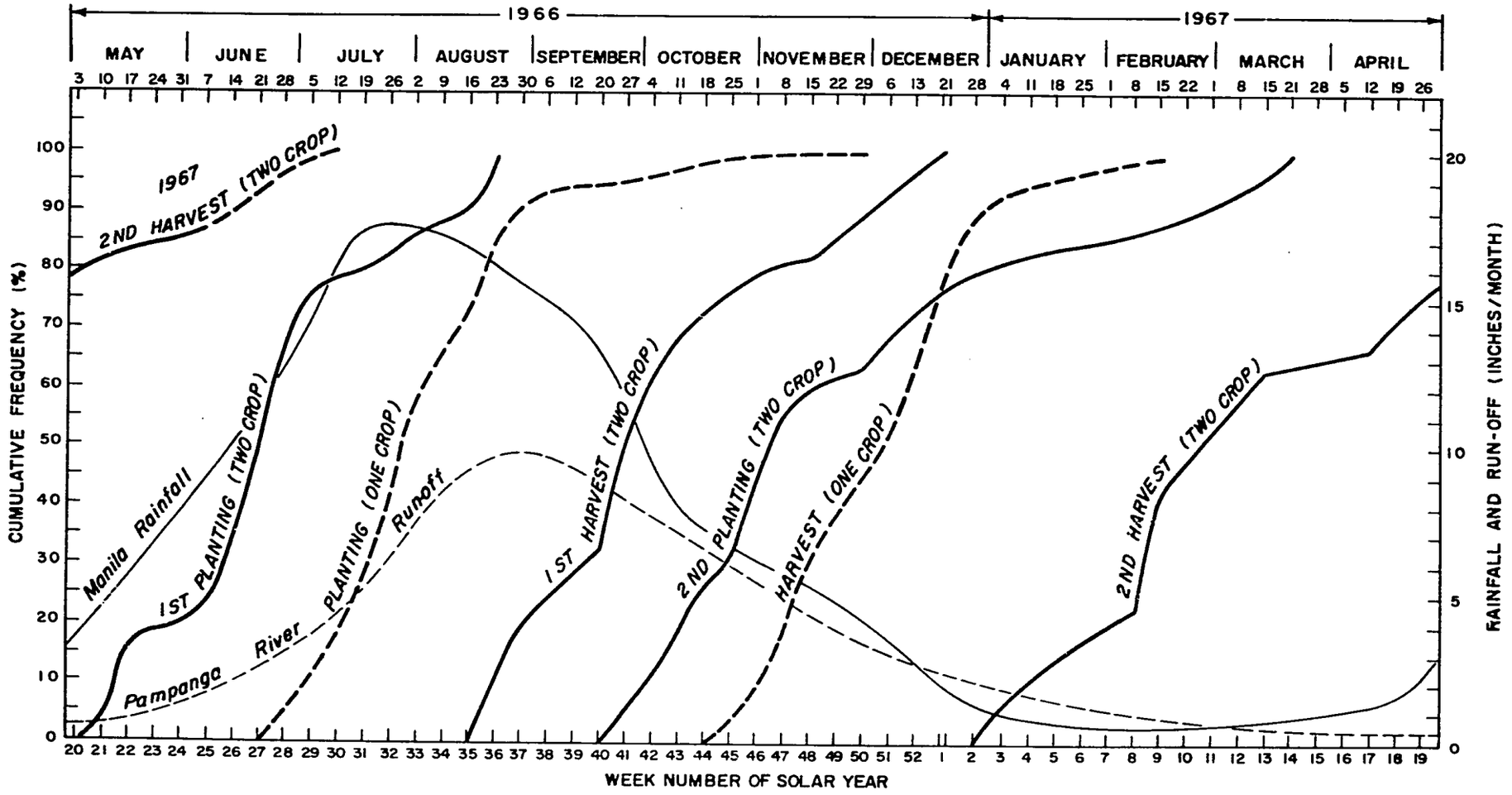


Fig. 8. Planting and harvest cycles for one- and two-crop rice sites in Central Luzon, Philippines, May 1966 to July 1967 (31 one-crop and 109 two-crop sites). Compared with average rainfall of Manila, Philippines and average run-off from the Pampanga River basin.

Fig. 9. SEQUENCE OF FARM OPERATIONS: ONE-CROP RICE SITES (ACTUAL NUMBERS)

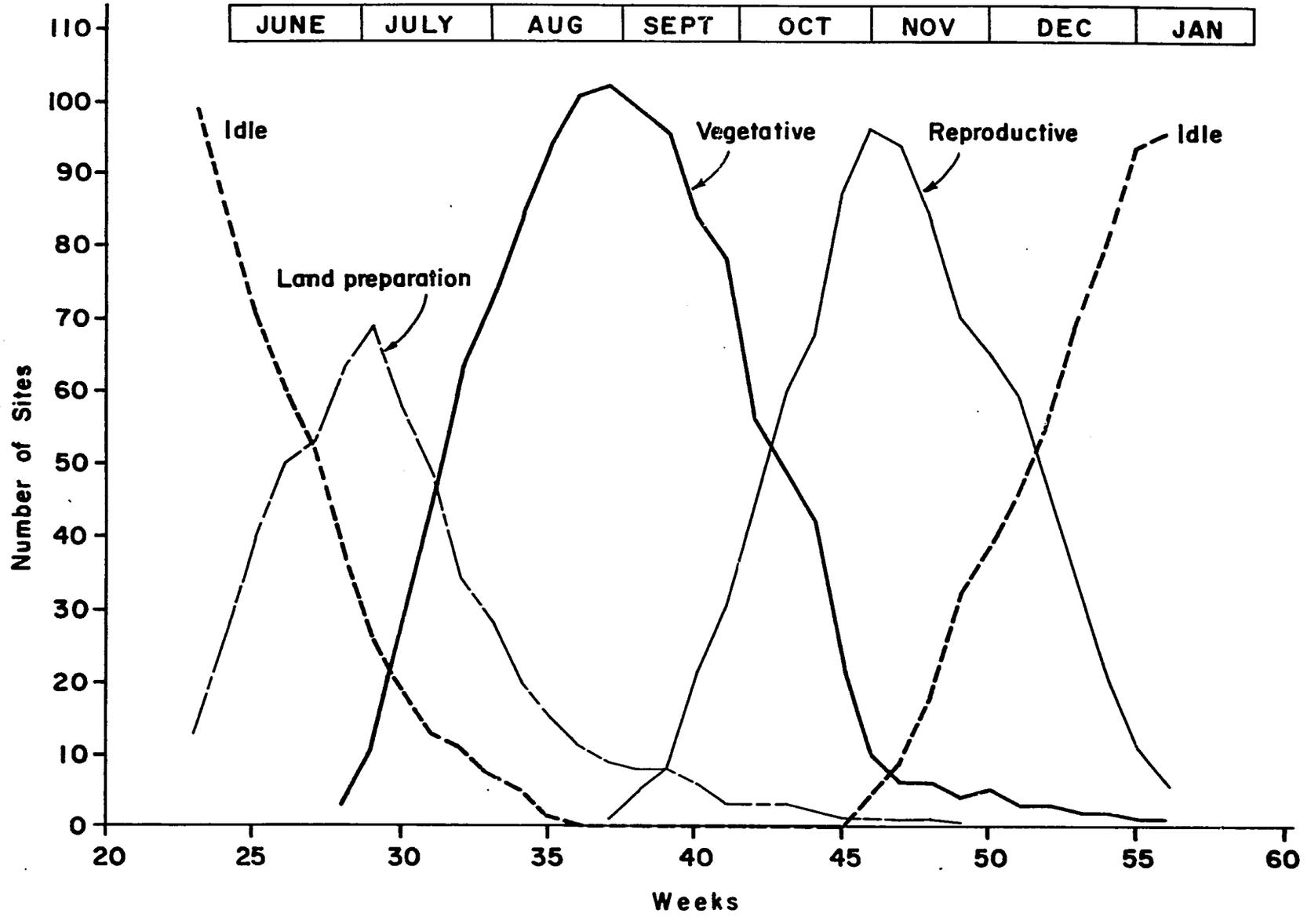


Fig. 10. SEQUENCE OF FARM OPERATIONS: 29 TWO-CROP SITES (IN PERCENTAGE)

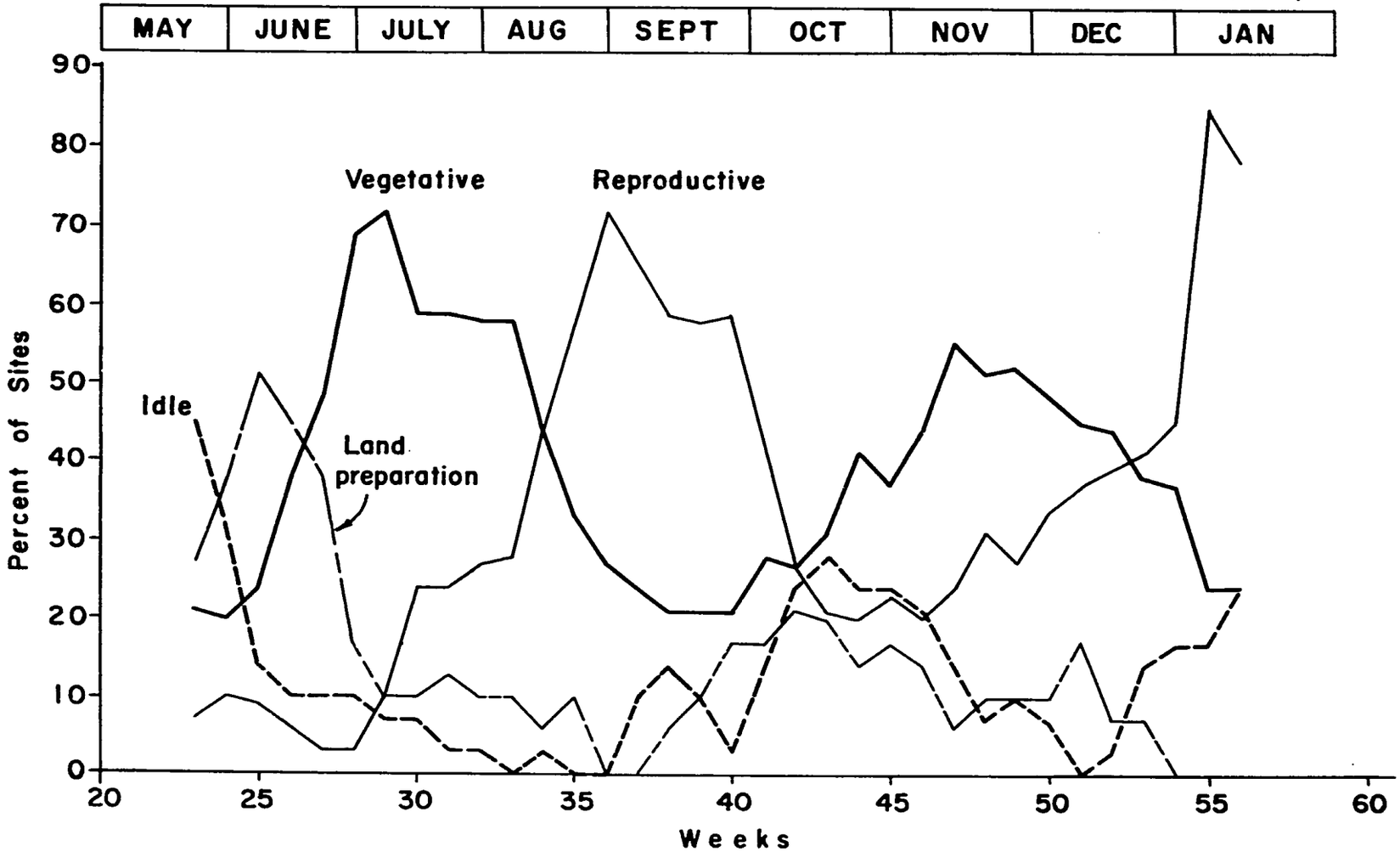
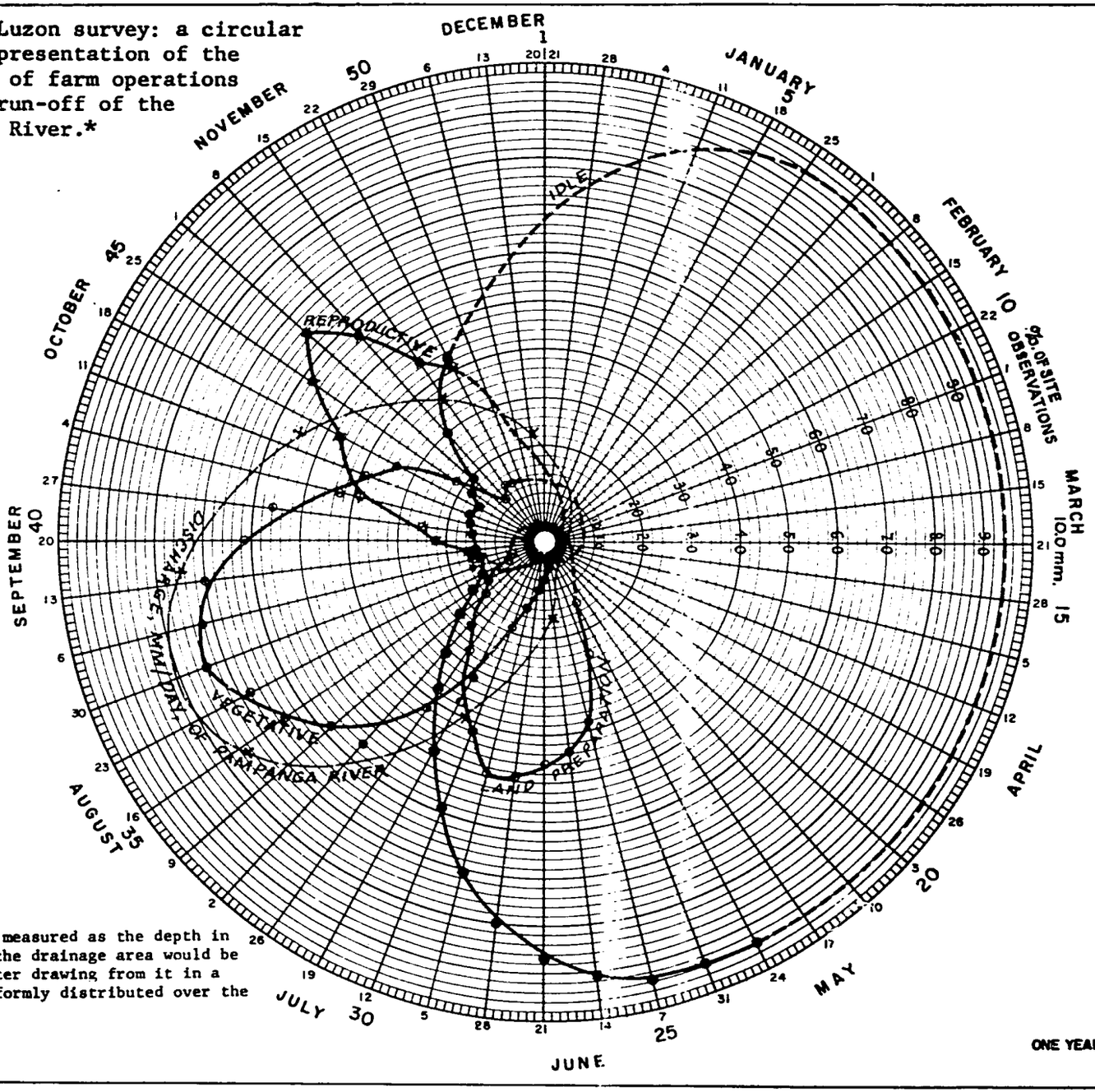


Fig. 11. Central Luzon survey: a circular graphic presentation of the sequence of farm operations and the run-off of the Pampanga River.*



*The stream run-off is measured as the depth in millimeters to which the drainage area would be covered if all the water drawing from it in a given period were uniformly distributed over the area.

JAN.20,1966

ONE YEAR – 52 WEEKS – 364 DAYS

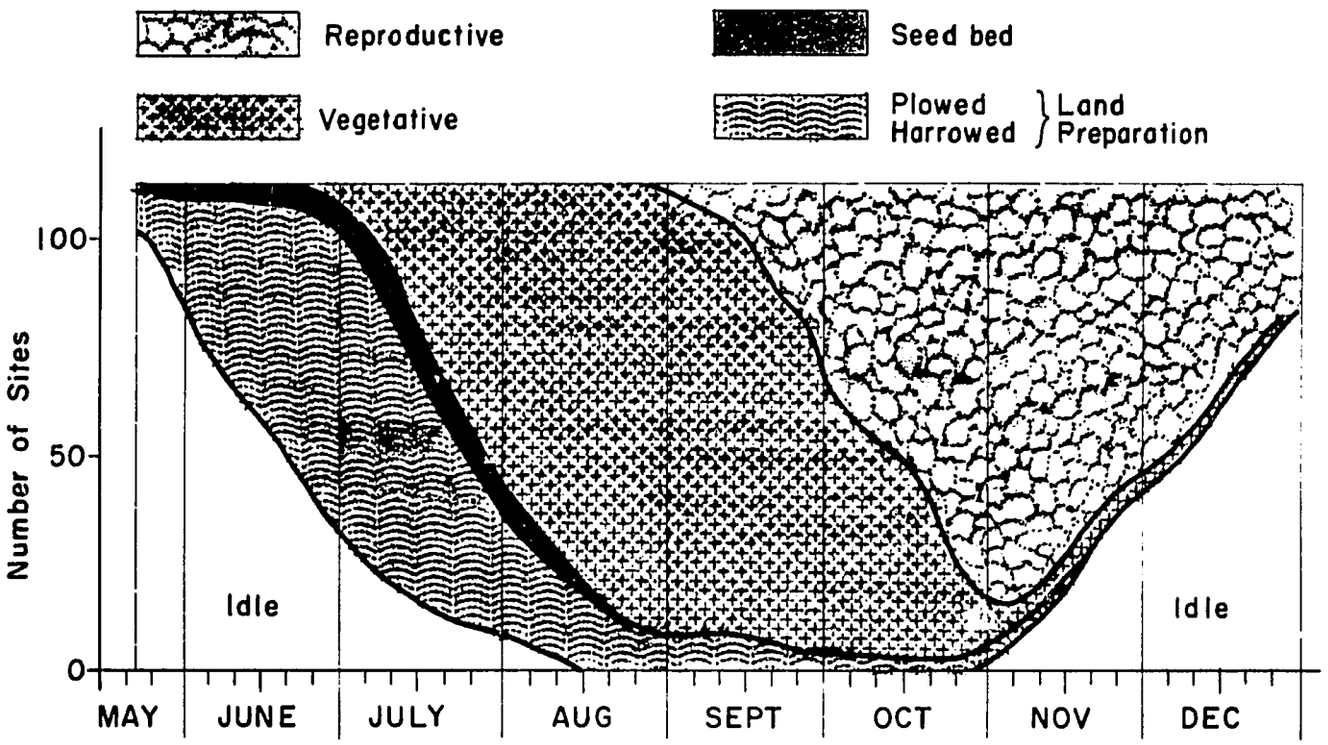


Fig. 12. Central Luzon survey: cumulative totals of the stages of the sequence of farm operations, 29 irrigated rice sites.

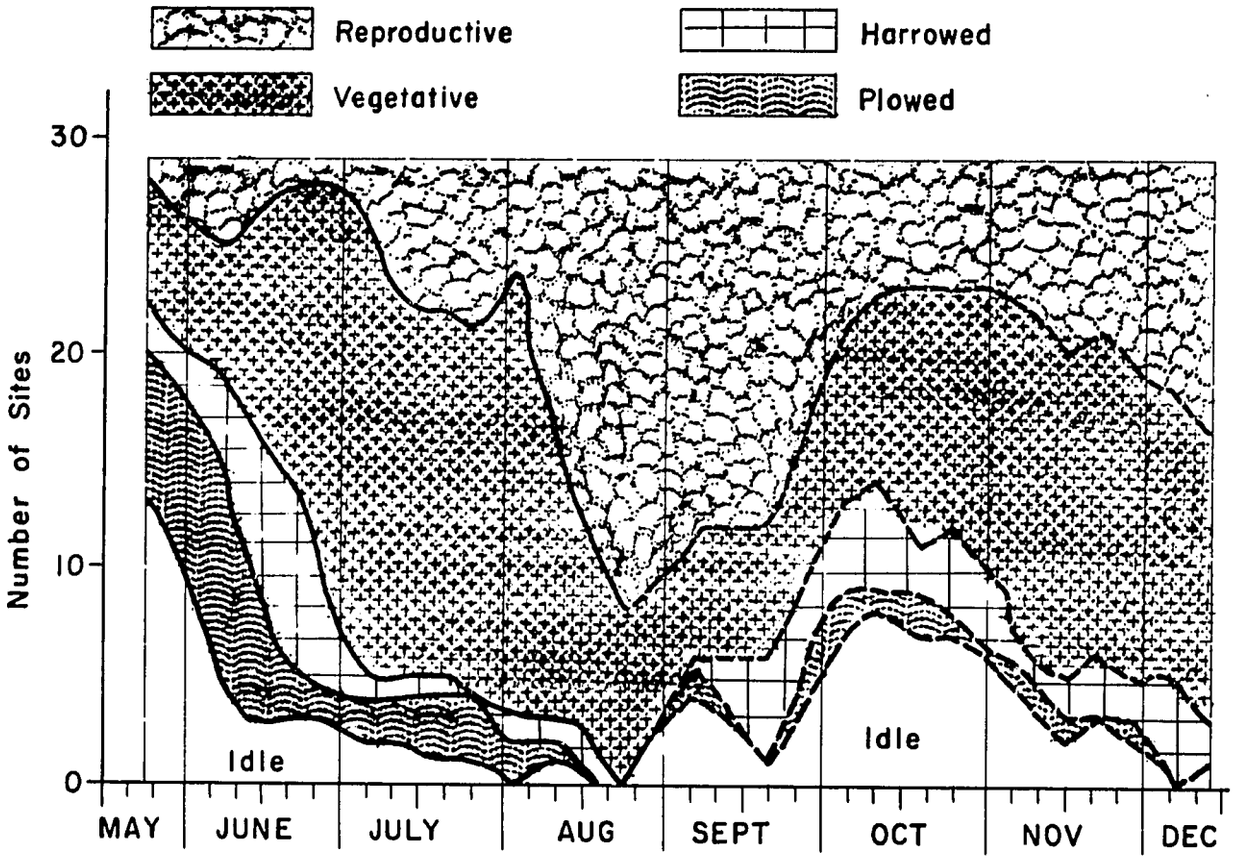


Fig. 13. Central Luzon survey: cumulative totals of the stages of the sequence of farm operations, 29 irrigated rice sites.

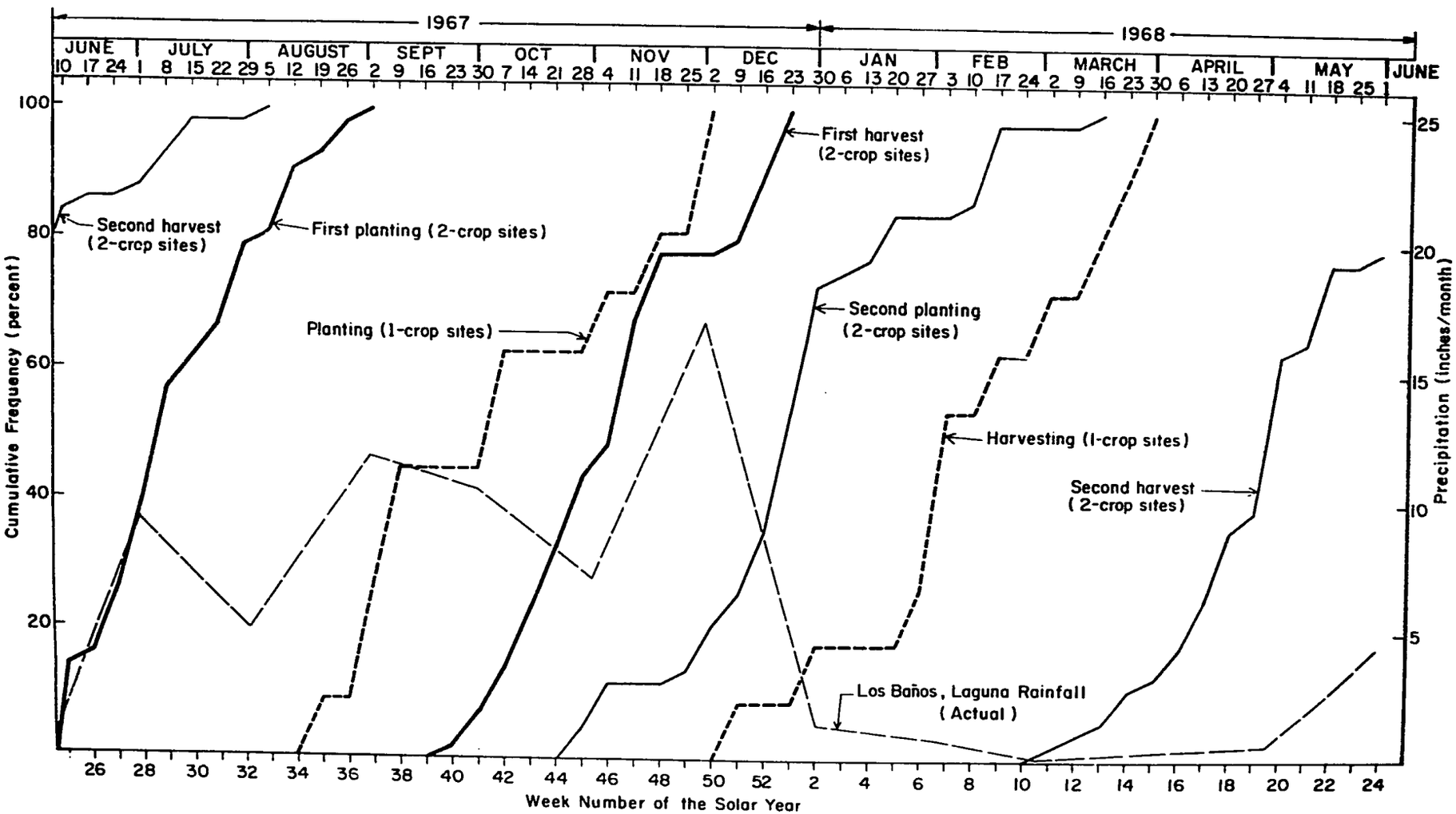


Fig. 14. Planting and harvesting cycles, 42 two-crop sites and 11 one-crop sites, Laguna, 1967-1968.

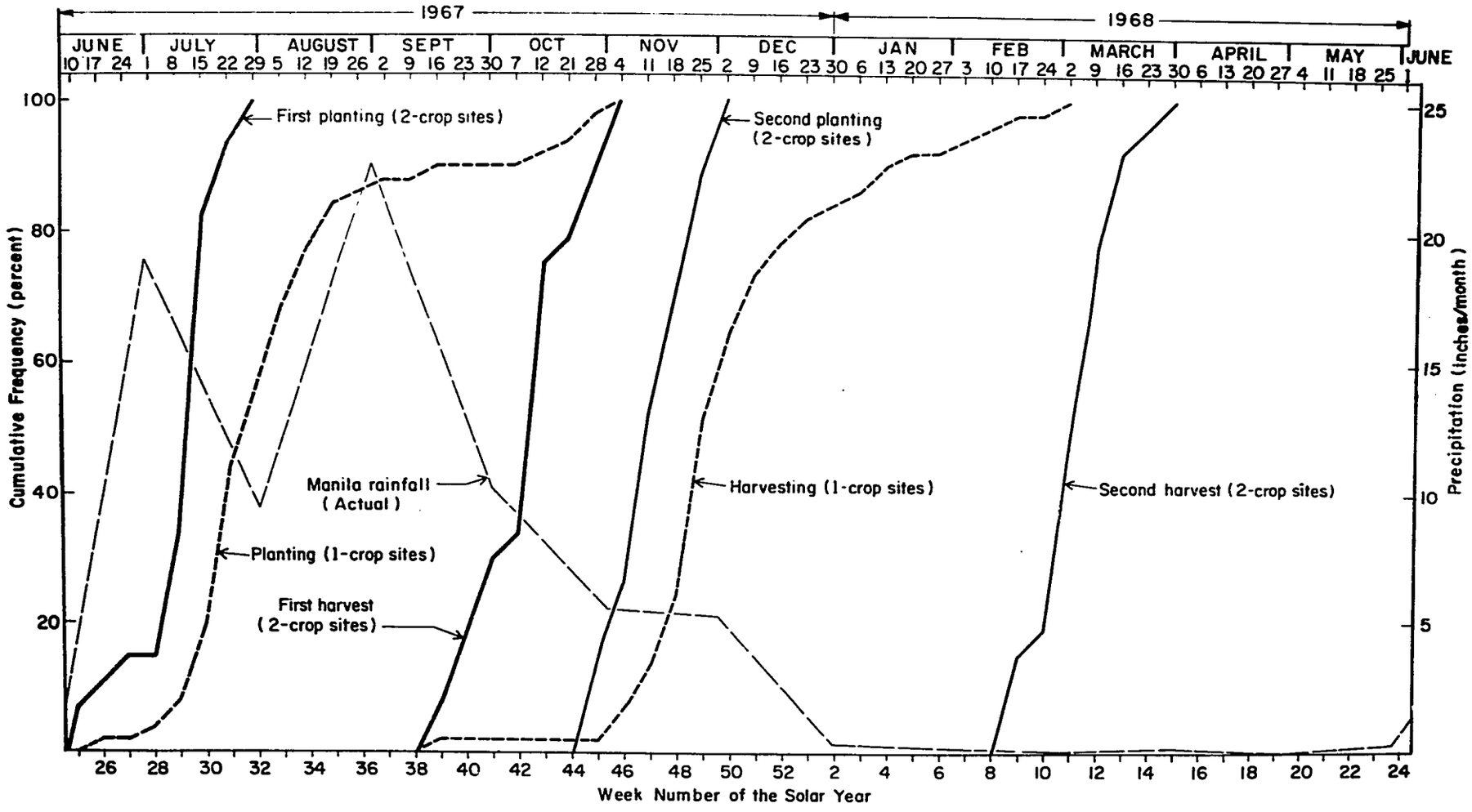


Fig. 15. Planting and harvesting cycles, 27 two-crop sites and 56 one-crop sites, Central Luzon, 1967-1968.

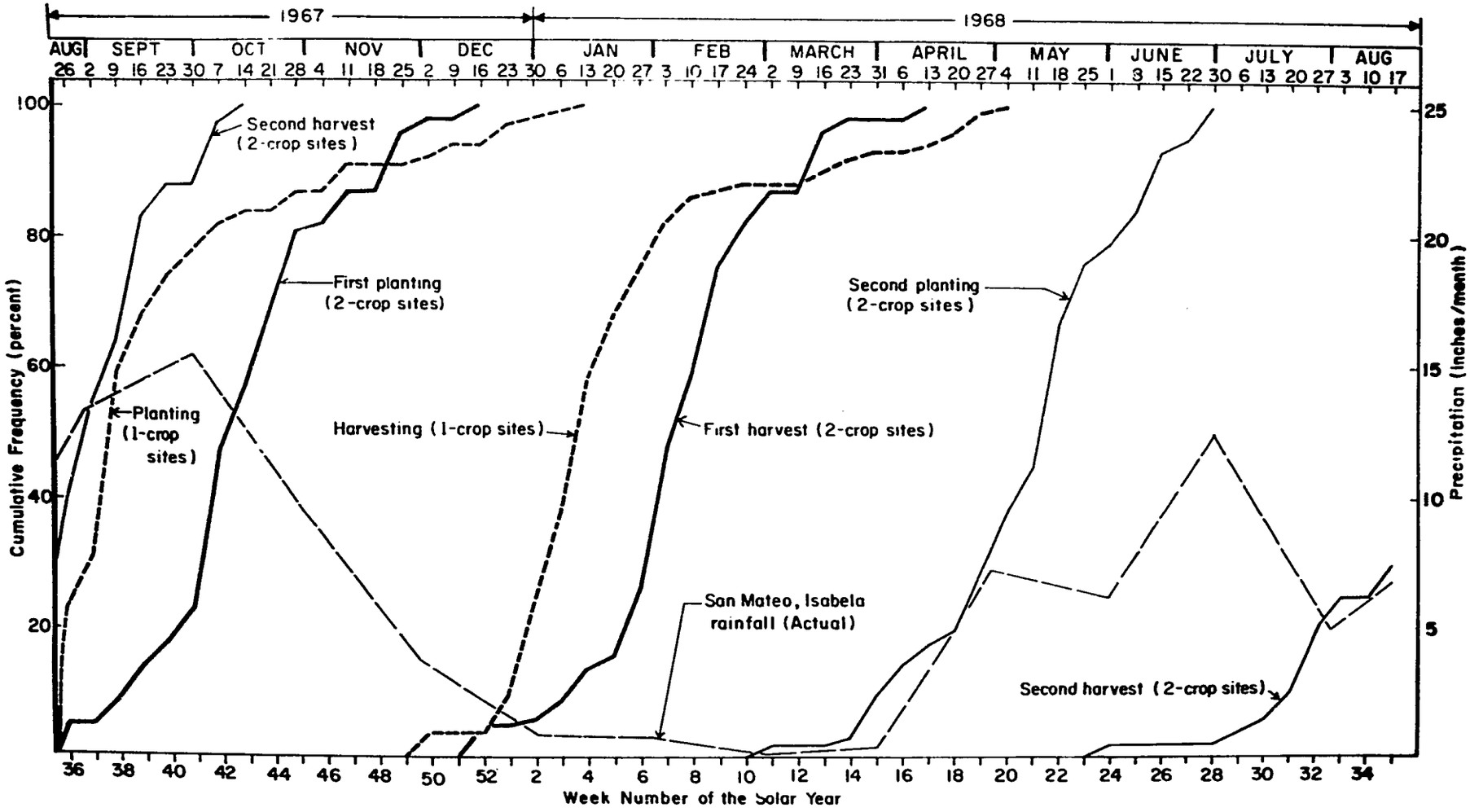


Fig. 16. Planting and harvesting cycles, 58 two-crop sites and 71 one-crop sites, Isabela, 1967-1968.

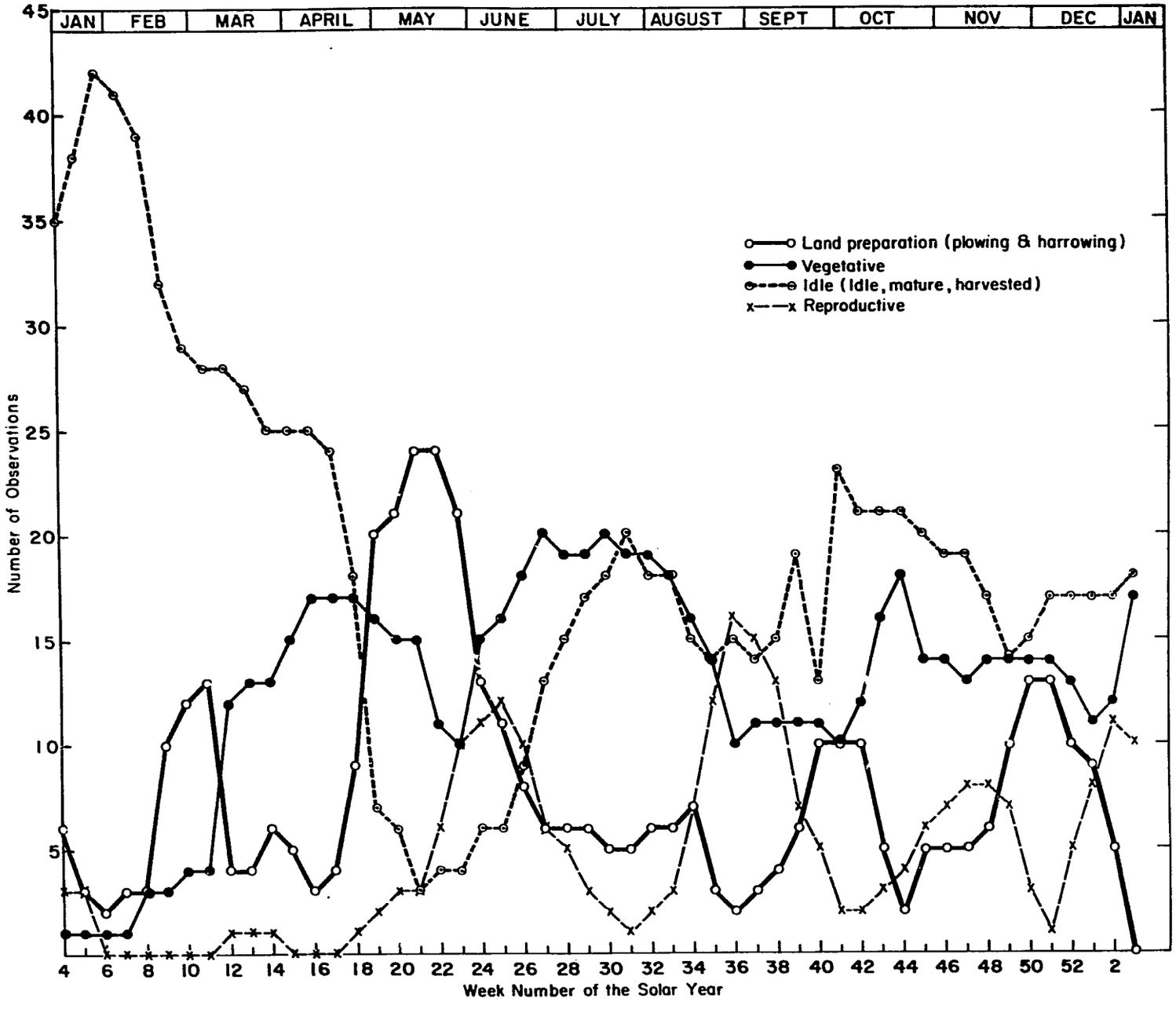


Fig. 17. Sequence of farm operations, Midsayap, Cotabato, 1968-1969.

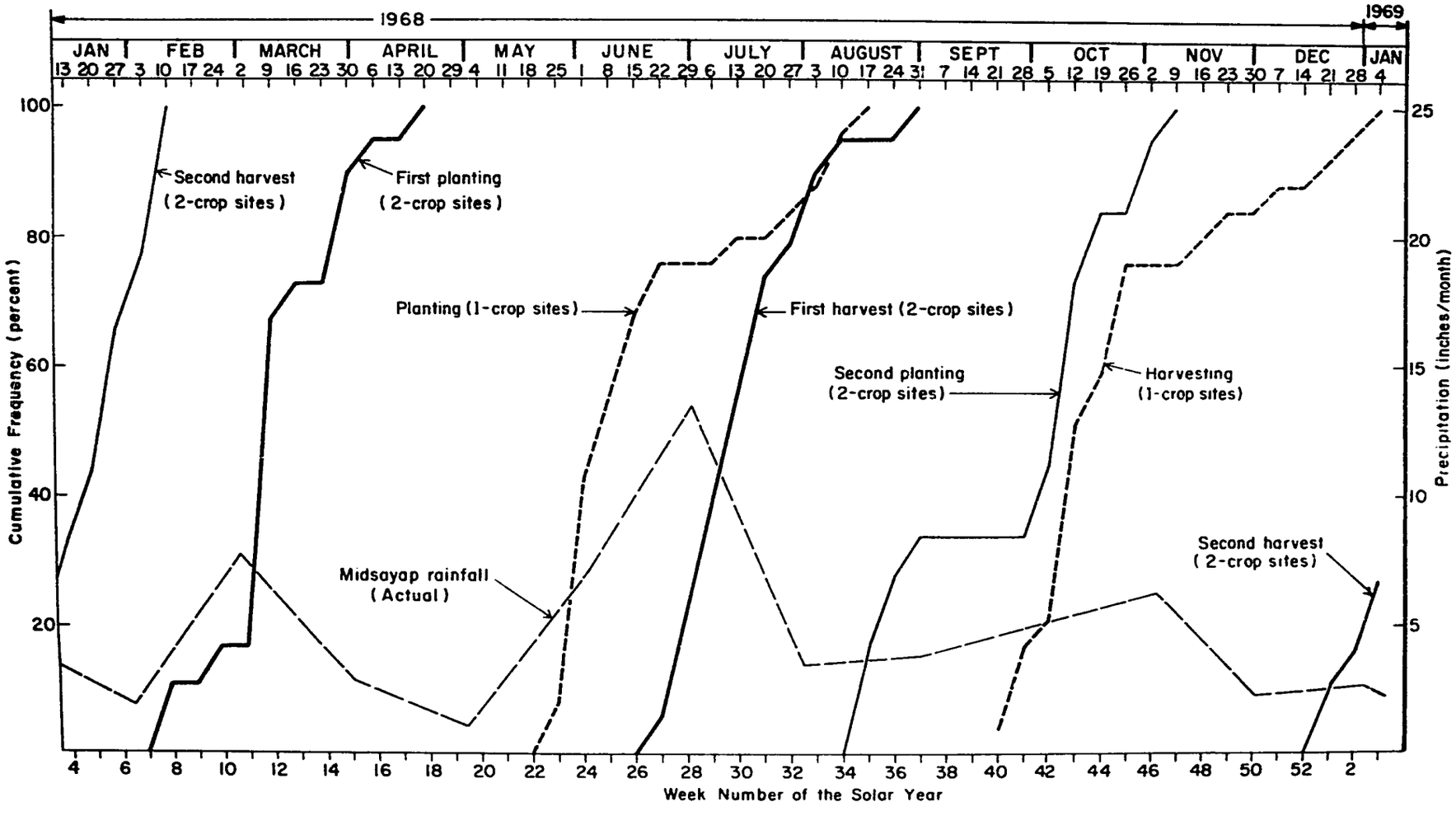


Fig. 18. Planting and harvesting cycles, 18 two-crop sites and 24 one-crop sites, Midsayap, Cotabato, 1968-1969

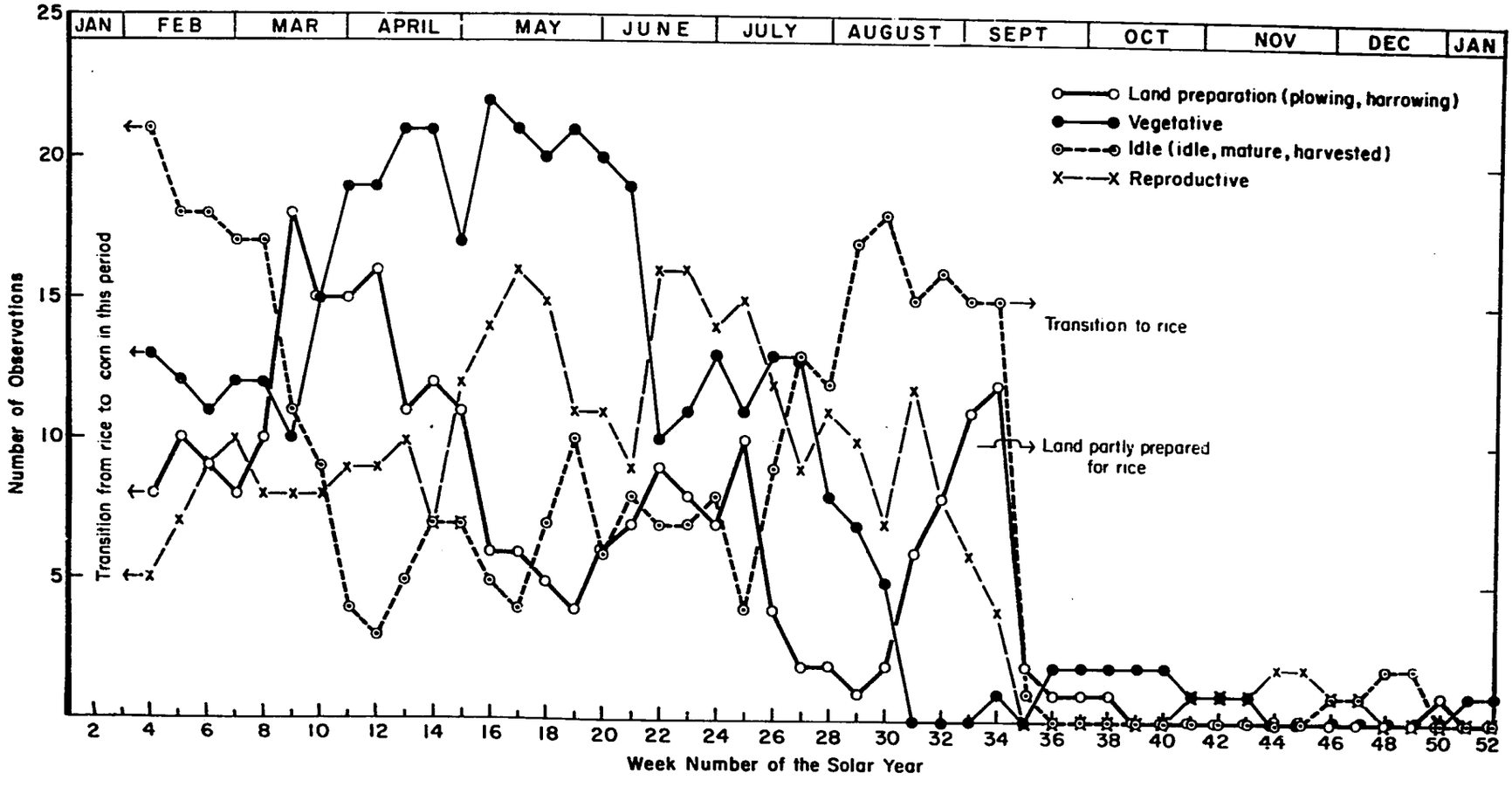


Fig. 19. Sequence of farm operations, Tacurong, Cotabato, 1968-1969 (corn).

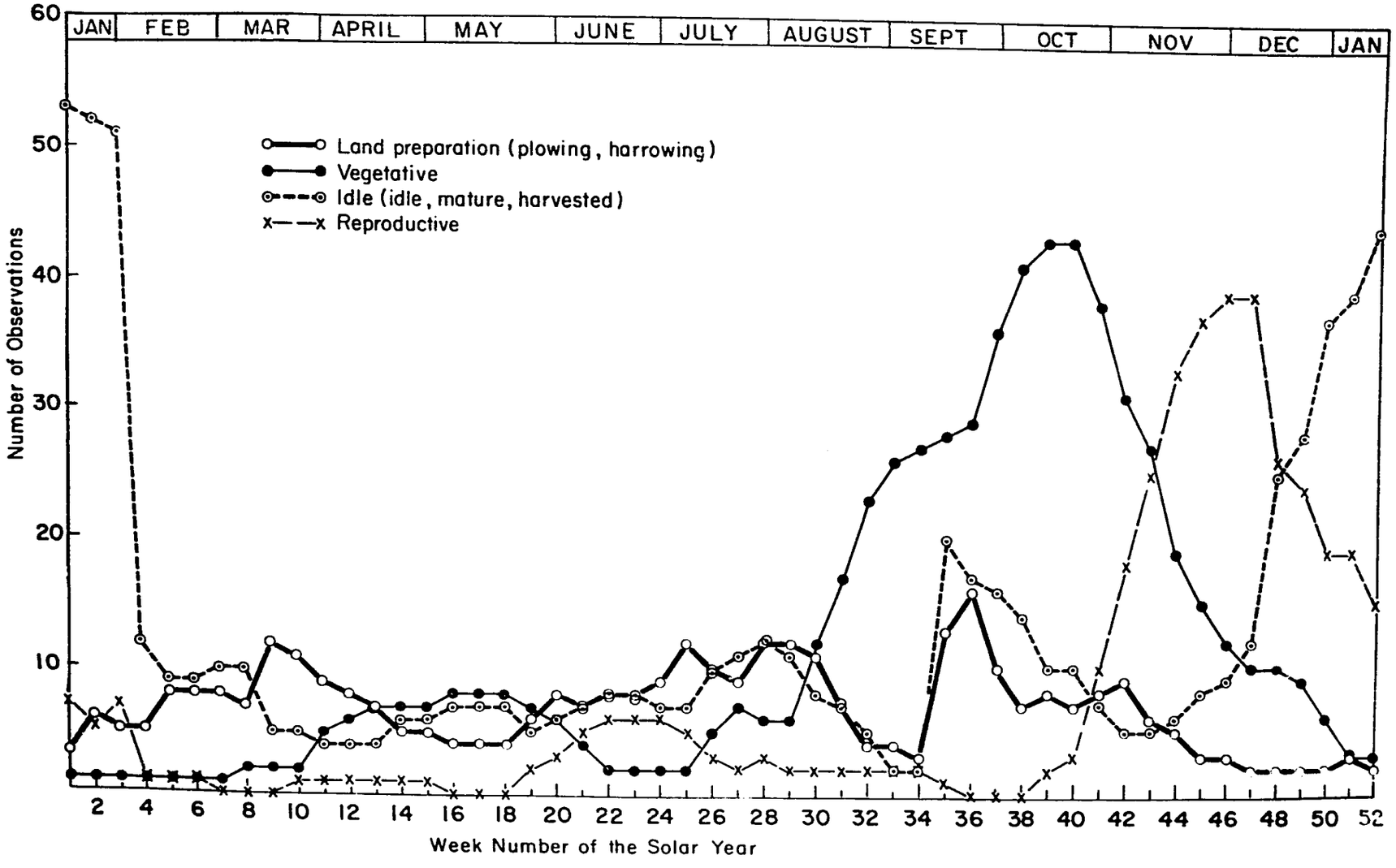


Fig. 20. Sequence of farm operations, Tacurong, Cotabato, 1968-1969 (rice).

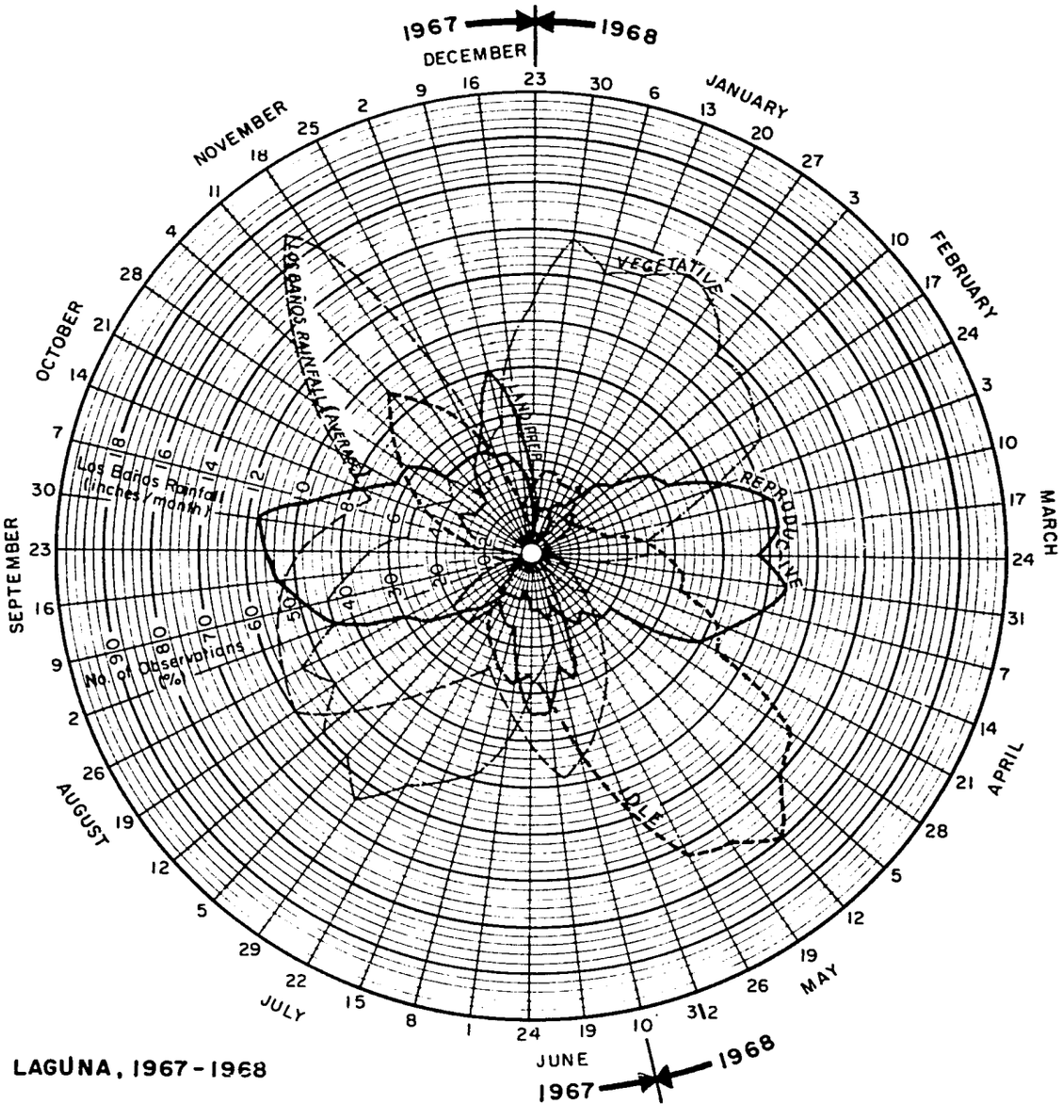


Fig. 21. Laguna Survey: A Circular Graphic Presentation of the Sequence of Farm Operations and Los Baños Rainfall.

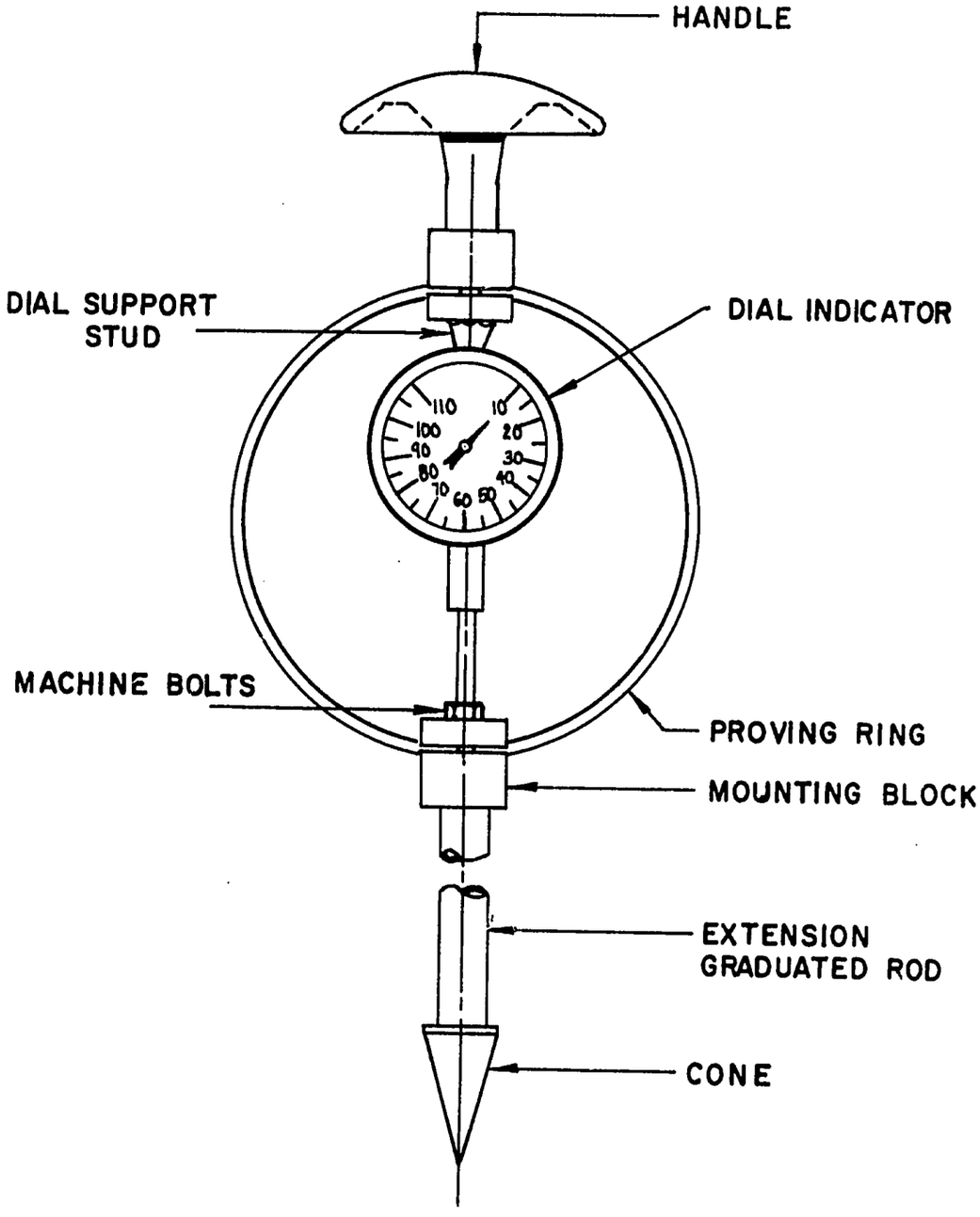


Fig. 22. A cone penetrometer.

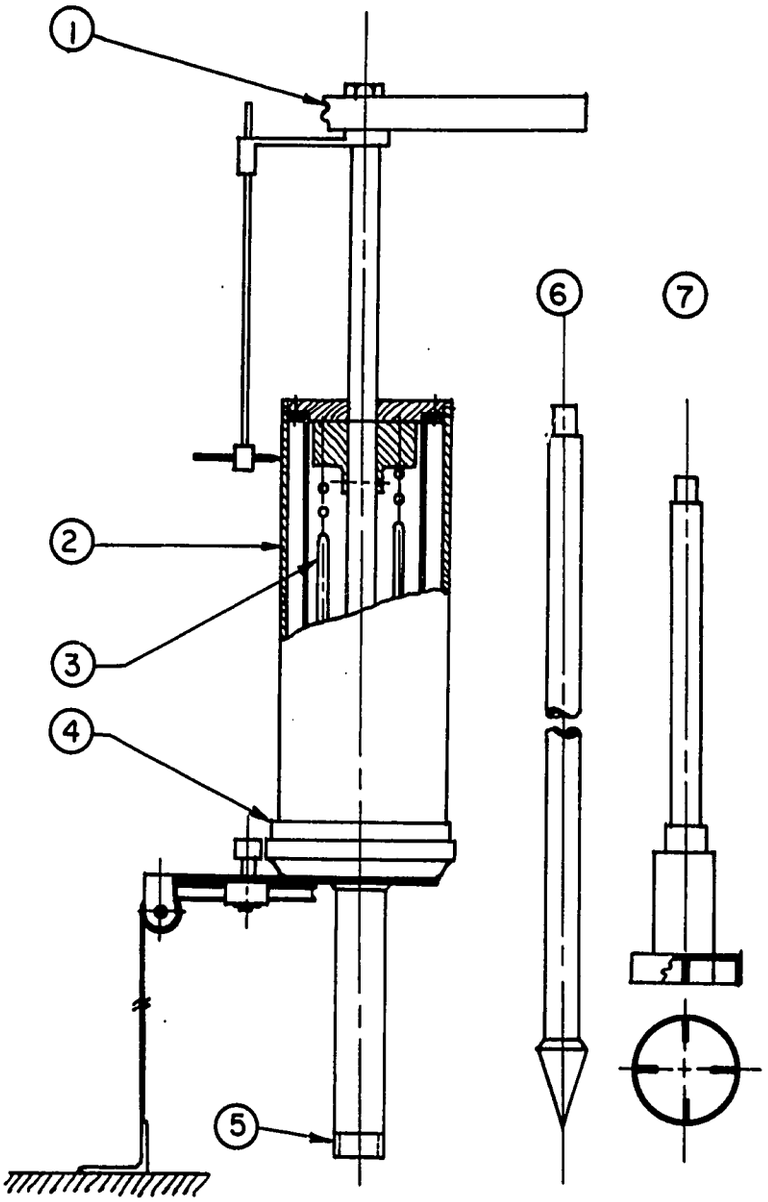


Fig. 23. Schematic drawing of a Soil Values Meter TN-4.

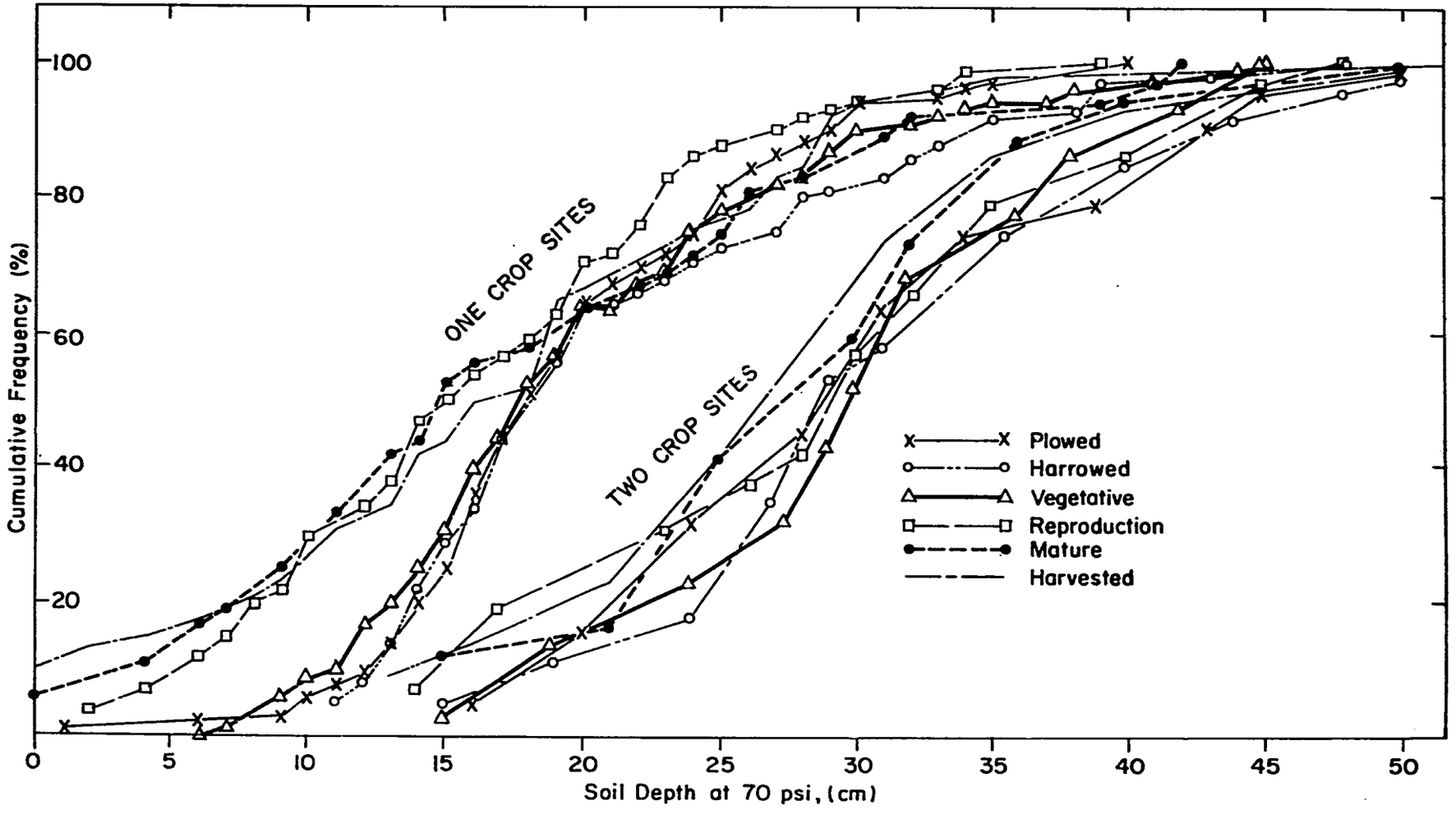
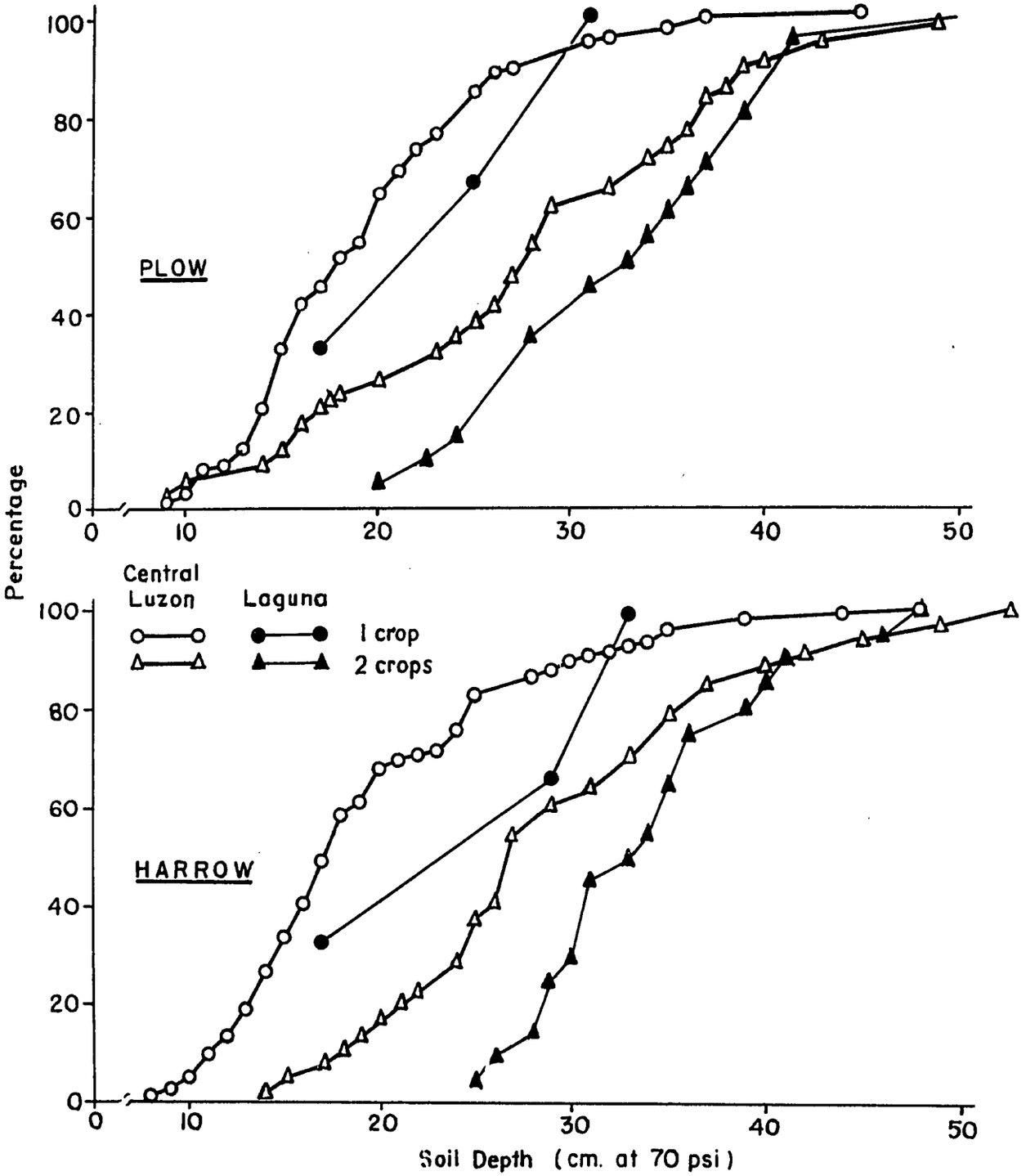


Fig. 24. Cumulative frequency of various soil depths (cm) at which a U. S. Army Corps of Engineers WES Cone Penetrometer had a rr istance of 70 psi.



Figs. 25, 26. Cumulative frequency of various mean soil depths (cm) during plowing or harrowing at which a U.S. Army Corps of Engineers WES Cone Penetrometer had a resistance of 70 psi: Central Luzon and Laguna Provinces, Philippines (1966-67).

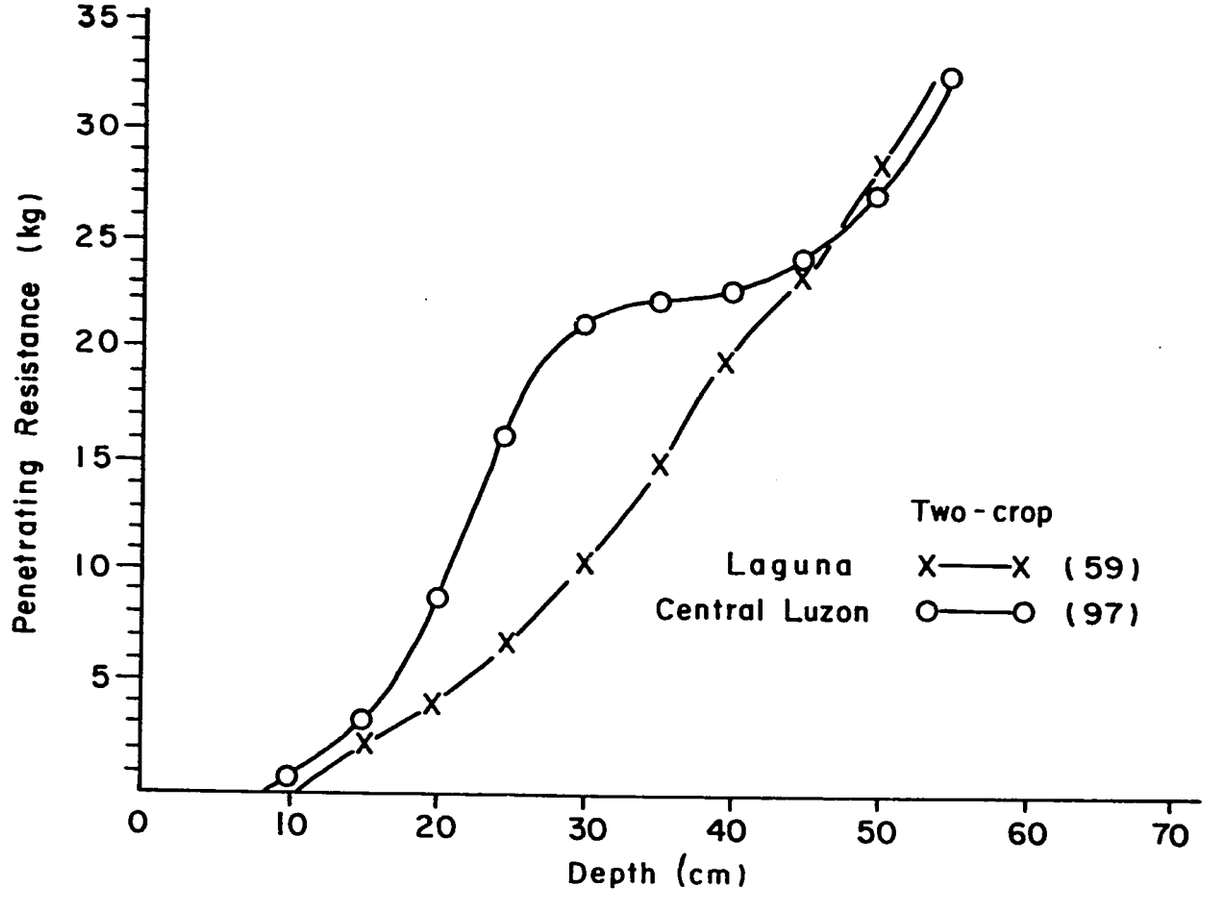


Fig. 27. Mean soil resistances at different depths (cone index) measured during final harrowing with the soil values meter TN-4. The numbers enclosed in parentheses refer to the number of measured sites. Laguna and Central Luzon, Philippines, 1967-68.

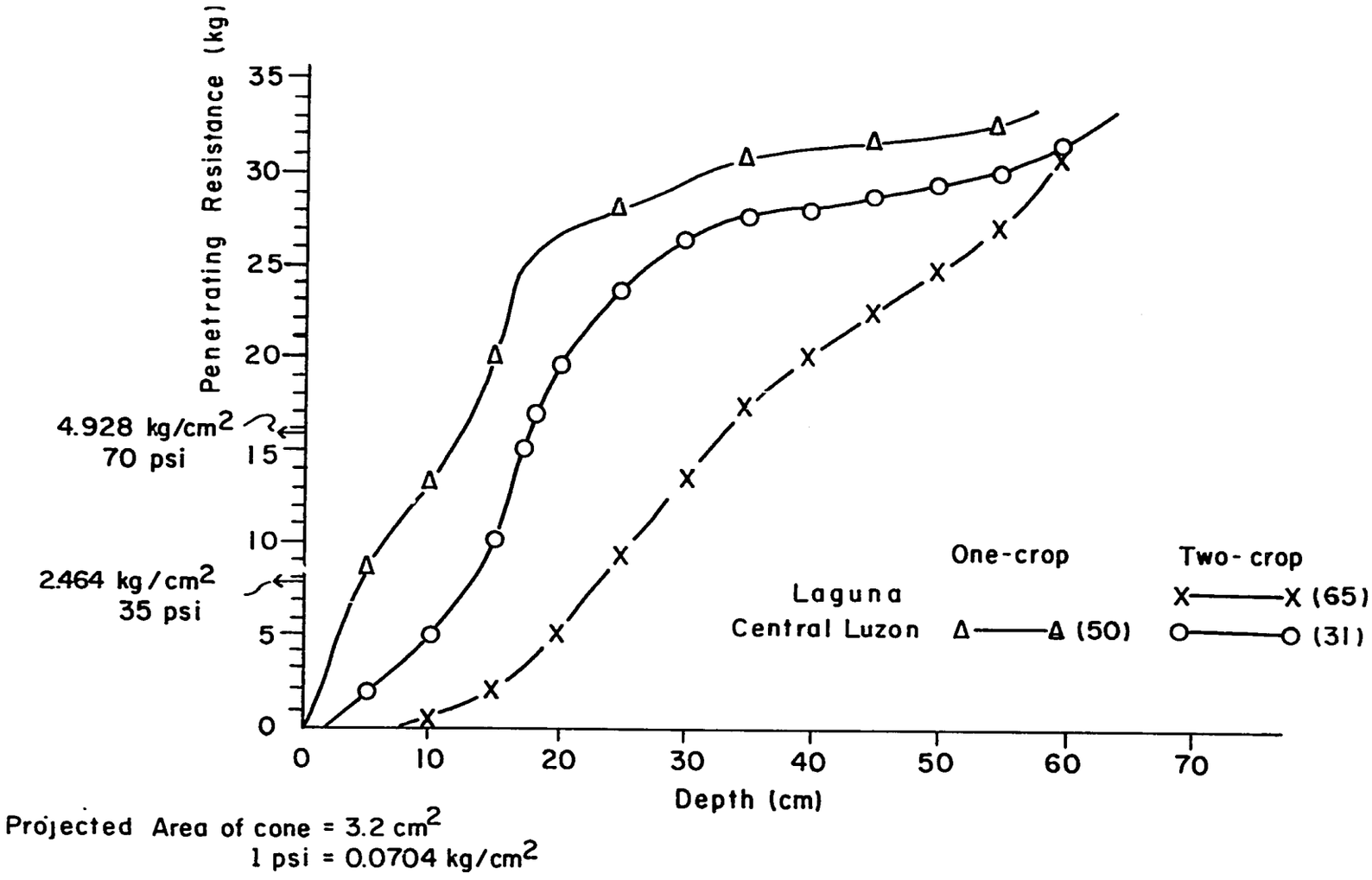


Fig. 28. Mean soil resistances at different depths (cone index) measured just before land preparation with the soil values meter TN-4. The numbers enclosed in parentheses refer to the number of measured sites. Laguna and Central Luzon Provinces (1967-68).

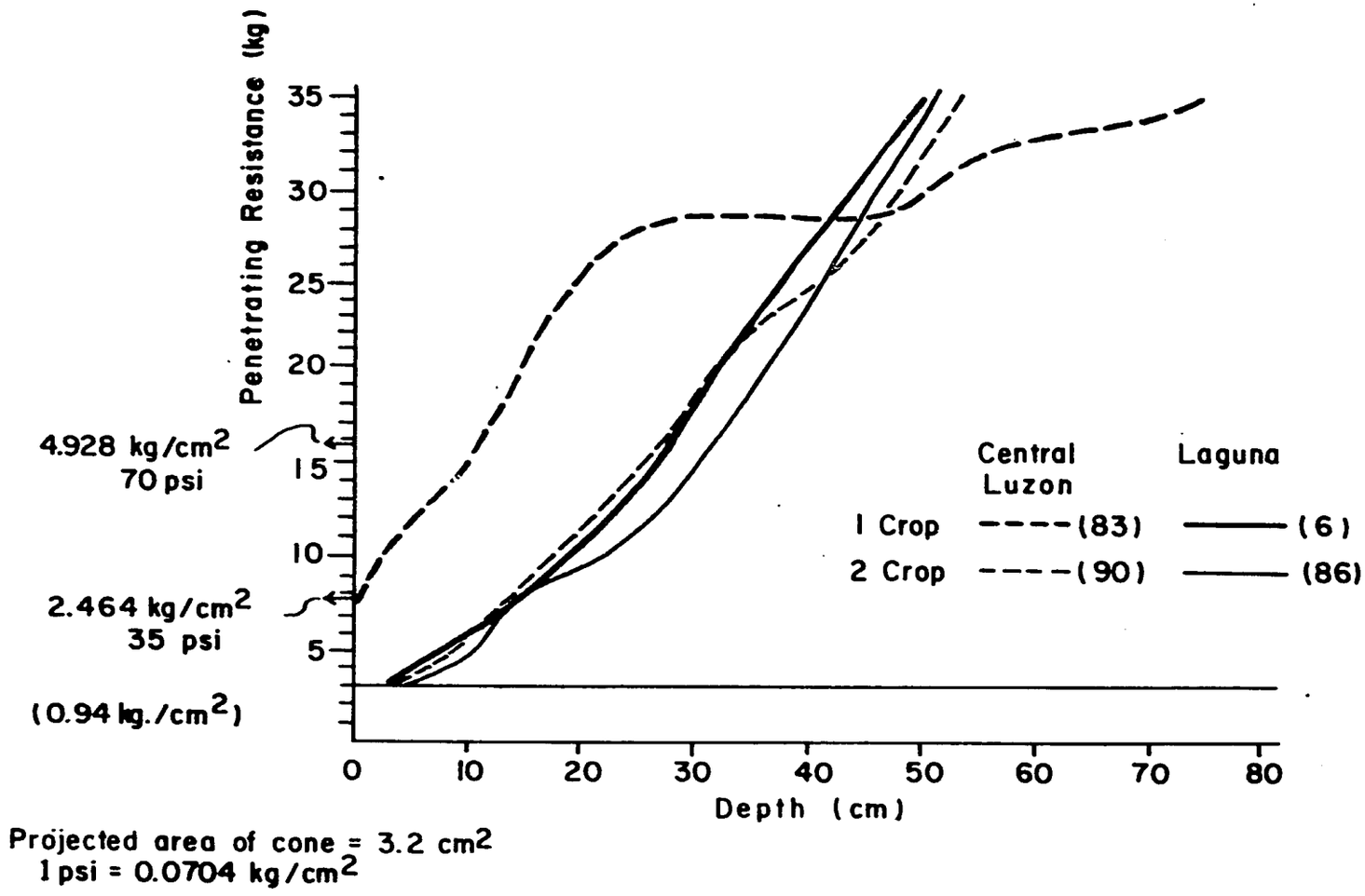


Fig. 29. Mean soil resistances at different depths (cone index) measured just after harvest with the soil values meter TN-4. Numbers enclosed in parentheses refer to the number of measured sites. Laguna and Central Luzon Provinces, Philippines (1967).

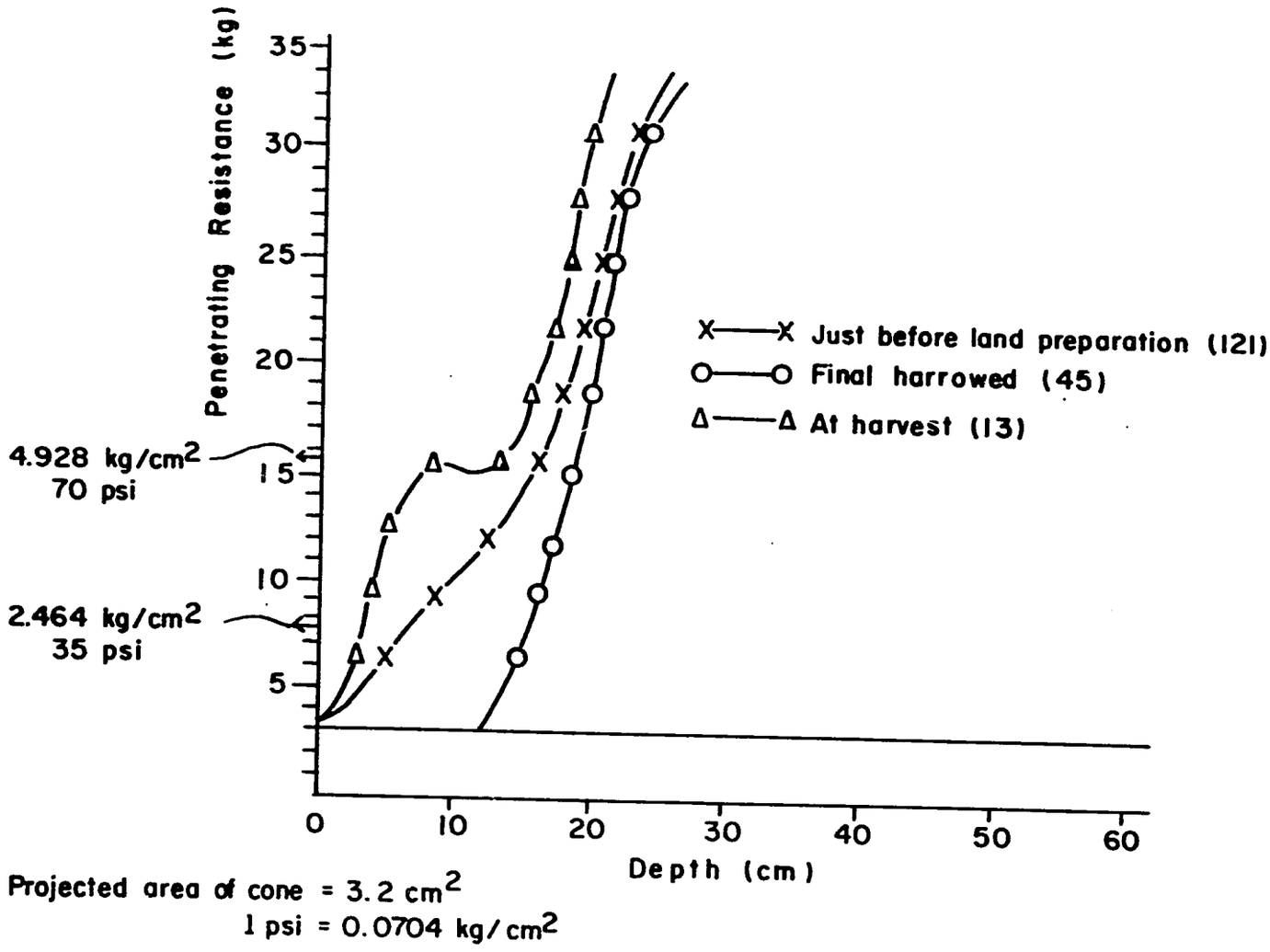


Fig. 30. Mean soil resistances at different depths (cone index) measured at different stages during the cropping season of two-crop fields with the soil values meter TN-4. Figures enclosed in parentheses refer to number of measured sites. Isabela Province, Philippines (1968).

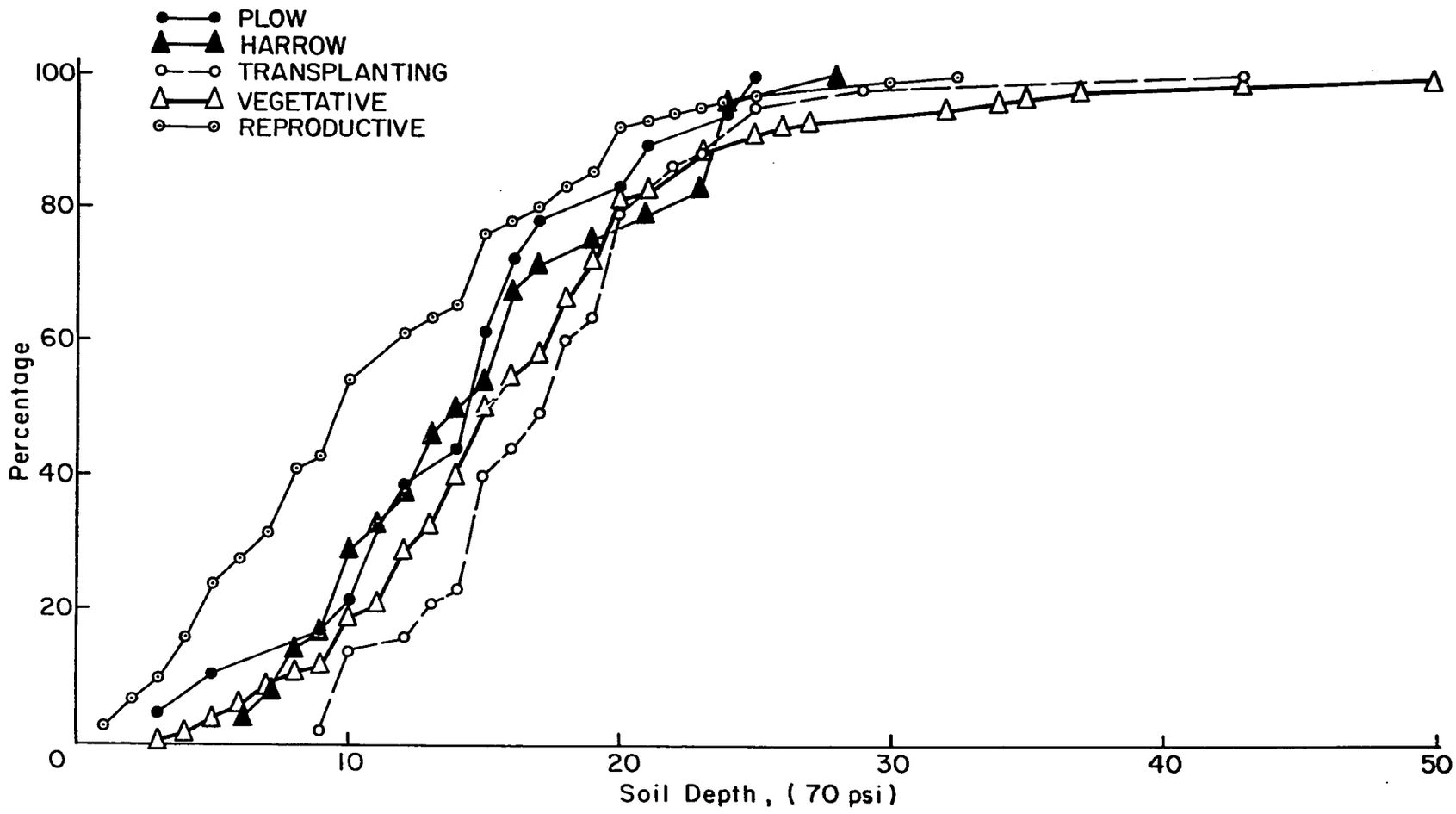


Fig. 31. Cumulative frequency of various mean soil depths (cm) during the plowing, harrowing, transplanting, vegetative, or reproductive stages at which a U. S. Army Corps of Engineers WES cone penetrometer had a resistance of 70 psi: Isabela, Philippines (October 23, 1967 - January 13, 1968).

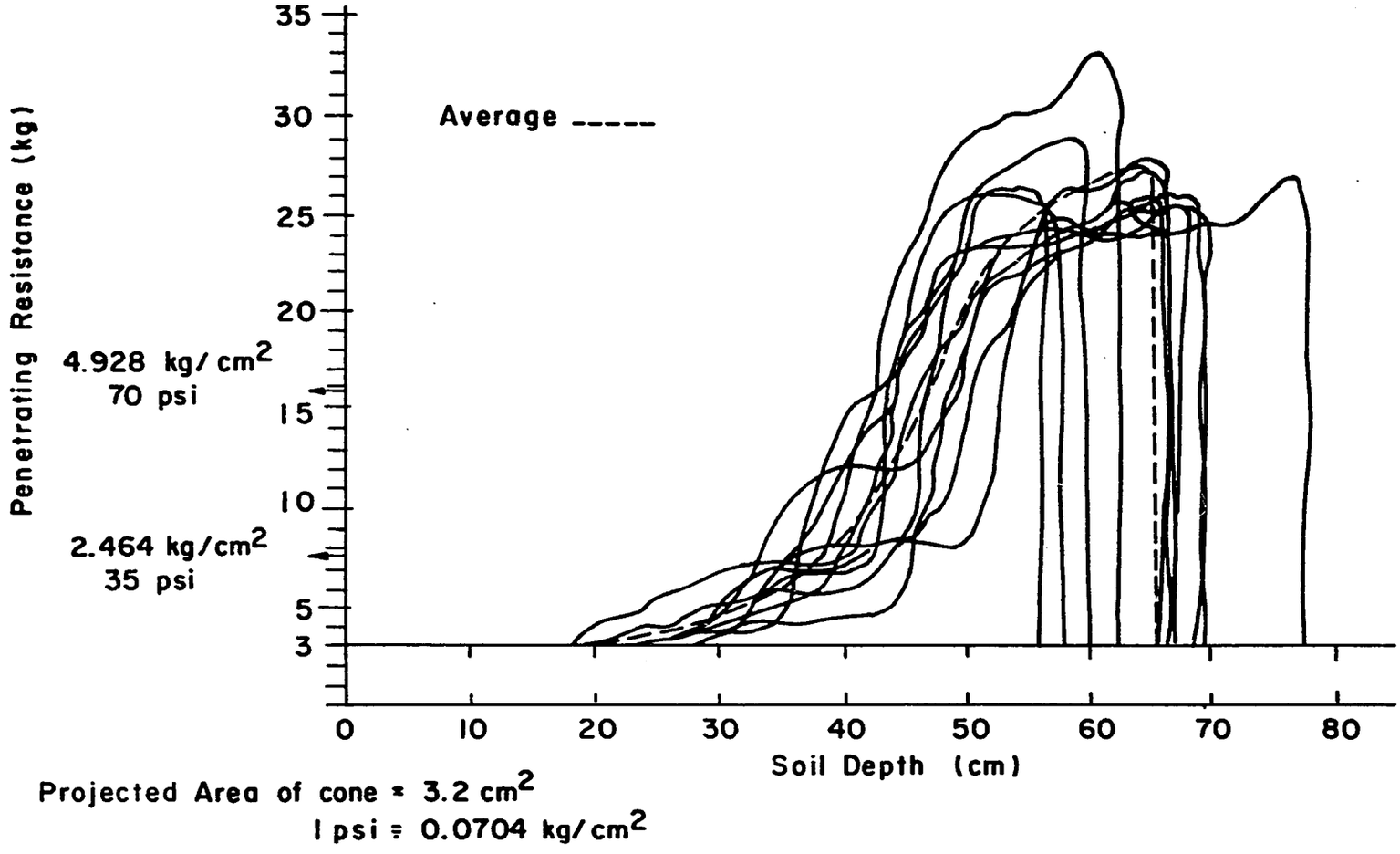


Fig. 32. Actual measurements recorded by the soil values meter TN-4 on one of IRRI's maximum production plots (3 crops per year), Laguna Province, Philippines (1967).

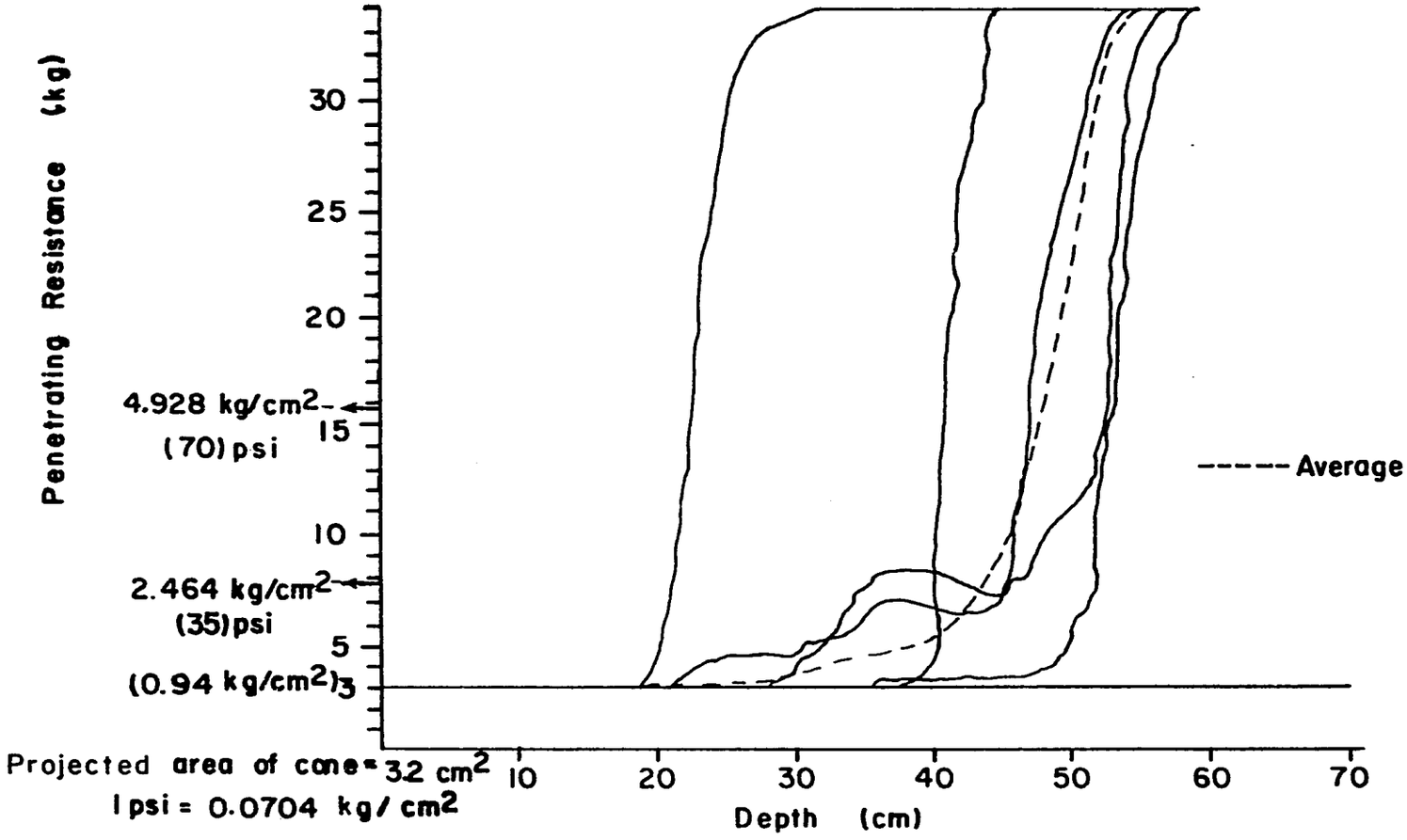


Fig. 33. Actual measurements recorded by the soil values meter TN-4 on a water-logged area. An Iseki KF-850 was tested on this field and bogged down. Isabela Province, Philippines (1968).

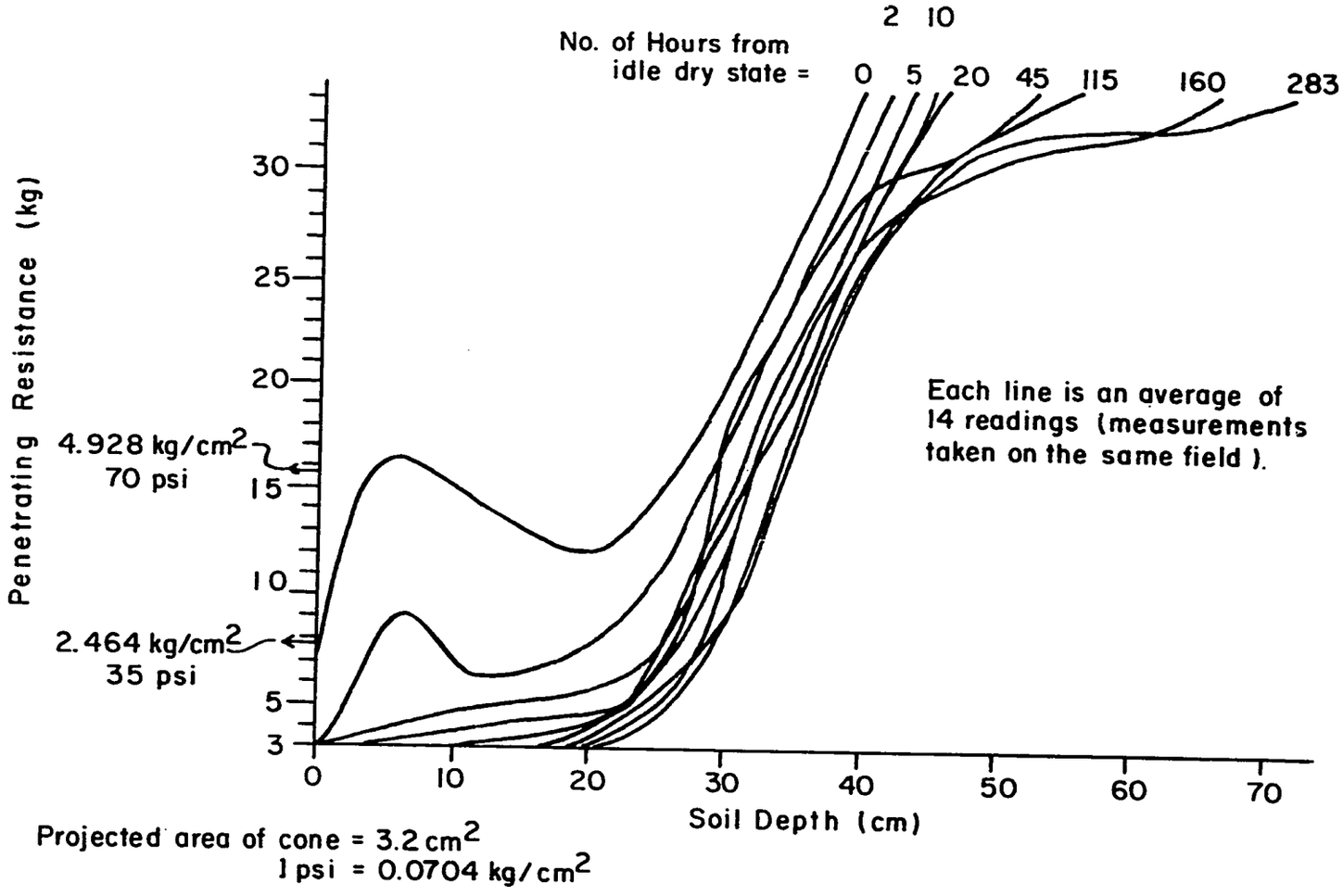


Fig. 34. Change in soil resistance from an idle dry state to a condition after the soil has been flooded for a time. Measurements made with TN-4 soil values meter. IRRI, Laguna Province, Philippines (1968).

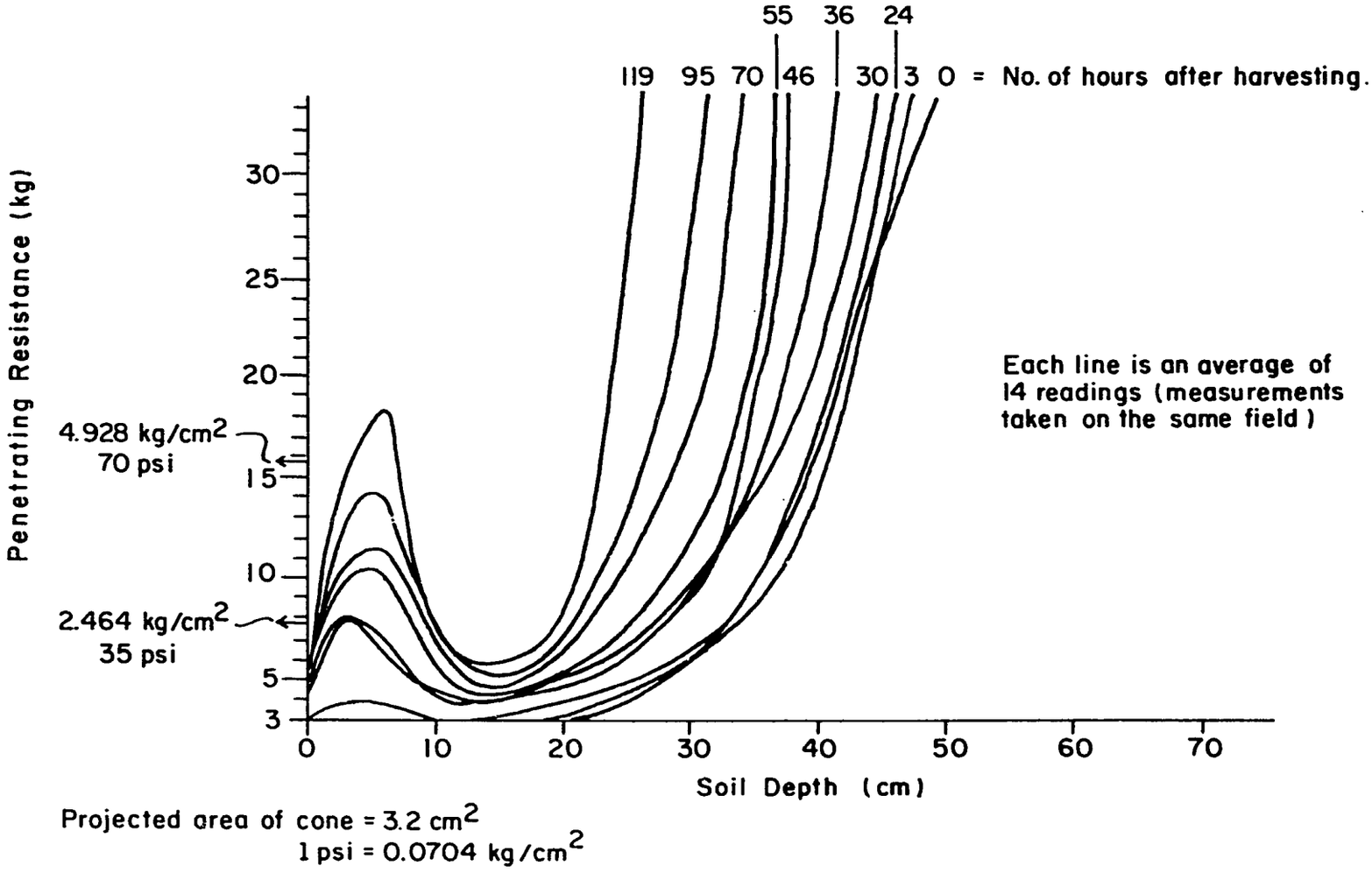


Fig. 35. Change in soil resistance from harvesting to a dry state measured with the TN-4 soil values meter. IRRI, Laguna Province, Philippines (1968).

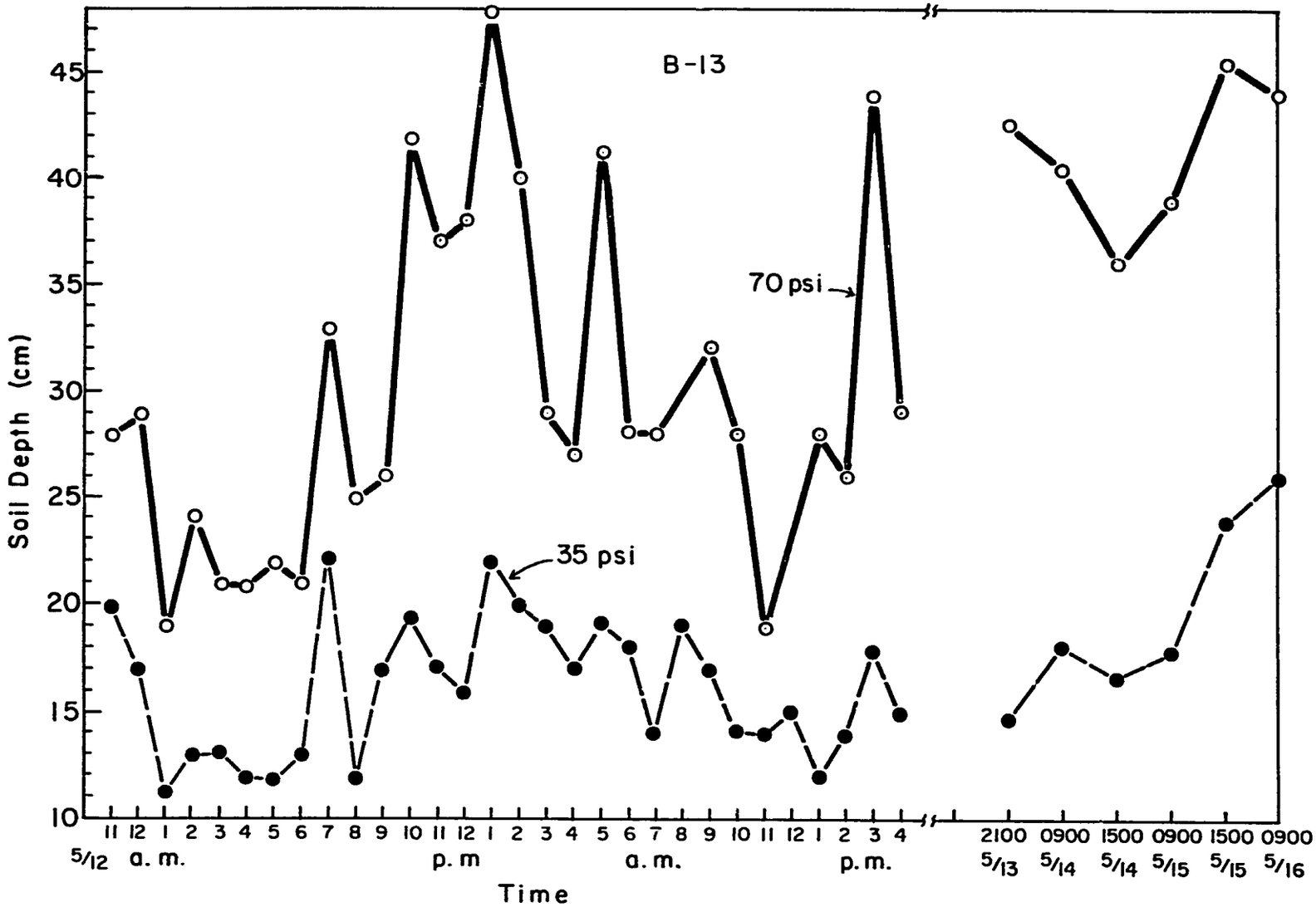


Fig. 36. WES Cone Penetrometer Measurements of Changes in Soil Penetrating Resistance from a dry to Flooded State (Field B-13, IRRI, 1969).

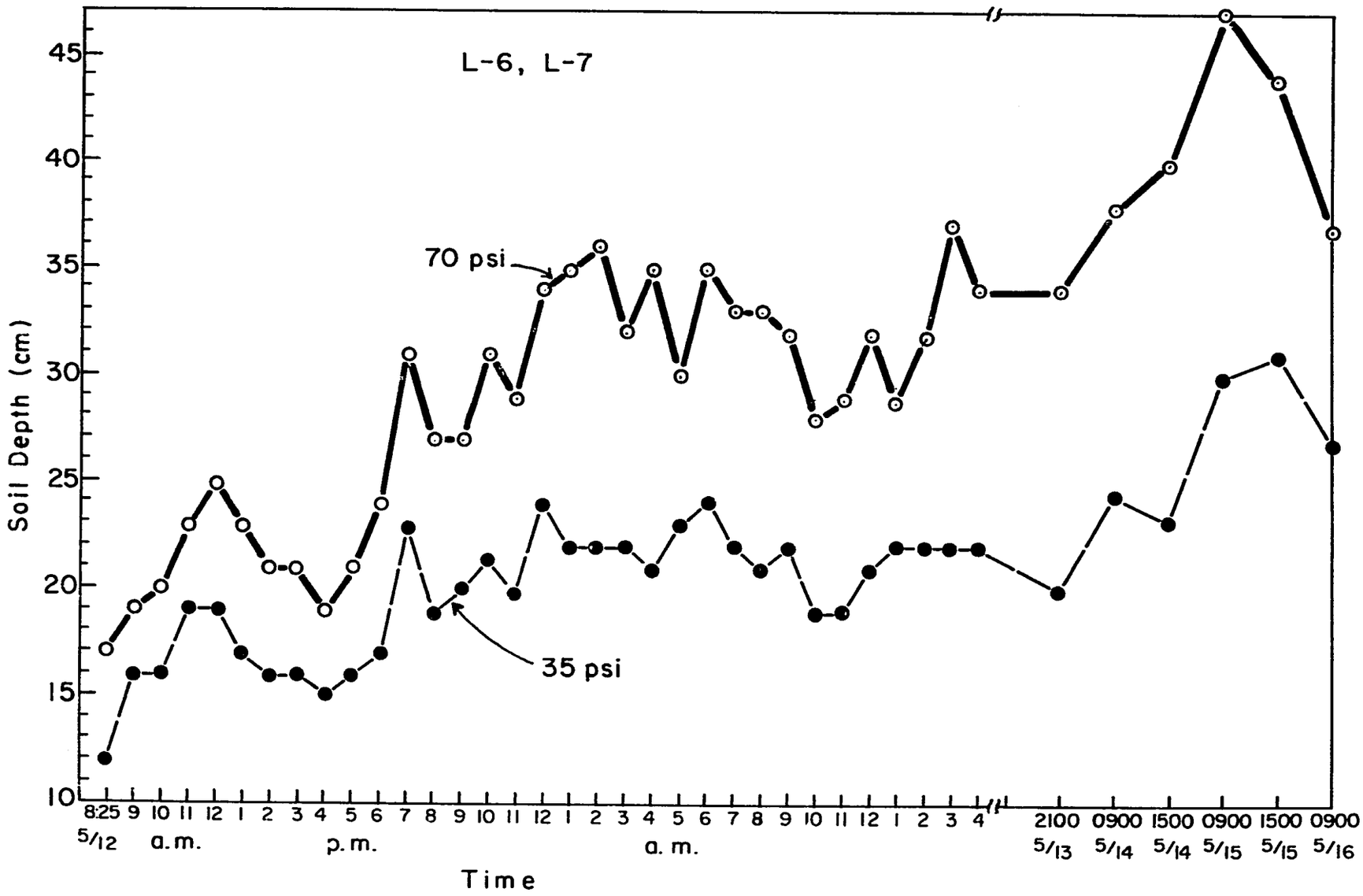


Fig. 37. WES Cone Penetrometer Measurements of Changes in Soil Penetrating Resistance From a Dry to Flooded State (Field L—6,7, IRRI, 1969).

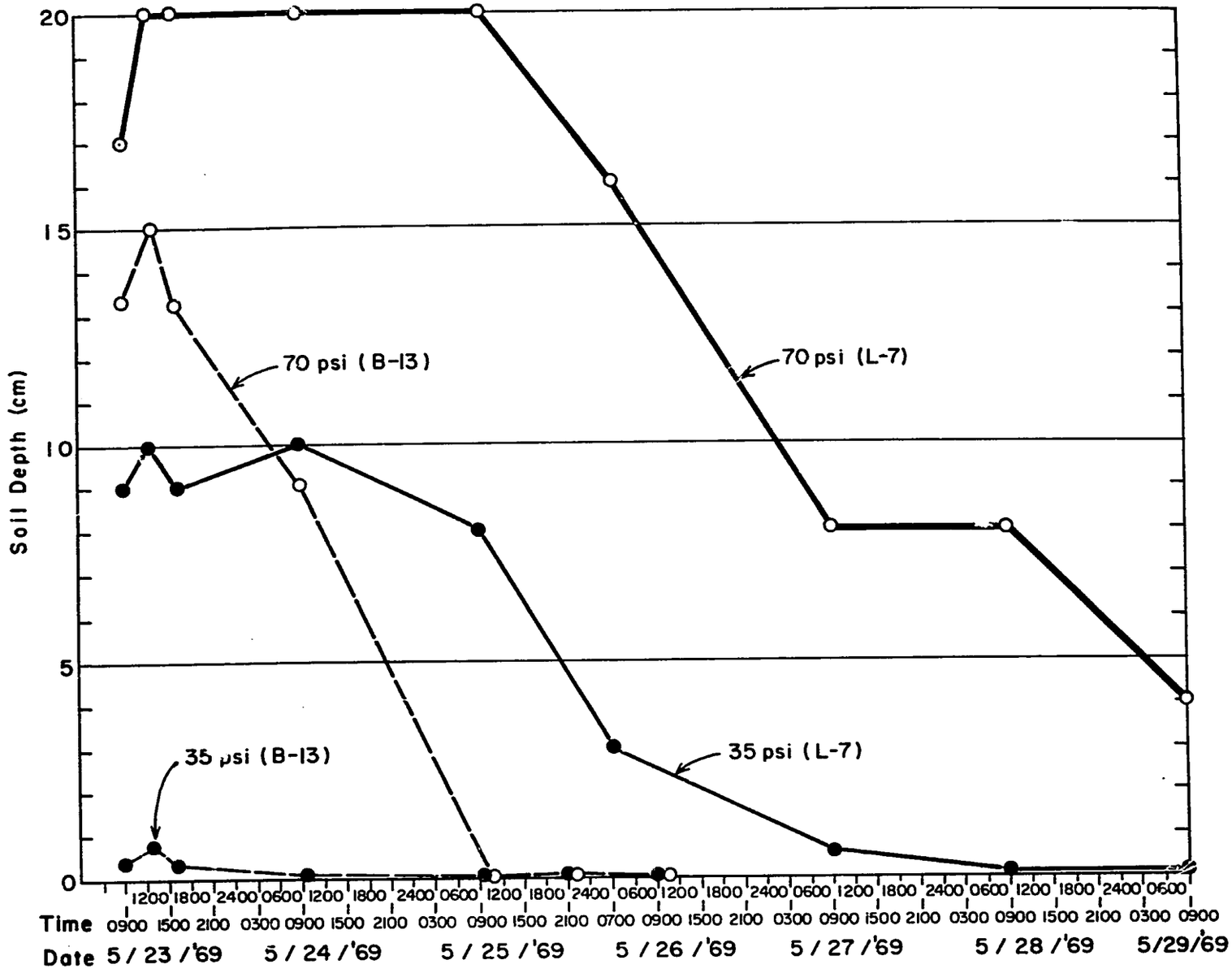
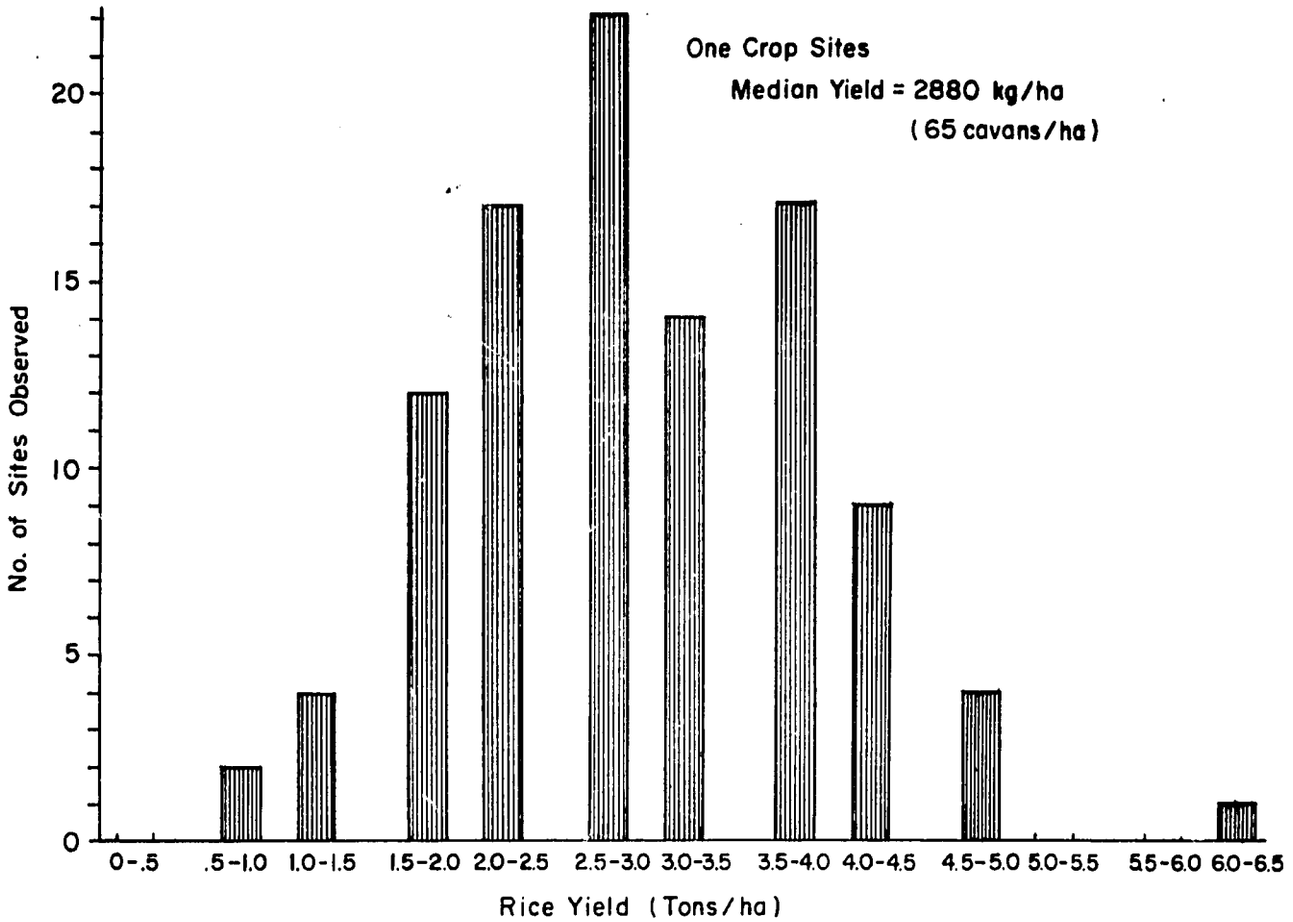


Fig. 38. WES Cone Penetrometer Measurements of Changes in Soil Penetrating Resistance From a Saturated to a Dry Condition (Fields B-13 & L-6,7, IRRI '69).



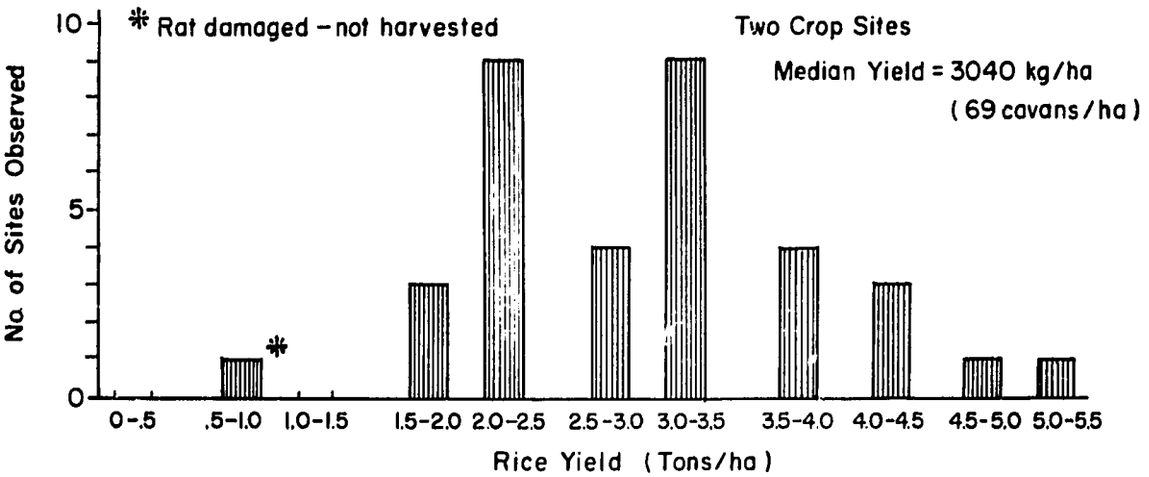


Fig. 39. Rice yields from one- and two-crop sites as estimated from a sample harvest of 4 sq m of the field arrayed in a frequency distribution.

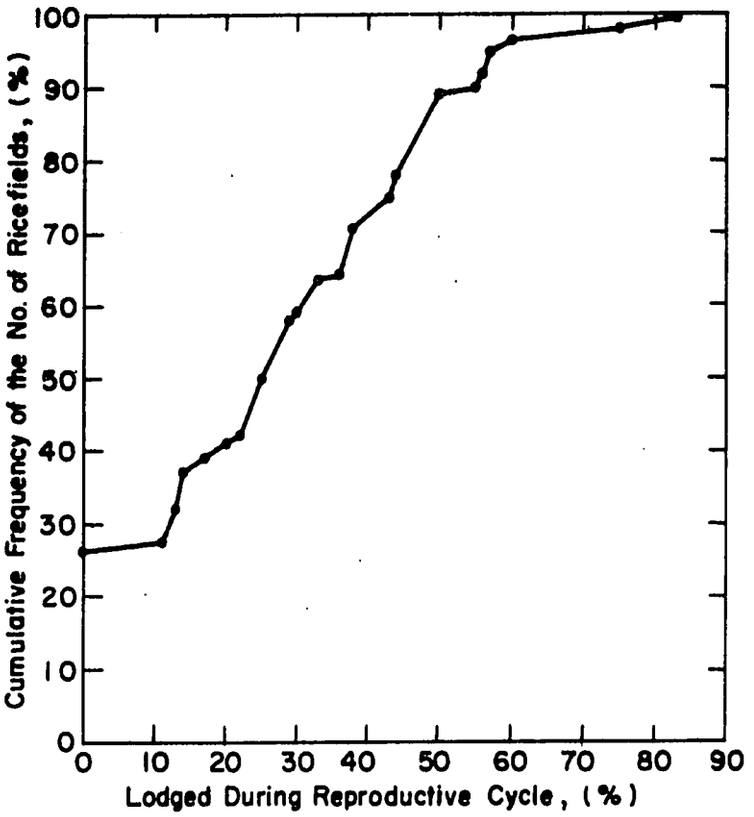


Fig. 40. Cumulative frequency chart of the percentage of the time that the survey rice crop lodged during the reproductive cycle.

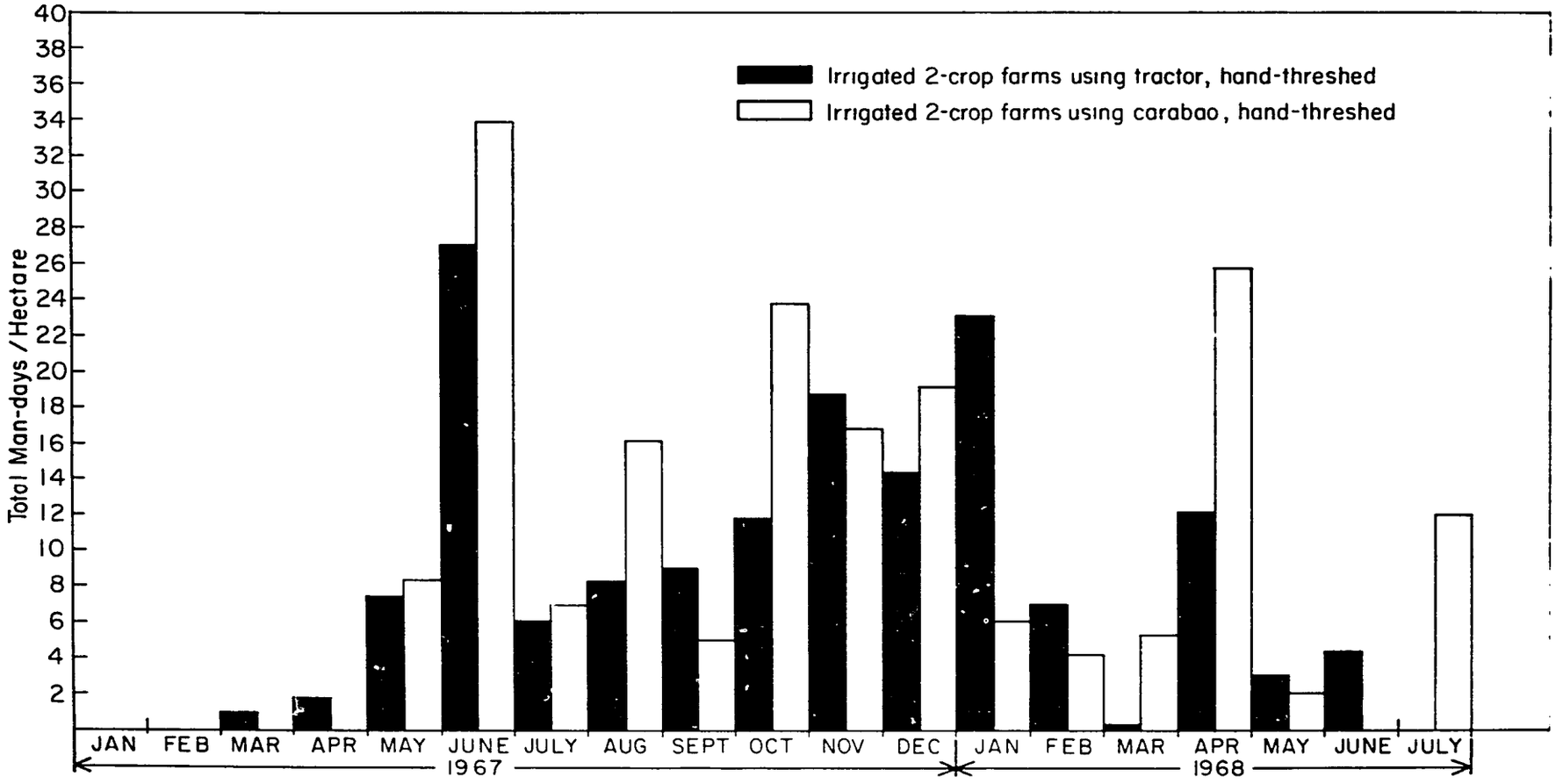


Fig. 41. Monthly Labor Distribution, 9 and 5 Irrigated 2-Crop Farms Using Tractor and Carabao, Respectively; Hand-Threshed Laguna, 1967-1968.

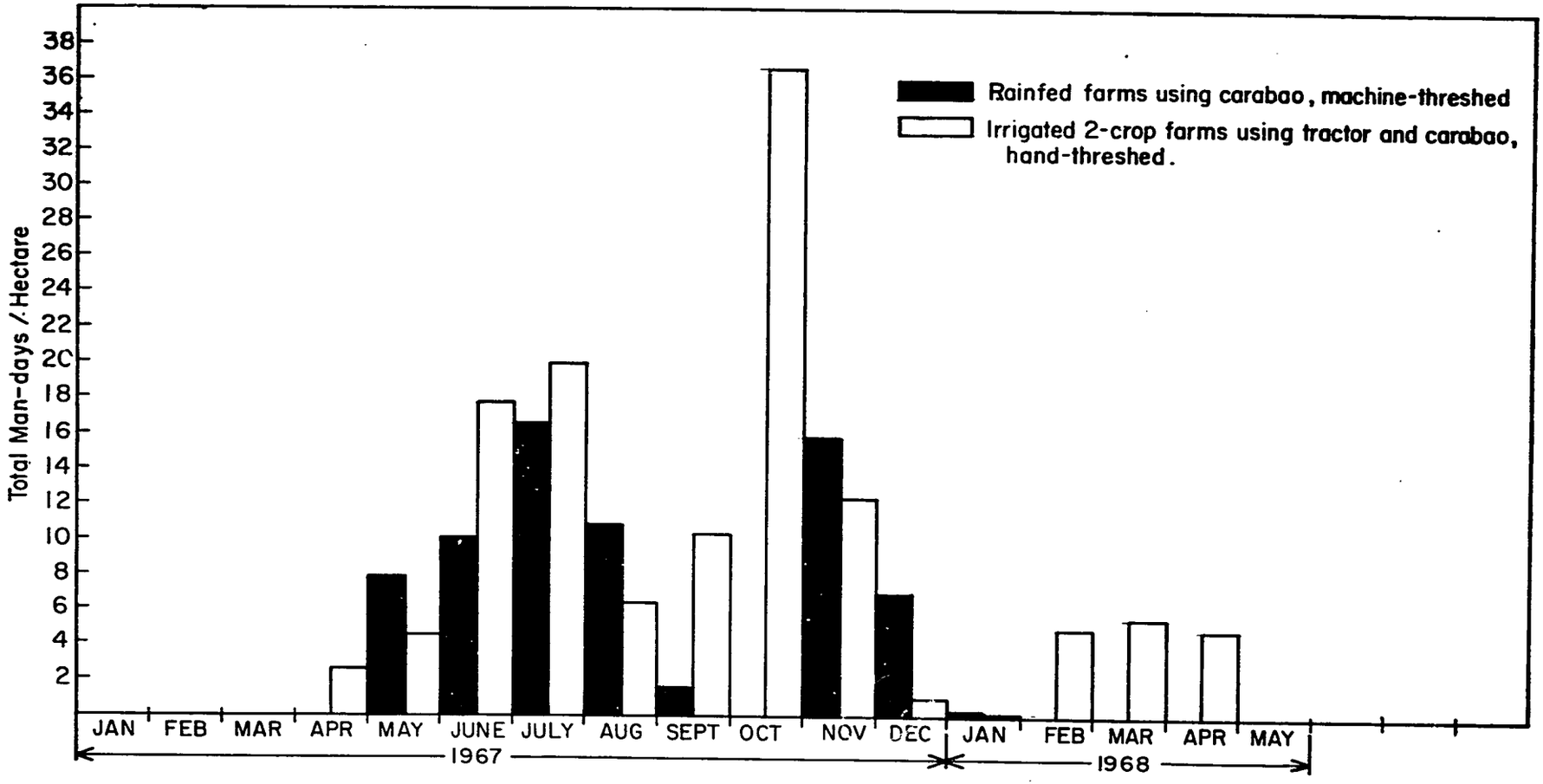


Fig.42. Monthly Labor Use Per Hectare, 10 Irrigated 2-Crop Sites Using Tractor and Carabao, Hand-Threshed and Rainfed Farms Using Carabao, Machine-Threshed, Central Luzon, 1967-1968.

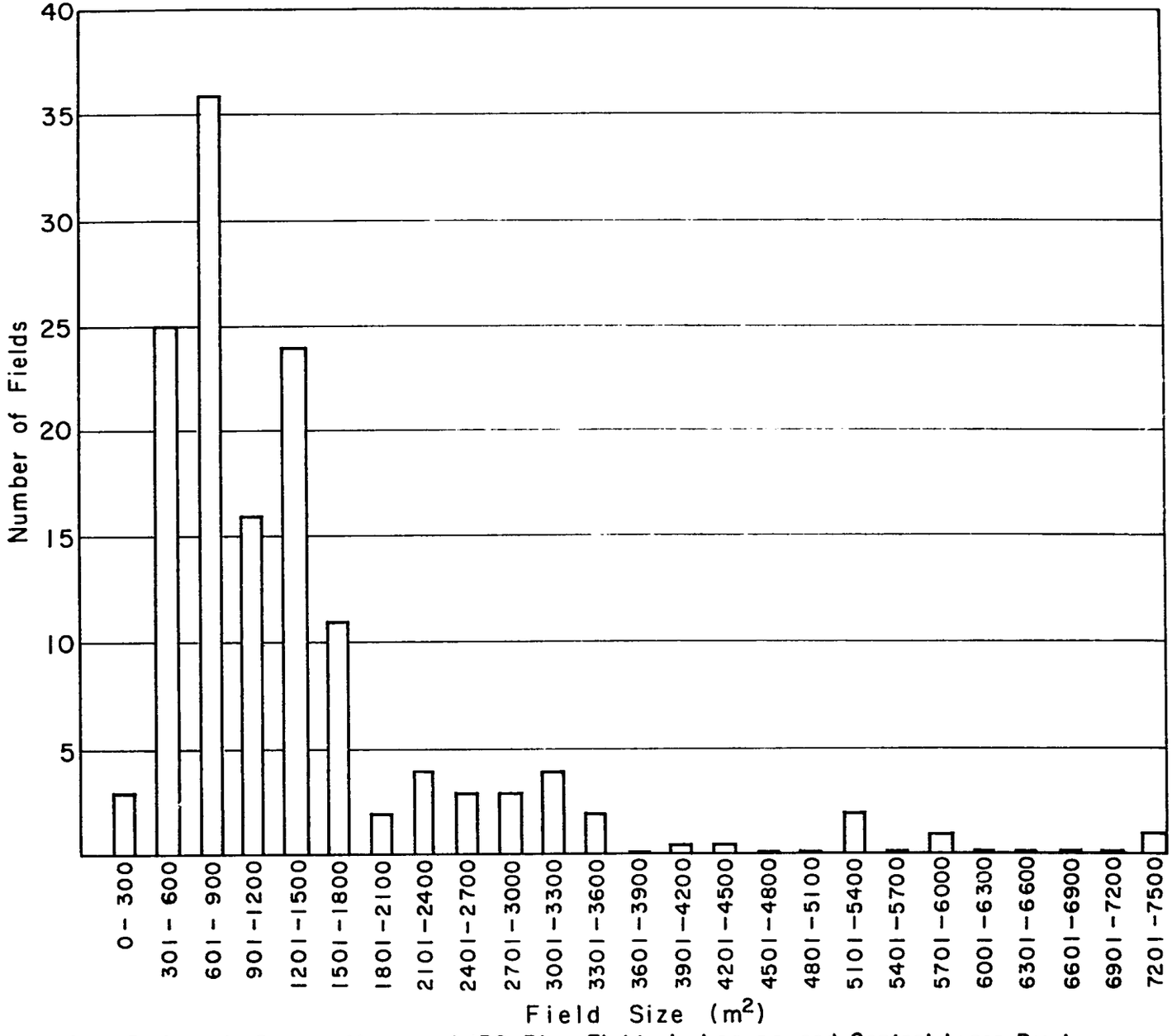


Fig. 43. Area in Square Meters of 139 Rice Fields in Laguna and Central Luzon Provinces.

Fig. 44. The IRRI three-row power weeder.

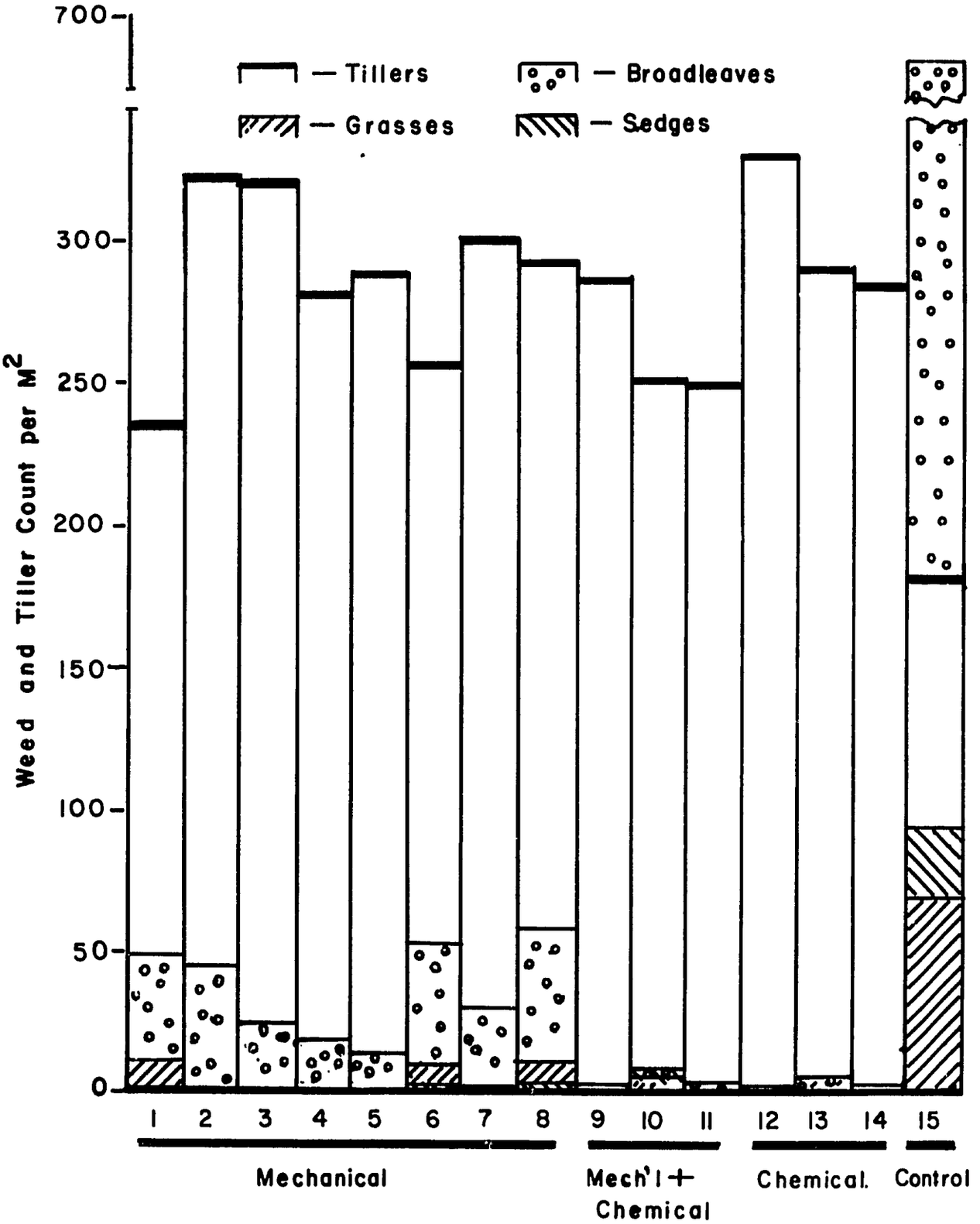


Fig.45. Effect of different weeding methods on weed population and tillers per square meter of IR8-68 at 45 days after transplanting, IRRI wet season, 1968.

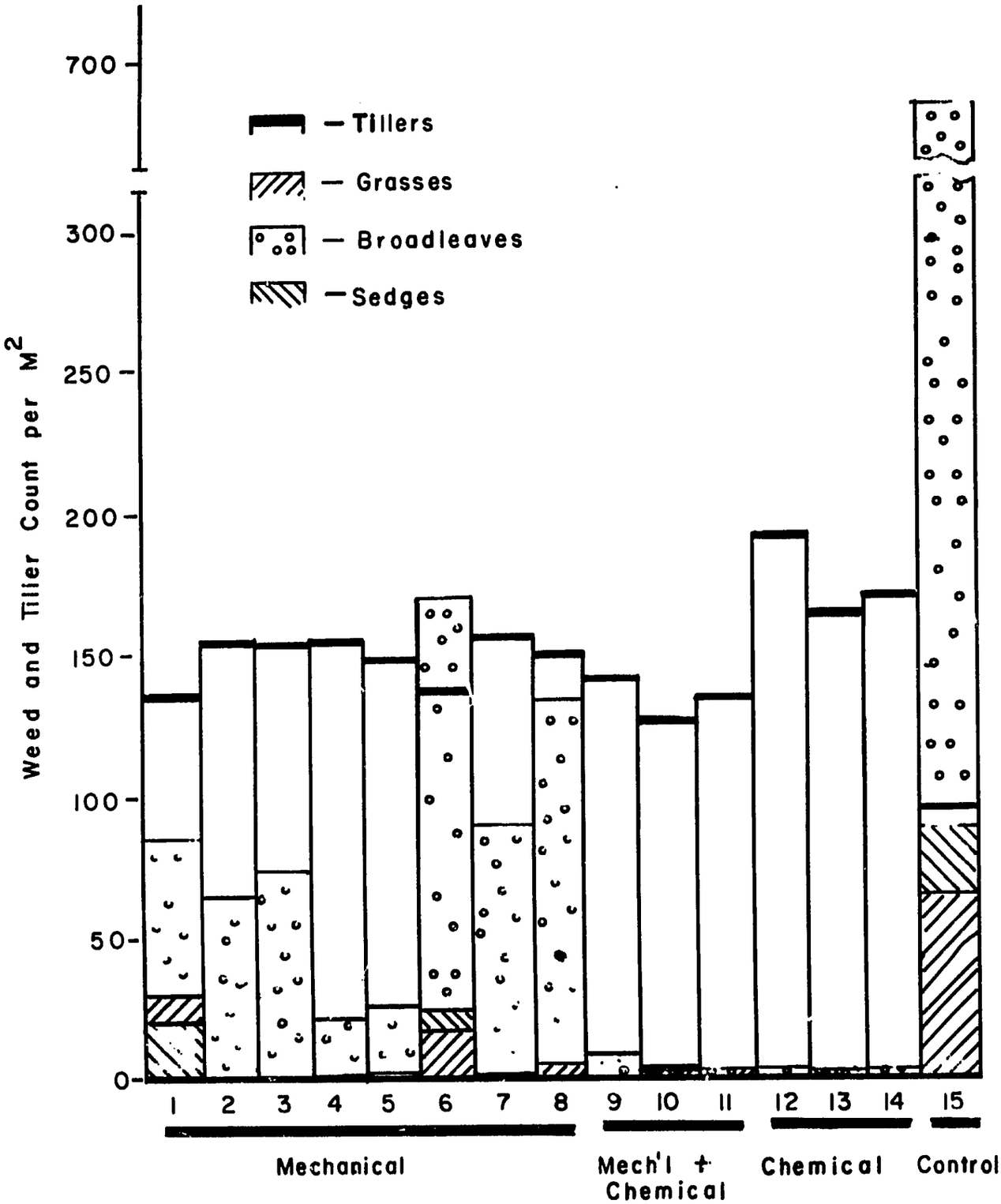


Fig.46 Effect of different weeding methods on weed population and tillers per square meter of Chianung 242 at 45 days after transplanting, IRRI wet season, 1968.

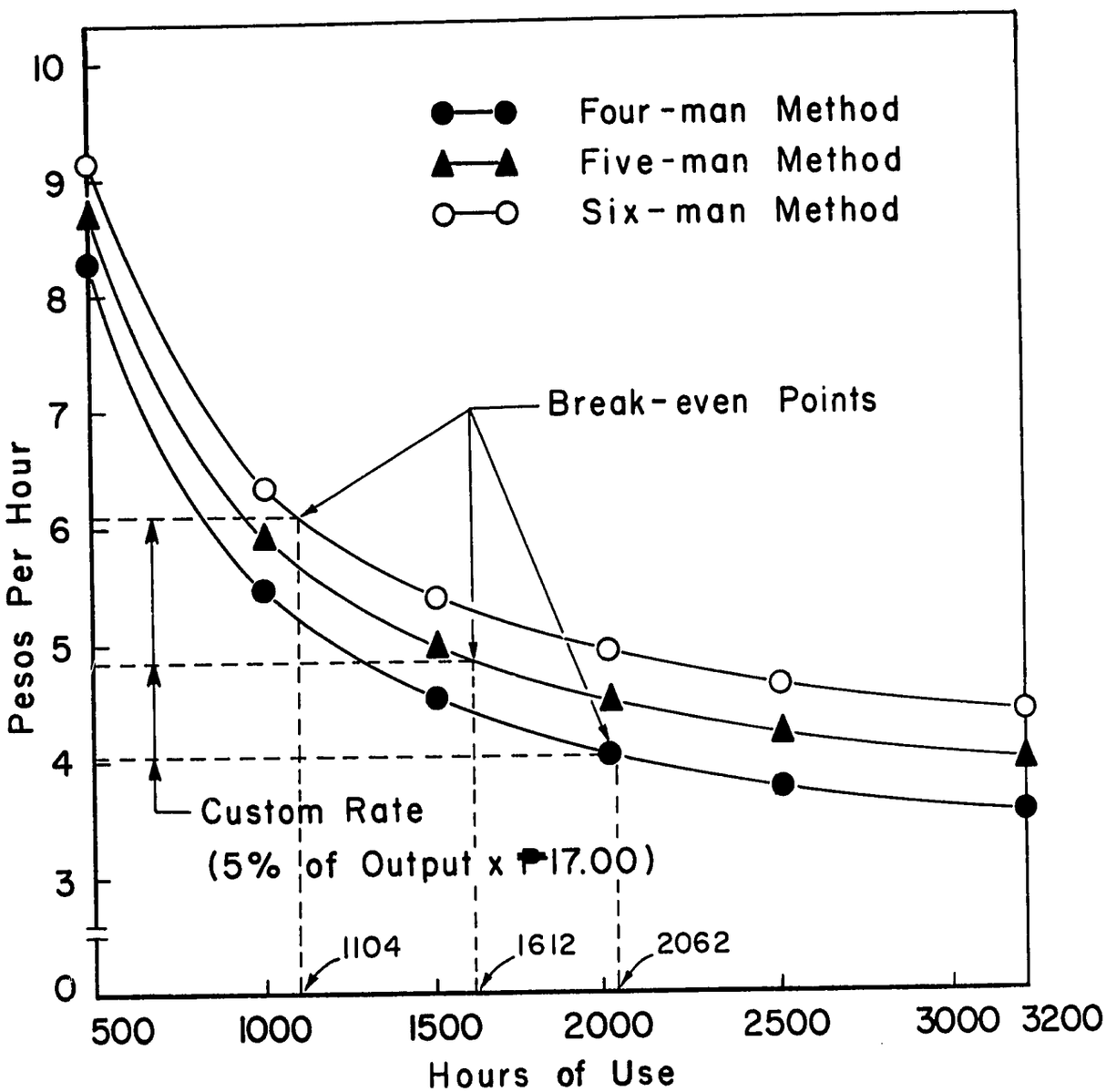


Fig.47. Average cost curves, IRRI Drum-type Paddy Thresher.

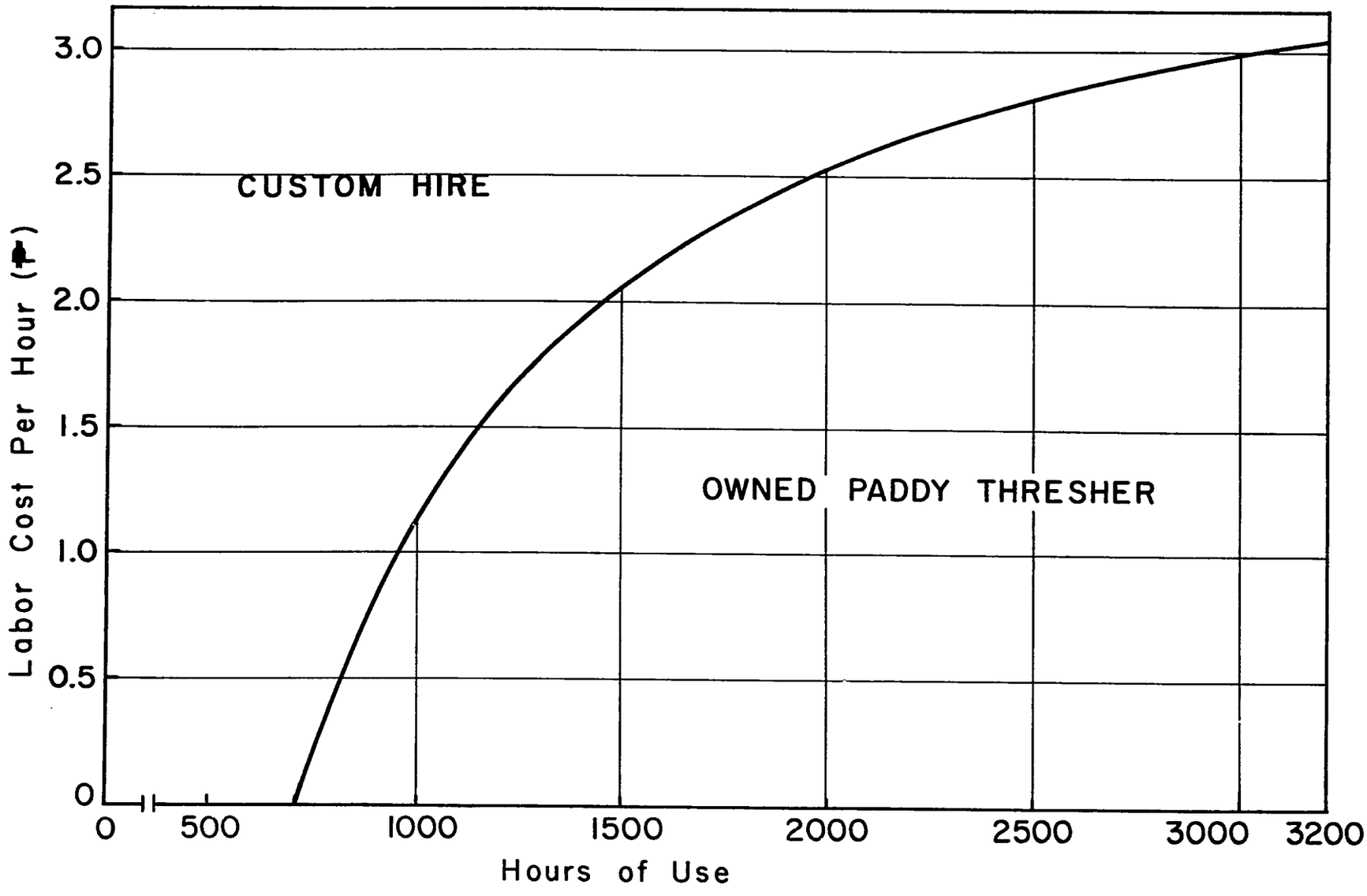


Fig.48. Zones of cost advantage: custom hiring vs owning IRRI paddy thresher using five man-method.