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TRACTION PROBLEMS ON FLOODED RICE SOILS

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TRACTION PROBLEMS ON FLOODED RICE SOILS

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The first question that usually arises is: Why not use standard dry farming practices to avoid the problem of traction on flooded rice soils? Unfortunately, the rice crop is grown in situations where these practices are not applicable.

First, the best yearly total rice production is to be expected from irrigated tropical areas where several crops may be grown annually. Many of the most productive sites have highly plastic, poorly drained, heavy, clay soils. With adequate water, good varieties, suitable farm equipment and good farming practices, these areas may grow two to three crops of rice per year. To dry the soil to the point where normal tillage procedures could be used would require 30 to 60 days, thus 10 to 20 percent of the year's production time would be lost. In addition, the dry soil would be hard and plastic and difficult to work.

Second, the areas without adequate impounded irrigation water or wells must depend on rain-fed fields or diversion type irrigation from rain-fed streams. The land may be prepared and planted in a dry condition after the 100- to 180-day dry season, but the first rains sprout the weeds as well as the rice. Poor and weedy stands of rice develop before adequate water is available to flood. The usual practice is to permit the weeds to grow until adequate water is available for wet land preparation.

In wet land preparation, the soil is made into a mud slurry or puddle, and the weeds are pushed 4 to 8 inches beneath the soil surface. The number of passes and degree of puddling depend upon the water supply, soil type, vegetation, power unit, and implements.

The most common method of preparing land for rice in the Philippines is to use a 4- to 6-inch moldboard plow drawn by a single carabao (water buffalo) (Fig. 1) for the first operation. Plowing partially buries the weeds, and they start to decay; it also breaks the soil into a ribbon for better soaking of the soil. One to three weeks

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after plowing, two to three passes are made with a comb harrow (Fig. 2) to puddle the soil; this leaves a smooth lake of mud with no weeds showing.

Tractive and rotary type tillers and tractors may be substituted for the animal plow and harrow (Figs. 3 to 8). The final results are comparable.

Land preparation methods, climatic conditions, irrigation facilities, and many farm practices affecting traction problems are interrelated and difficult to change. Other factors related to traction problems, such as field sizes, levee shapes, access roads, and equipment design, may be changed. Soil conditions can be measured and expressed in objective terms to aid in the selection of suitable equipment, and local land preparation, drainage, and irrigation practices may be modified to reduce the areas of very soft soils.

Rice soils are usually of a heavy clay which is firm when first wet but may be progressively softened as flooding continues. Soil strength values vary with the duration of flooding and with the location of the plow sole or hard pan. Figure 9 shows cone penetrometer readings (1, 3) taken in paddy fields in Thailand. These data were originally summarized in a table which indicated that most of the fields were idle and in short grass at the time the readings were taken. The relatively high cone index (CI) values at 0 to 6 inches thus probably indicate that rainfall had not been adequate for planting rice.

In Thailand, the plow sole or hard pan is indicated at a depth of 6 to 9 inches, with no increase in strength from 9 to 30 inches. However, many flooded rice soils increase in strength with depth. Figure 10 shows CI readings taken on 57 plots on the IRRI experimental farm. The values for June after 1 to 2 months of heavy rain and flooding are similar to the data for Thailand. The values for October after 5 to 6 months of flooding are much lower.

Figure 11 shows CI readings for two plots which had been flooded and plowed several times during a 12-month period. These plots were difficult to prepare with presently available equipment. Mean cone index values were usually under 40 psi before bogging occurred, and many pieces of equipment operated at a CI below 30 psi. Measured values of rolling resistance coefficients ranged from 0.20 to more than 1.00 and generally increased with sinkage. Both rolling and traction coefficients increased with the use of lugged wheels. Traction coefficients ranged from zero to 0.70.

Further tests must be completed to clarify the interaction of cone index, weight, lug action, and net traction available. Until this is accomplished, the publication of traction values will not be worthwhile. Field observations seem to favor the open lug wheel which provides traction without much displacement of the soft mud. Wide pneumatic tires provide flotation and traction, but the wide ruts are a handicap in land preparation where one of the major considerations is to leave the soil level.

Ground contact pressures for most equipment used in wet fields range from 1/3 to 2 psi while most standard tractors have contact pressures of 5 to 8 psi when equipped with regular tires. The method used by Knight and Freitag (1) to compute the mobility index seems to give reasonable results under field conditions when the cage wheels are considered as tires and the sinkage is estimated as 0.3 of wheel diameter to estimate contact area. The front wheels may be assumed to carry no load under extreme conditions.

Traction may be increased by the use of rotary tillers which give a thrust of approximately 50 lbs per foot of width in very soft soils, instead of a draft of 90 lbs or more required by a disc harrow. Rotary tillers help only in forward movement while preparing the flooded soil. Backward movements, turns, levees, ditches, and areas which must be left untilled prevent the use of the additional thrust from the rotor tiller.

Most traction failures occur while maneuvering on turns or traveling from field to field. Steep ditches and levees which must be crossed to move from field to field cause most traction problems. Most levees are approximately 1 foot high, 1 foot wide at the top, and 2 feet wide at the bottom. Levees are generally of firm soil while the soil next to levee is soft, and a vehicle may sink from 6 to 12 inches. Thus the levee is an obstacle equivalent to crossing a 12- 24-inch log with soft slick soil on each side of the log. Often the rotary tiller must be backed up to destroy the levee before a standard tractor can cross to the next field. However, two-wheel power tillers with lugged wheels easily move over the levees and make the many sharp turns required in small fields.

Field size and shape are now fairly uniform in areas where draft animals and small tillers are used. Measurements of 457 fields on 13 Philippine farms show the average field to be 18.7 meters by 31.1 meters. The average area is about 590 square meters or one-seventh of an acre. These small fields require an excessive number of

turns in which only one wheel must provide all the traction. Bogging and traction failures often occur when turning. In order to use larger equipment, the Japanese are now enlarging their rice fields (2) from 500 square meters to 3000 square meters or more. Changing of field size requires additional farm power and investment, but the change will result in better equipment operation. The small 1- to 3-hectare farms presently have 20 to 60 fields. Fields on these small farms can be improved for better use of larger equipment. Larger fields with fewer levees and more access roads would eliminate many traction problems and permit the use of larger equipment.

The question then centers on why one should consider larger equipment. Japanese 4- to 10-HP tractive type and rotary type tillers, already available, are capable of working in the present small fields with many steep levees and narrow right of ways. But these tillers presently cost the farmer $150 to $200 per rated HP and have a probable life of 5000 hours, while standard 25- to 70-HP tractors cost the farmer $75 to $125 per rated HP and have a probable life of 10,000 hours. Even in Japan, farm machinery and practices (2) are being changed to utilize the larger, more economical machinery.

The Agricultural Engineering Department of IRRI is interested in working with farm machinery manufacturers and farmers to develop more efficient farm layouts and machines. Data on farm size, field sizes, type and number of farm operations, levee sizes and shapes, soil conditions, equipment output per HP hours, wheel types, rotary tiller blades, and other traction devices, are or will be part of the research and development program. Suggestions and inquiries will be welcomed from interested manufacturers and research groups.

Fig. 1. Carabao (water buffalo) pulling 4-inch moldboard plows.

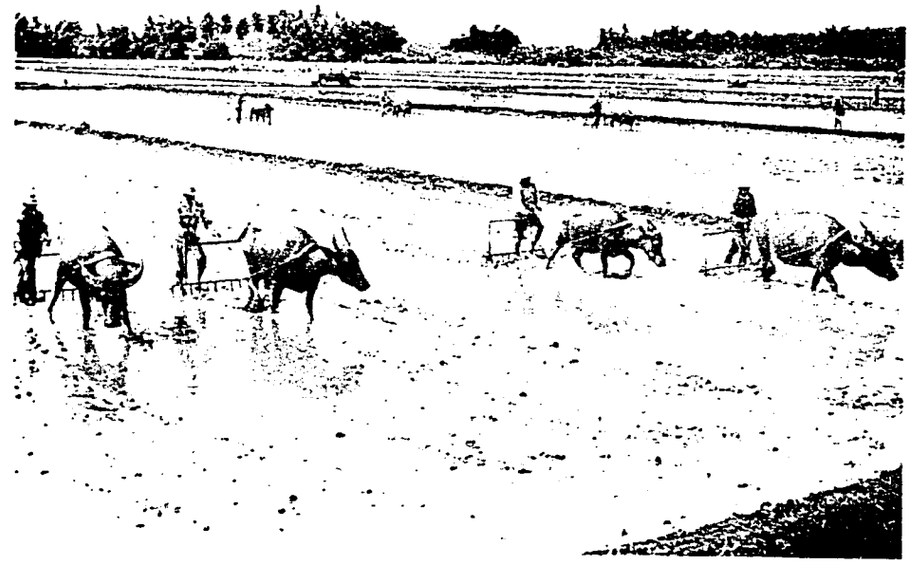

Fig. 2. Comb harrowing with carabao continues until all weeds are pressed under the mud slurry.

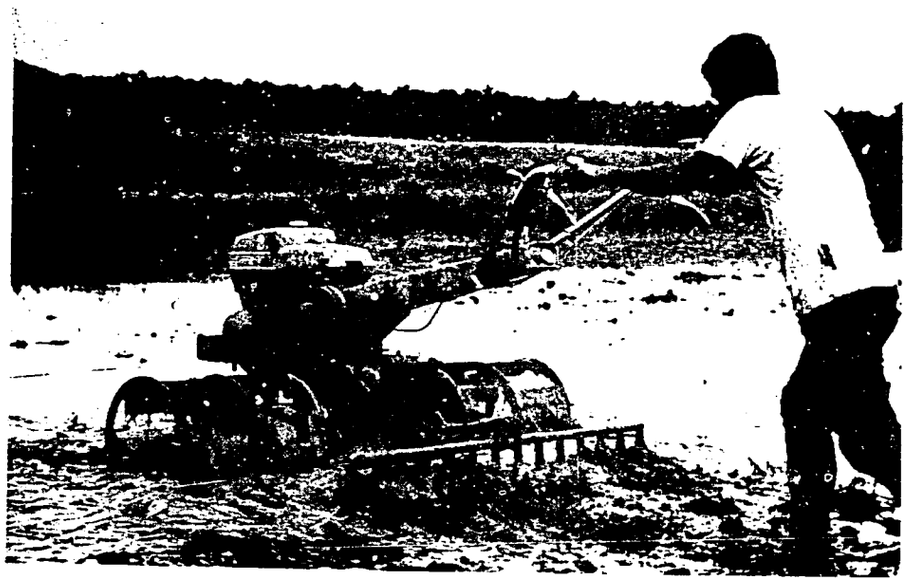

Fig. 3. Iseki KT-400, a 4-rated horsepower tractive type power tiller with 39-cm diameter and 75-cm wide puddling wheels and 106-cm comb harrow.

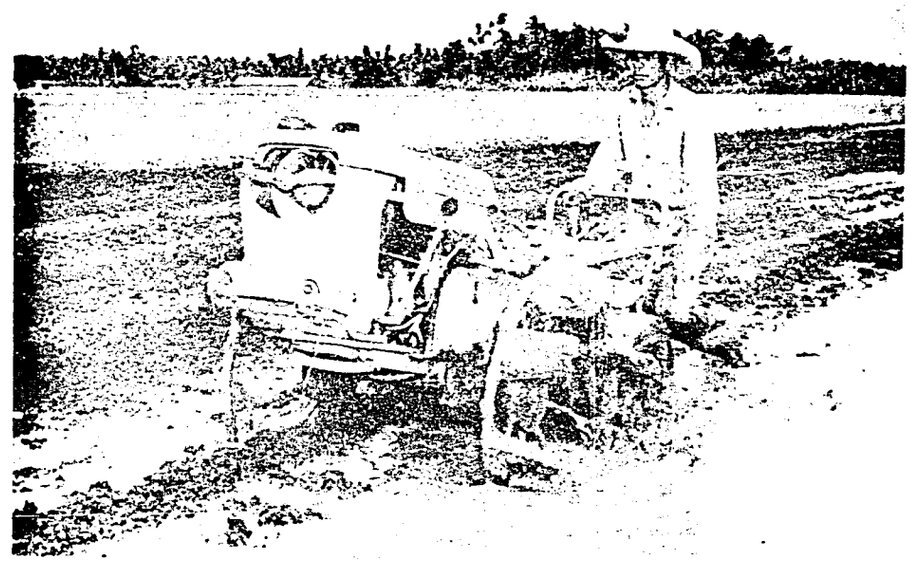

Fig. 4. Iseki KF-850, an 8.5-rated horsepower rotary type power tiller with 80-cm diameter and 30-cm wide 45° angle lug wheels.

Fig. 5. Iseki KB-503, a 5-rated horsepower rotary type power tiller with 70-cm diameter and 28-cm wide 45° angle lug wheels.

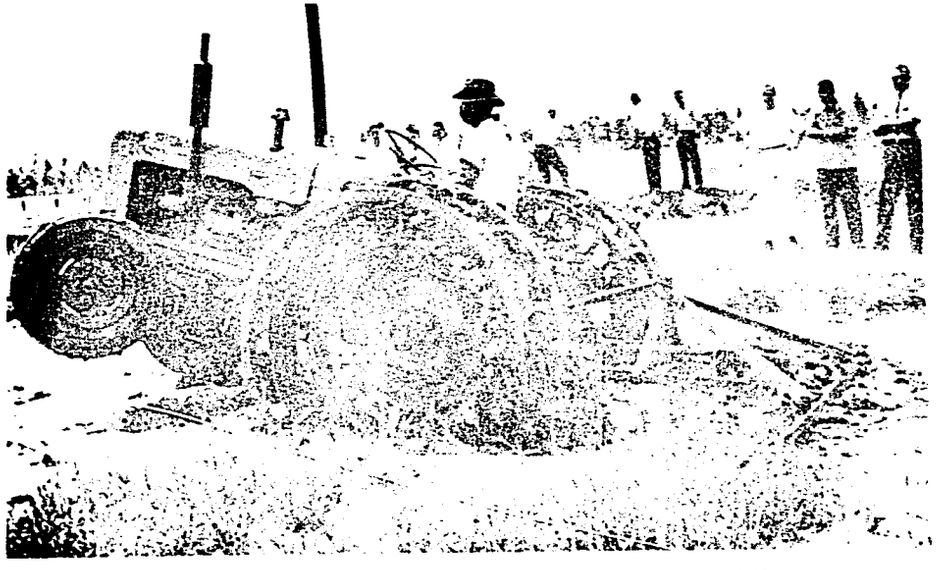

Fig. 6. The Fordson Major with special puddling wheels and pegtooth harrow.

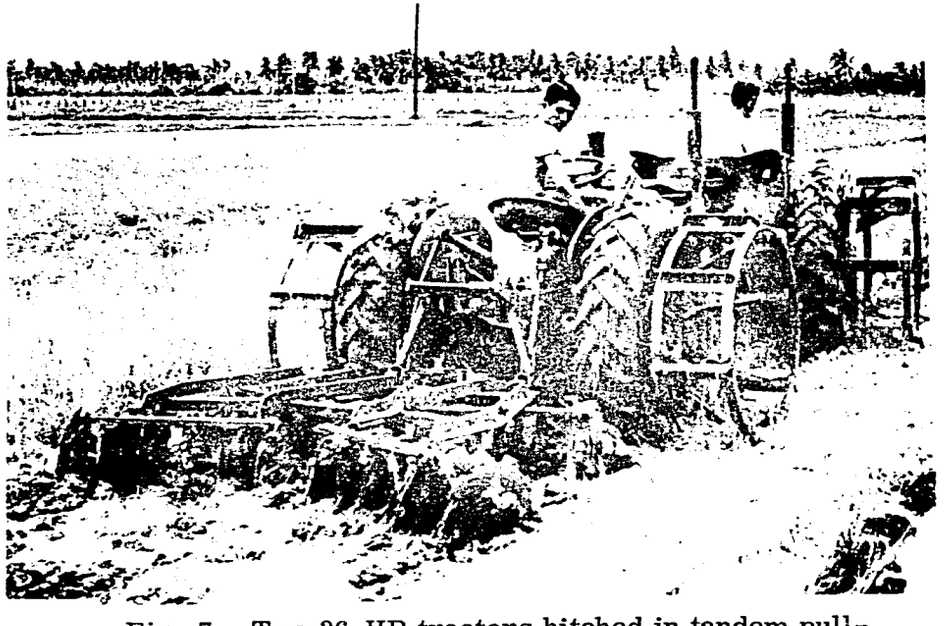

Fig. 7. Two 36-HP tractors hitched in tandem pulling a disc harrow.

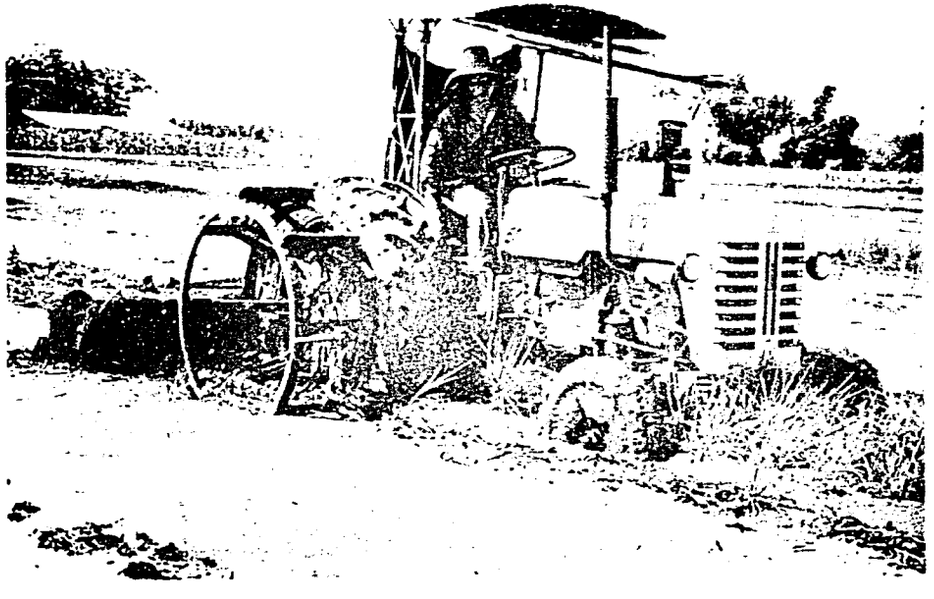

Fig. 8. A 36-HP I.H. D-436 with cage wheels and offset rotary tiller.

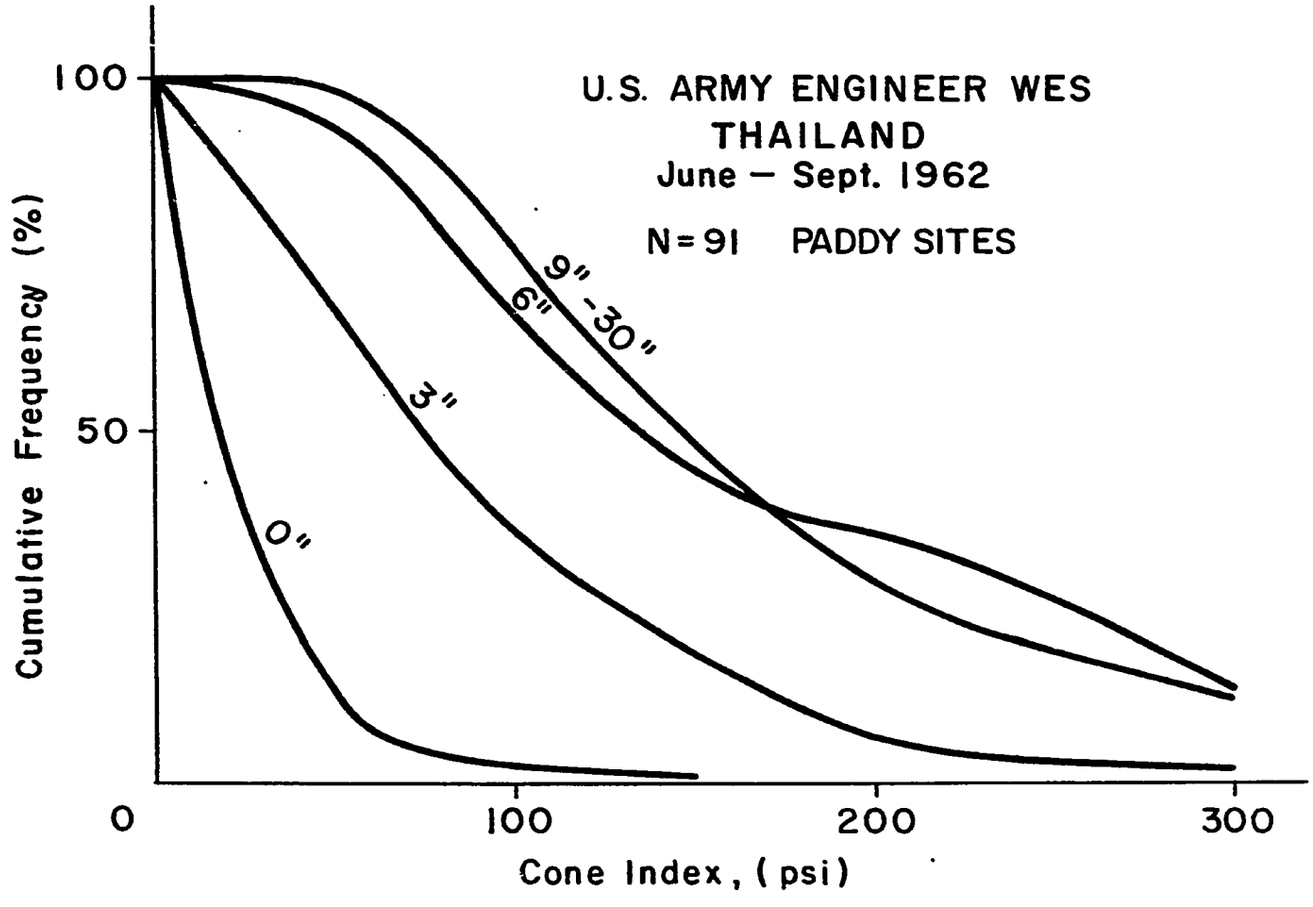

Fig. 9. Cumulative frequency of cone index measurements on 91 paddy sites in Thailand. Rula et al. (3).

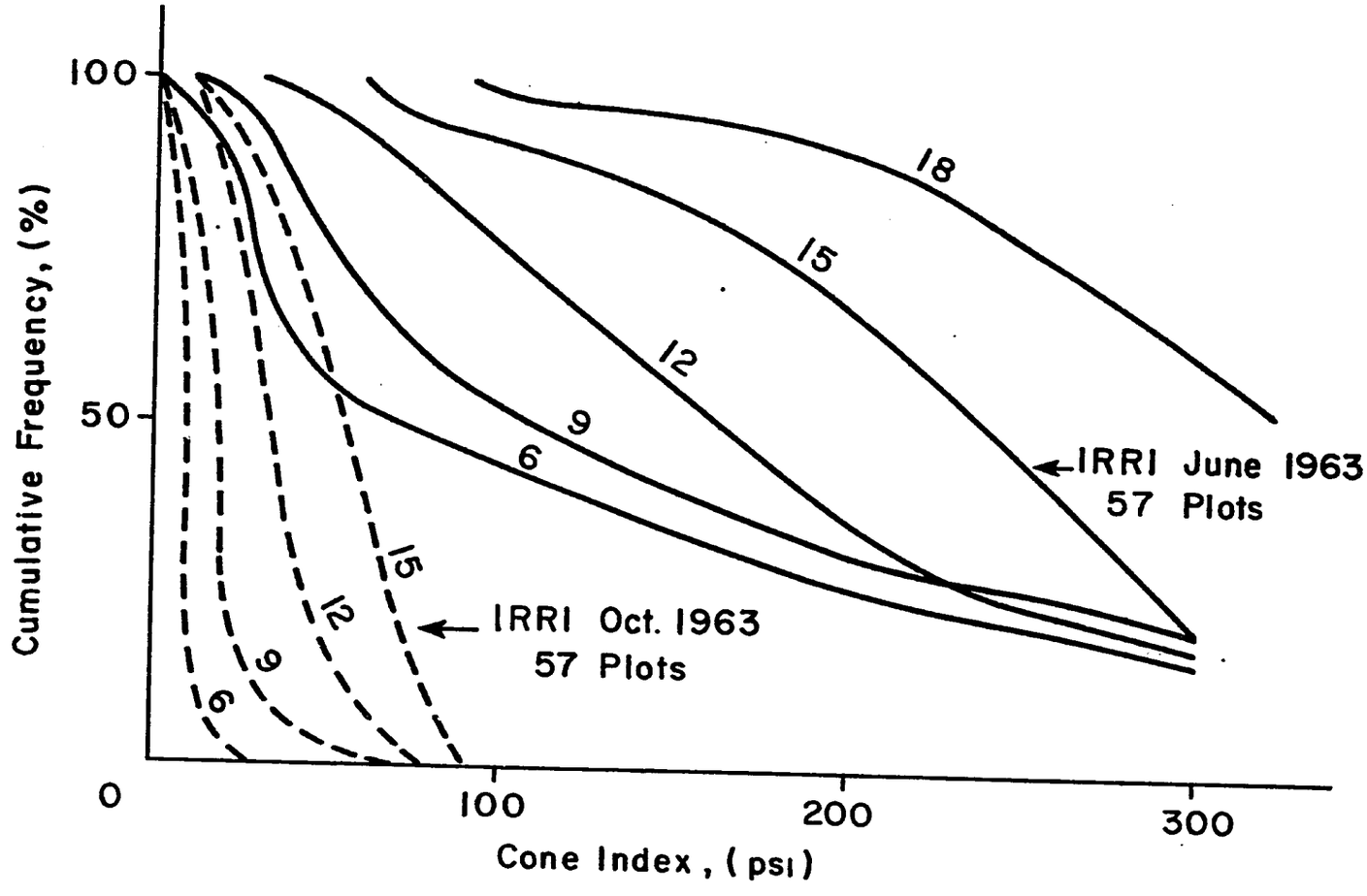

Fig. 10. Cumulative frequency of cone index measurements on 57 plots of The International Rice Research Institute experimental fields.

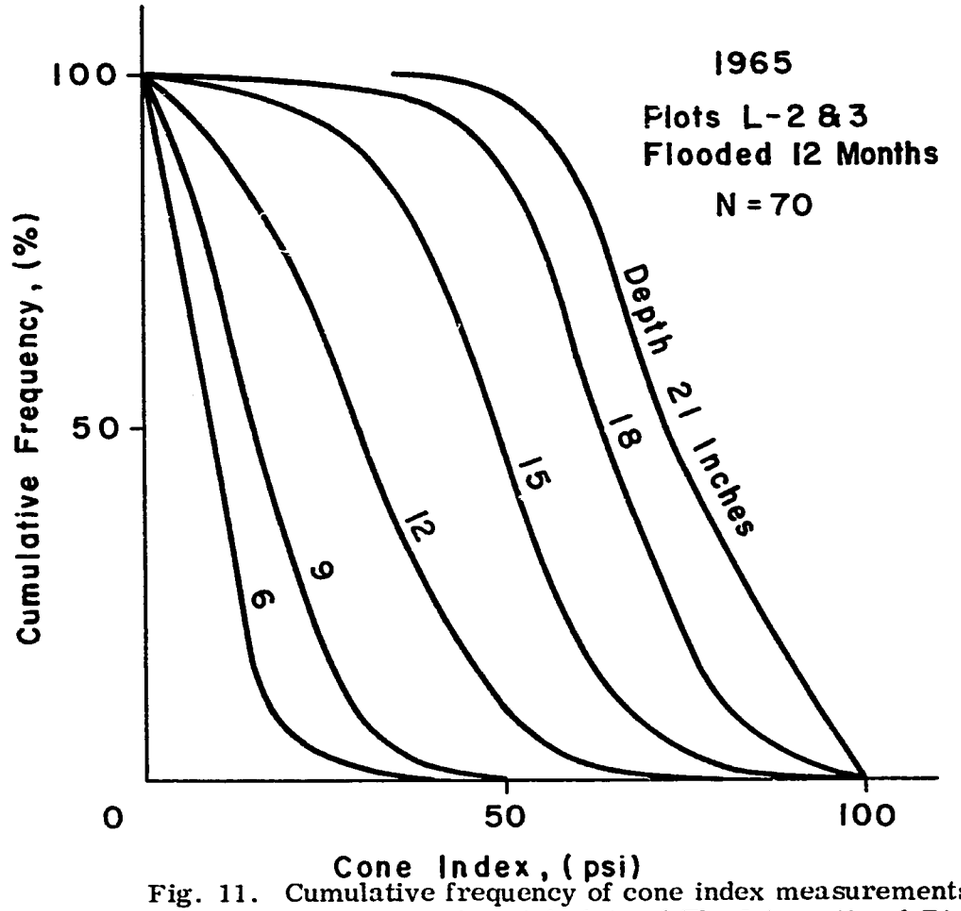

Fig. 11. Cumulative frequency of cone index measurements in two experimental plots of The International Rice Research Institute. These plots were difficult to prepare with presently available equipment.

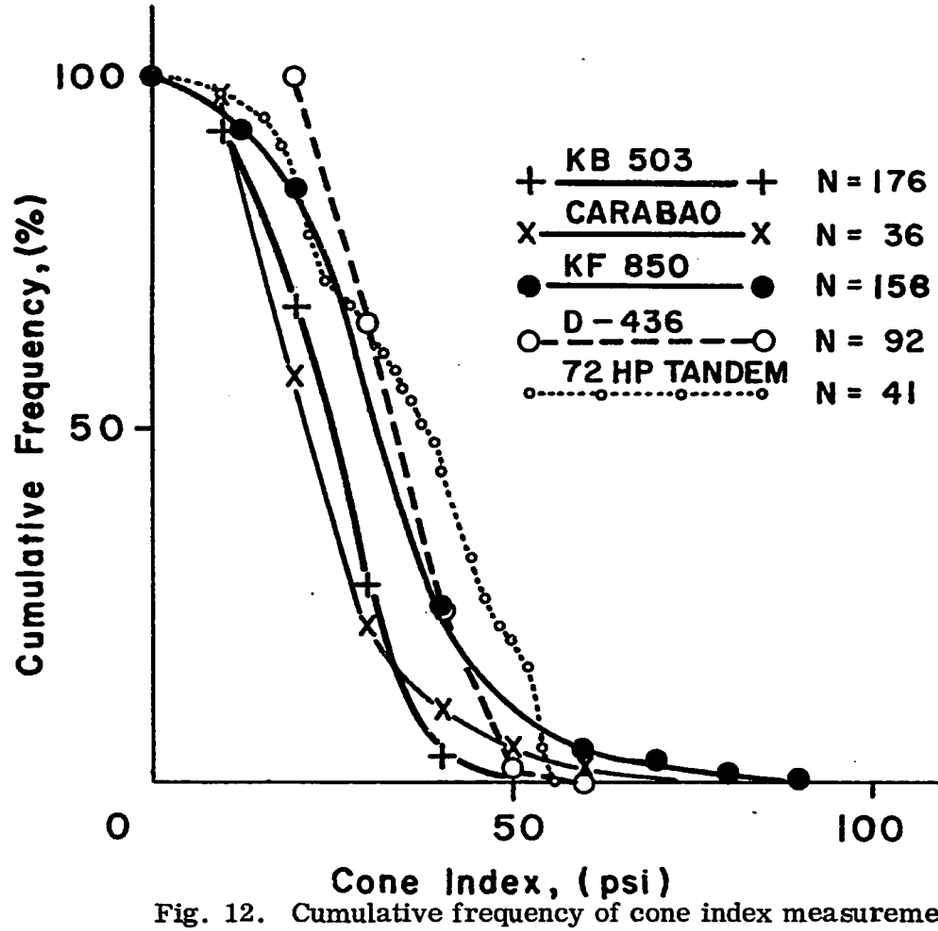

Fig. 12. Cumulative frequency of cone index measurements taken in the wheel tracks of several power units while preparing experimental fields at The International Rice Research Institute under routine conditions.

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