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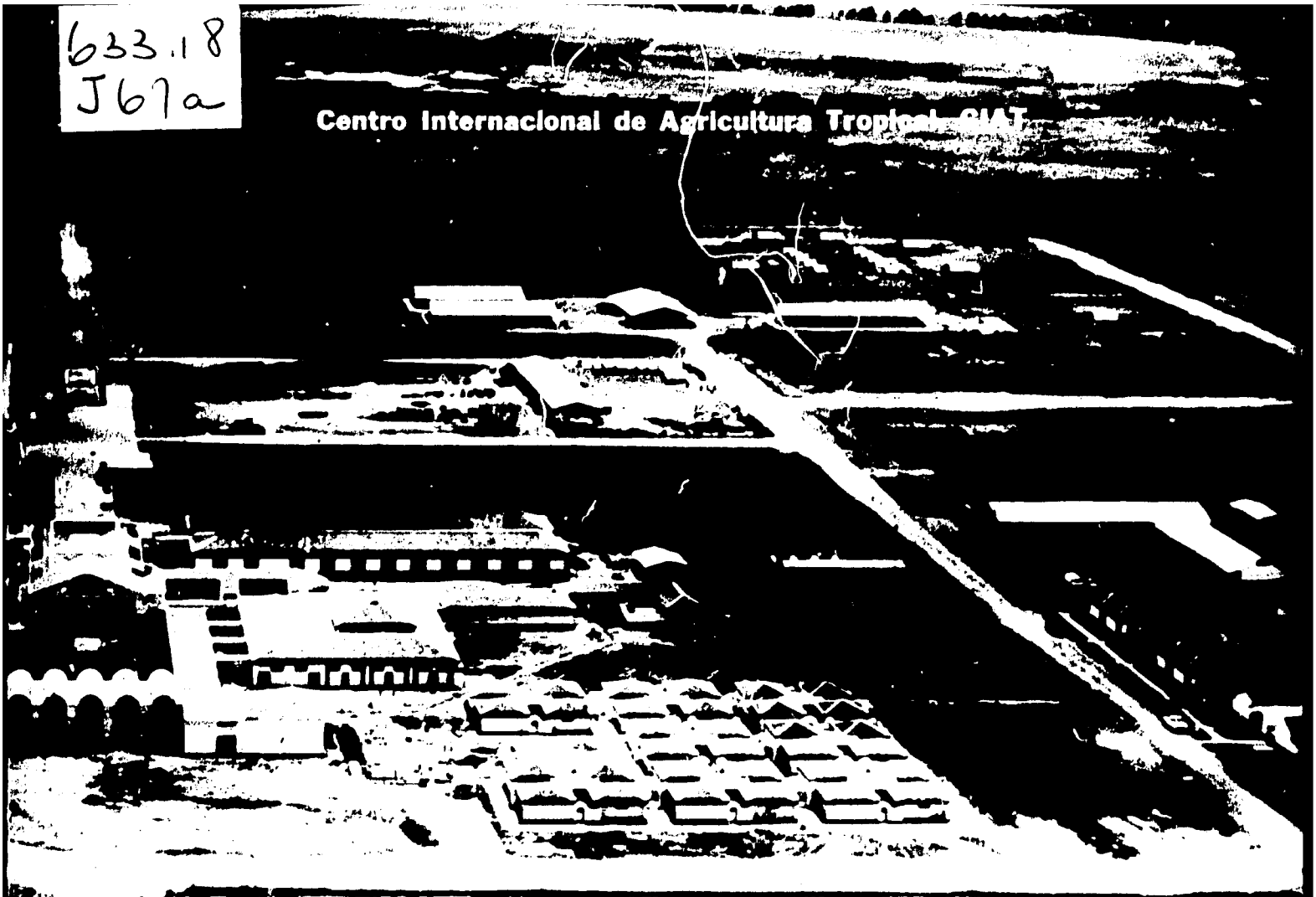

A continuous rice production system

Loyd Johnson
Alfonso Diaz D

Information Bulletin No. 2 E
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PN-AAG-139

A CONTINUOUS RICE PRODUCTION SYSTEM

Loyd Johnson and Alfonso Diaz-D.*

Rice may be planted, harvested and immediately replanted where favorable conditions of water, temperature, soils, equipment and skills exist. However, much of the American lowland tropics is wet, poorly drained and has little value for normal dryland agriculture. A modified Asian wetland culture, with rice planted and harvested weekly throughout the year, will convert these lands into food factories. The steady utilization of labor, land, and equipment can provide an attractive income while production cost and capital investment remain low. If crop diversification is desired, one or two rice crops level the land so that row crops may be grown on beds and irrigated easily during the dry season.

This bulletin is intended for farmers and students interested in our experience and suggestions on continuous rice production, especially on: 1) selection of the farm, 2) selection and operation of equipment, 3) farm layout and development, 4) cultural practices. The ideas and methods presented here are only suggestions as techniques may improve with additional experience. Your field observations and results are solicited to modify the bulletin in the future.

Selection of the farm

A farm for continuous rice production should meet the following conditions:

Water control

Water depth should be maintained between 0 and 10 cms. Water is temporarily drained only after seeding or for herbicide application; otherwise the soil is flooded. Unlike other crops draining and drying the soil is not necessary. The water may be obtained either by gravity or by reliable and inexpensive pumping techniques. Land with adequate water control for continuous rice production is available in the new irrigation and drainage districts. Two liters per second is required for soil preparation and one liter per second per hectare is required to maintain water on the fields.

Soils

Heavy clay soils with an average slope of less than three meters per kilometer are best. Heavy clays are easy to prepare wet as they give better support to tractor tires, cause less wear to the rototiller blades, and produce a mud which levels more easily and hardens more slowly. Loams and sandy soils cause excessive bogging of the tractor, require more water and fertilizer, and settle so rapidly that they are harder to level and prepare.

Land clearing

Land free of stumps, roots and logs should be selected when possible. Low areas planted in corn, upland rice, bananas, and pastures are available and are easy to develop. Forested areas may be cleared by traditional methods, burned and planted to rice, corn, and pasture for two to three years while the stumps and logs decompose.

Farm size

The farm size for continuous rice production ranges from 2 hectares to more than 100 hectares. The smallest economic unit would be one man with two hectares. Farms larger than two to four hectares require hired labor for crop care and harvesting. The maximum size of the farm depends upon managerial capabilities and operating capital for labor and equipment services. An experienced rice farmer can manage 40 to 400 hectares on a full time basis. Cooperative or corporate farms could be developed on a continuous rice production basis for areas from 100 to more than 10,000 hectares. Major problems would be skills, capital, income distribution and social-political objectives. This bulletin will not attempt to cover these variables.

* Agricultural Engineer, Leader Agricultural Engineering and Station Operations, and Agricultural Engineer, Superintendent of CIAT Experiment Station, respectively.

Selection of the equipment

Modification of existing equipment and training tractor operators to work in flooded field are critical elements in a continuous rice production system.

Dealer

A reliable and interested dealer having available parts and good service.

Tractors*

We have used medium sized 60 to 80 horsepower tractors such as the John Deere 2120, Ford 5000, Massey-Ferguson MF178, International IH856 and Same Leone 70. Other tractors with the same horsepowers and weights may be used. Important tractor features to consider are:

Three point lift

A category II lift able to lift and sustain a heavy rototiller at all times. Because the soil is too soft for depth control devices, the depth control and all forces must be supported by the 3-point lift.

Power take off

A power take off capable of continuous use with a rototiller with the rated horsepower of the tractor, without excessive repairs is ideal. The standard rated speeds of 540 RPM is acceptable but the additional ability to drive in ground speed at nine revolutions per meter and at 1000 RPM is preferable. Be careful to check the length of the telescopic PTO drive shaft to the individual tractor and rototiller models so that the shaft functions safely as the implement is raised and lowered over the entire range. Too short a shaft will slip apart and too long a shaft will break the PTO.

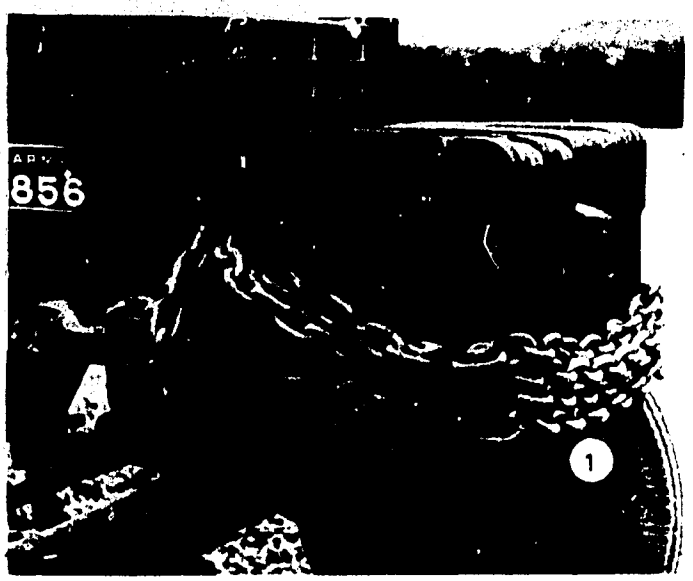
Brakes

Sealed disc brakes in an oil bath are most reliable. Any tractor used in mud and water must have a well sealed brake system.

Power steering

Power steering is recommended for ease of operation and more efficient use of time.

* All commercial trade names are given only for information and do not imply endorsement by CIAT of any of them.



Front weights, chain and pull points to stabilize the tractor and for pulling when stuck in the mud.

Electrical system

A heavy duty starter and battery with well protected wires and contact points are necessary as the tractor, when operating in mud, often stalls because of overload from the PTO.

Tires

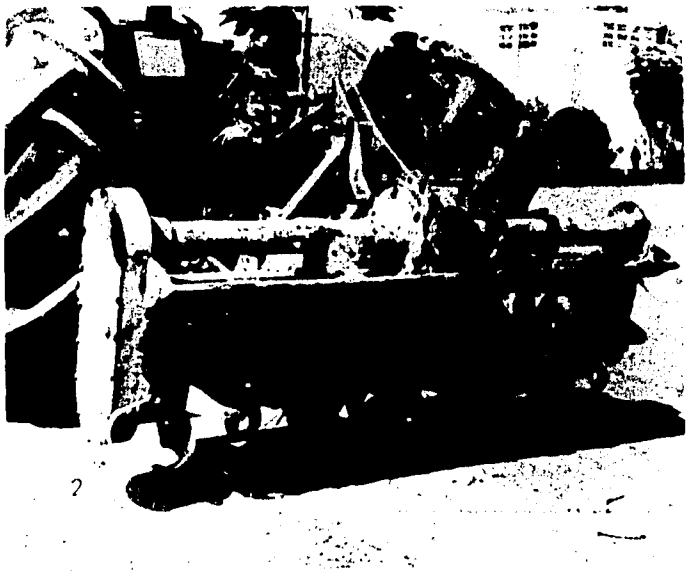
Working in mud requires high lug rice and cane tires either 23.1" x 26" or 23.1" x 30". These tires are not normally used on medium size tractors as the tires have a greater load capacity than is essential. Since they are not standard equipment the farmer must purchase 20" x 26" rims or 20" x 30" rims and have the tires mounted. The tires are inflated to five psi and the tractor operates without additional weights and without water in the tires for increased mobility in the mud. The oversize tire is used only for flotation work in wet rice fields. The manufacturer's design criteria would be exceeded if the tires were used with water and ballast on dry soils. These tires give acceptable mobility in more than 90 percent of the fields. The remaining fields demand tractors with four wheel drive and 23.1" x 26" tires or dual tires of 23.1" x 26".

Weights, pull points, and chain

Weights are added to hold down and stabilize the front end. These weights should be added to a sturdy frame on the front of the tractor. This frame should contain holes or hooks for attaching a heavy-duty 20 to 30 meter chain for disengaging the tractor when bogged. The same frame when not in use, can also serve to store the chain. (See Photo 1).

Four-wheel drive

When the same tires are used, four wheel drive tractors with a normal clearance and turning radius perform better under all soil conditions than two-wheel drive tractors. For best performance, use 23.1" x 30" or 23.1" x 26" rice and cane tires on the four wheel drive.



Rototiller designed for both wet and dry fields.

Rototillers

Rototillers developed for use in muddy rice fields are preferred over models designed for general dryland agriculture. We have used the Maletti Model 200R rototiller satisfactorily and have fabricated and used our own prototypes. Sturdy construction, well sealed bearings and transmission, and light weight are the important features. Rototillers can be locally built using imported transmissions, bearings, shafts, seals, high strength steel and high strength welding rods. We continue to modify the available rototillers to mount levee and bed makers. (See Photo 2).

Levee and bed makers

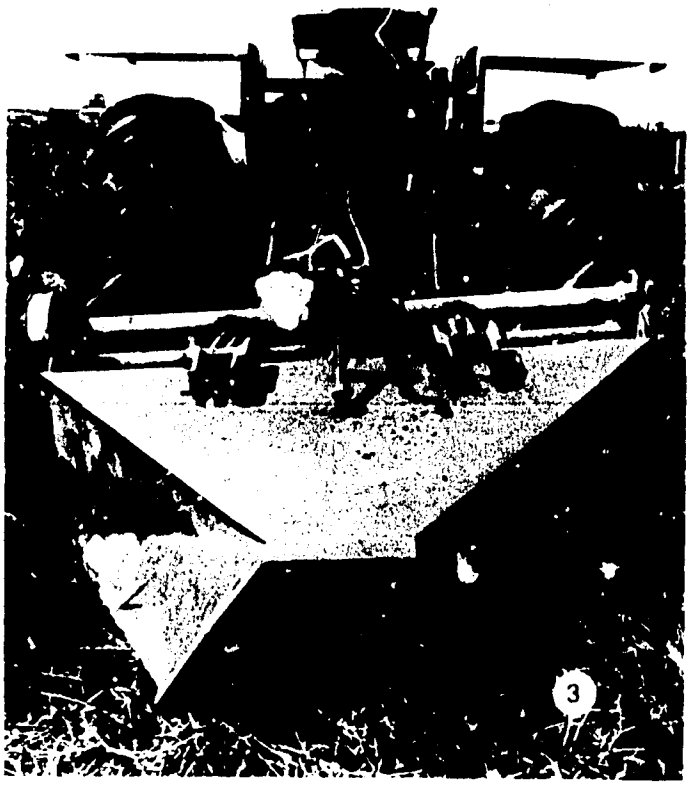
A levee and bed maker designed and fabricated at CIAT can form levees in both dry and wet soils or beds in dry soils. (See Photo 3). Drawings are available upon request.

Blades for soil movement

A three point mounted blade is used for rough leveling. It requires considerable draft and it is difficult to control the depth of cut. We are experimenting with a rototiller blade attachment to move the earth cut and loosened by the rototiller. This is still in the first prototype stage. (See Photo 4).

Spike tooth or comb harrow

A spike tooth or comb harrow buries the vegetation under the mud and provides clean, level field surface. A standard spike tooth dry-land section harrow suspended from a 3-point mounted tool bar gives excellent service. Many United States and European manufacturers produce this harrow; local shops can also fabricate it. (See Photo 5).

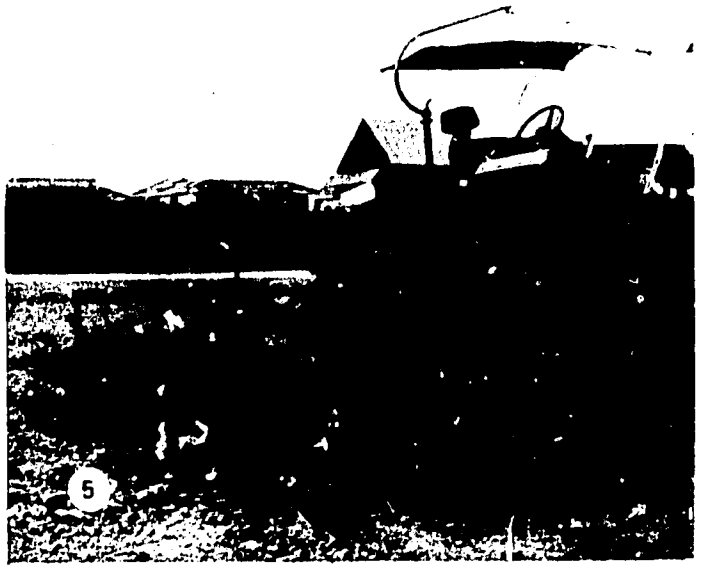


Levee maker designed and fabricated by CIAT personnel.

Seeding, fertilizing, and spraying equipment

At present wage rates, equipment to replace hand broadcast of seed, fertilizers, granular insecticides, or granular herbicides have no advantage in the developing countries. When insecticides and herbicides are not available in granular form, knapsack sprayers or contract aerial spray services are used. To

Blade mounted on rear of rototiller for cutting and movement of soil.



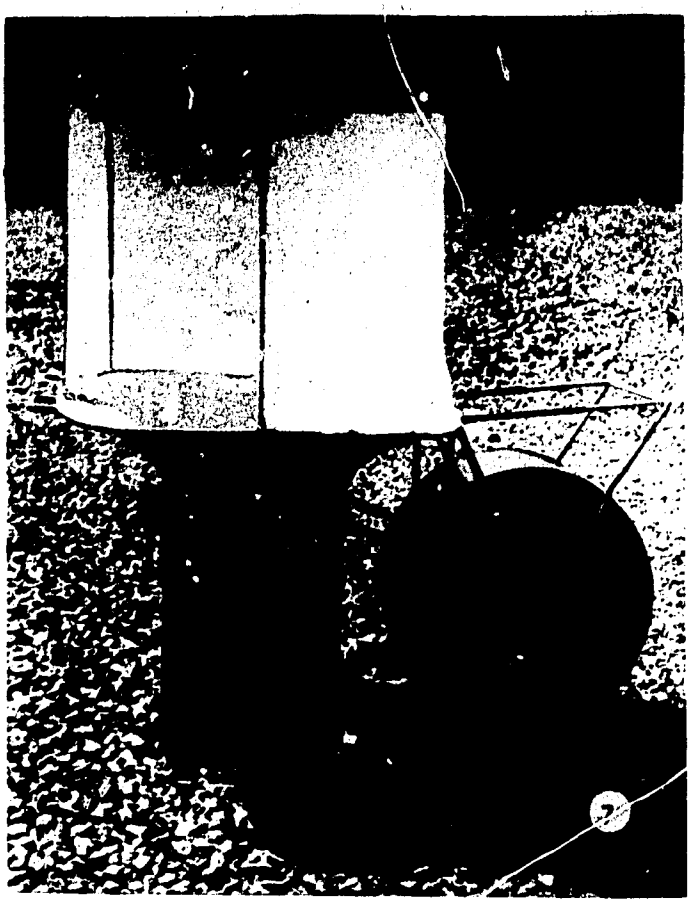
Spike tooth harrow for leveling and final smoothing of field. Note the boards which aid in moving mud.

permit uniform application, the knapsack sprayer should be equipped with a three to five meter wooden boom, quality calibrated spray nozzles, and a pressure gauge. (See Photo 6). This adaptation must be made locally, as available sprayers have poor nozzles and no pressure gauge.

Harvesting equipment

The rice combine with rice tires or half tracks is suited to large areas and satisfactory weather conditions. The average farmer cannot afford a combine but must depend upon custom services or upon hand harvest. CIAT has developed a portable thresher which permits two men to cut, thresh, clean, and bag 500 kilograms of paddy daily. At current wage rates or less than US$ 3 per day, hand harvest is economically feasible. The portable thresher may be made locally for less than US$ 40 from plans developed by CIAT. (See Photo 7).

Back pack sprayers and 6 meters boom built in CIAT shops.



Portable rice thresher designed and fabricated by CIAT personnel.

Drying equipment

The freshly harvested paddy is usually sold on a wet basis to avoid drying and storage problems. In low wage areas, if a market is not immediately available, sun drying on a concrete patio and storage in sacks is feasible. Forced air drying in bins is practicable if the relative humidity is less than 75 percent during two to three hours per day. The fans are run continuously for grain over 18 percent moisture while grain under 18 percent moisture is dried by running the fans when the air has less than 75 percent relative humidity. Normally only skilled personnel should use heated air drying.

Operation and care of equipment

Maintenance and the operator's interest and skills determine the productivity and durability of the equipment. Some key factors to remember are:

Personnel

Select, motivate, train, and supervise the best men available. Pay on an incentive basis when possible and penalize for negligent operation or maintenance.

Manuals

Obtain operator maintenance and spare parts and service manuals for all equipment. To prevent loss or misplacement, control by a record and filing system. These manuals should be read and used by all operators, maintenance, and supervisory personnel.

Records

For each piece of equipment open a record book to register hours of work, work accomplished, materials used, maintenance and repairs performed, and expenses.

Lubricants

Use a high quality water resistant lithium base grease for all equipment. To avoid excessive wear use high quality oils and fuels. Check manufacturer's manuals for recommendations and consult a lubrication engineer through your oil company supplier about standardizing oils and grease. Buy these in drum lots to save money and to assure their constant availability.

Spare parts

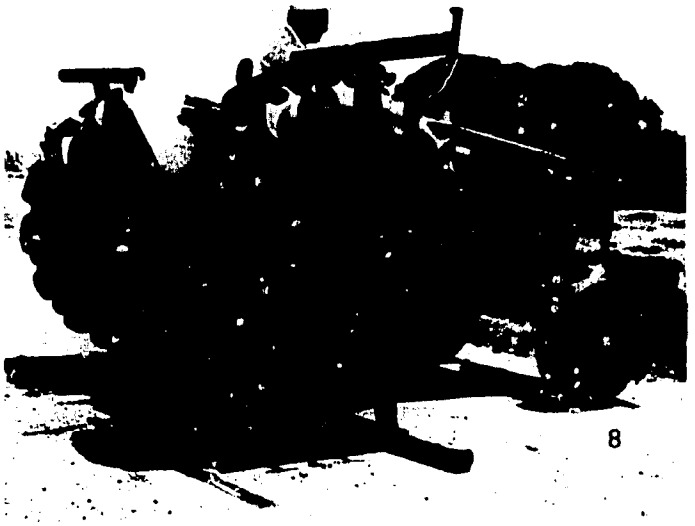
Buy genuine manufacturer's spare parts when possible. Other suppliers may furnish quality bearings, belts, hoses, and filters. Always keep a large assortment of high strength nuts, bolts, and pins available.

Shop tools

A complete set of quality wrenches is essential. Careless use of adjustable wrenches damages equipment. Socket and box wrenches are preferable to open end wrenches. Adjustable and pipe wrenches are unsatisfactory subsistitutes. Electric and gas welders and high quality welding rods are recommended to prevent excessive down time and extra trips to town. Invest in high pressure pump and hose to clean muddy equipment.

Field operation hints

Survey fields for holes, obstables, and soft spots before entering with equipment. Walk in most rice fields with knee high rubber boots and two pairs of heavy socks. When the mud is too sticky or deep for the boots, check the area barefoot or back the tractor slowly into the area for increased chances to go out in a forward direction. If your wheels spin stop immediately to avoid digging into the axle. Use the differential lock and with a minimum of wheel spin make tentative efforts. If available use a second tractor and a long chain or cable to pull from firmer soils. Two tractors are more efficient than one to reduce time loss from bogging. When only one tractor works, the operator should avoid bad spots as well as provide lugs on the wheel rims to attach a pipe in the form of an "I" longer



Four-inch pipe attachment in form of "I" designed and built in CIAT to increase traction when bogged. When used always operate tractor in reverse to prevent accidents.

than the tire diameter. (See Photo 8). Attach a pipe "I" form to each tire and back out the tractor in reverse to avoid overturning. Keep depth control of the rototiller by using the 3-point lift and listening to the engine to prevent overloading and stalling. Beware of areas with stiff, deep mud as these clog the tire lugs, rototiller blades, and give maximum rolling resistance. Work whenever possible in water-covered areas because the water lubricates the tire to prevent mud from sticking.

Layout and development of the farm

Careful initial layout and development of the farm for continuous rice production saves considerable equipment, management and time and reduces future operational costs.

Farm map

The land title should provide a map of the farm boundaries. This can serve as a basis for future survey work. Clean farm boundaries and markers to clearly expose them in an aerial photograph. An aerial photograph with a negative contact scale of 1:10,000 with 60 percent overlap should be made. Establish a set of permanent concrete and metal bench marks with elevation and coordinates tied into the national geographic survey. A scale mosaic for permanent reference should be made from the aerial photographs. A photograph should then be made of the scaled mosaic and a scale transparency prepared for working prints. A topography crew can take elevations on the ground and enter them directly on the working print. The cost of aerial photographs, mosaic, transparency, and working prints ranges from US$1 to US$5 per hectare depending upon the area. The photographs are less expensive, more detailed, and more useful than a normal plane table map.

Roads, irrigation canals, and drains

The existing and future network of roads, irrigation canals, drains, fences, etc. should be drawn on the working print. Since the topography in rice areas usually has a gradient of less than three meters per kilometer make the main roads and drains in the direction of maximum slope. Raise the base of the roads with the earth from the drains. Use straight and parallel roads, drains, and canals to form uniform fields where the topography permits. This procedure will simplify future work.

Location of levees

The levees are staked on a 25-meter by 25-meter grid which results in easily handled cuts and fills when the land slope is less than three meters per kilometer. One set of well built levees runs down slope near and parallel to the drains. Additional small interior cross levees are also made parallel to the roads and drains at 25-meter intervals. Well constructed levees are then made every 25 meters either perpendicular to the roads and drains or approximately on the same level. (See Photo 9). Next, water is introduced to the field. Adjacent plots with similar elevations are joined by removing the smaller cross levee to make 25 x 50, 25 x 75 or 25 x 100-meter plots. Plots longer than 100 to 150 meters are not recommended because water control is difficult. This method requires no topographic detail and can be carried out in high weeds and over uneven soils such as in pastures with pronounced humps. Other methods of locating levees such as contouring or on grading fields are not recommended unless designed by a skilled topographer or engineer.

Construction of the levees

Permanent field levees for continous rice production should be about 25 cm high, 80 cm at the base, and 40 cm at the top (See Photo 10), which gives about 0.15 cubic meter per linear meter of levee. A man can construct 30 to 50 liner meters per day whereas a tractor with a rototiller and levee shaper, (See Photo 11), can construct 350 to 500 meters of finished levee per hour which includes making two or three passes in difficult areas. Both men and machine are required; the machine completes the major sections and the men close the corners and raise the levees in low, wet, or weedy sections.

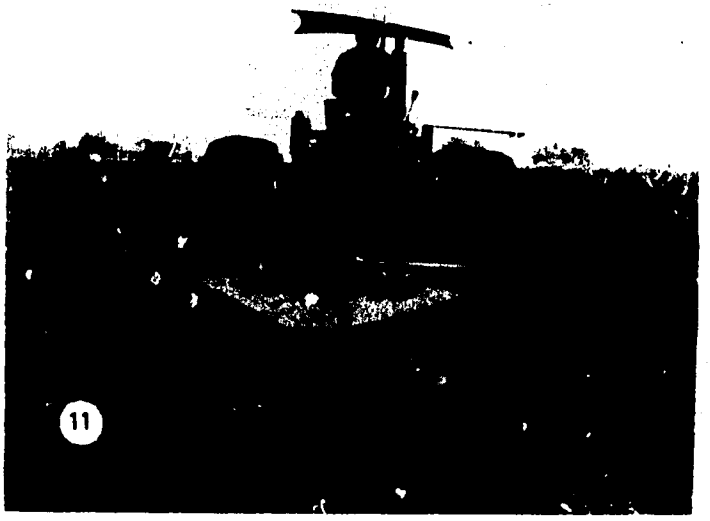
Layout of levees in a field in the process of wet land preparation and development.

Levee formed by levee maker designed and fabricated in CIAT. The levee dimensions are 80 cm base by 25 cm height by 40 cm top width.

First wet leveling and land preparation

The first wet leveling and land preparation is the principle undertaking in land development for continuous rice production whereas future land preparation is easier and less expensive. Careful and thorough leveling and land preparation pays for its cost in the first crop through increased yield and reduced fertilizer, water, and herbicide expenses. Once the levees are constructed and the weak sections repaired the fields is flooded leaving only the high spots partially exposed. The operator loosens the high spots with a tractor and rototiller. This loose earth and mud are moved to deeper water to fill the low spots. A blade attached to the rototiller tail flap permits cutting and earth movement in a single operation. (See Photo 12). A 3-point mounted blade may be used (See Photo 13) but traction and depth control are difficult. After removing the high spots and filling the low spots, the entire field is rototilled to a 15 to cm depth. A 3-point mounted spike tooth harrow is then used for the final leveling and to bury the weeds and grass. (See Photo 14). Average tractor and implement times are as follows:

Rototill high spots:	0.4 ha per hour
Movement of earth to low spots:	0.2 ha per hour
Rototill entire plot:	0.4 ha per hour
Final leveling with harrow:	0.7 ha per hour



The levee maker mounted on the rear of a rototiller in action.

A blade mounted on the three point hitch cutting high spots.

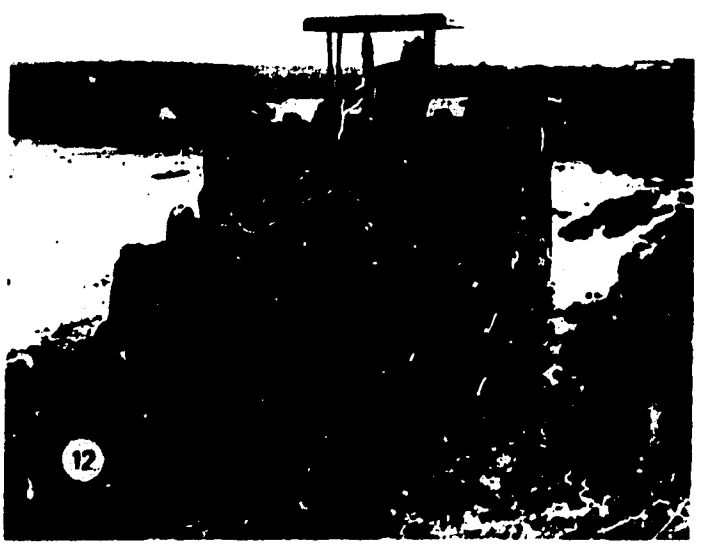
When completed the field is level and a layer of water one to five cms deep covers a weed-free mud surface. Pregerminated seeds are broadcast at this time.

Cultural practices

Planting

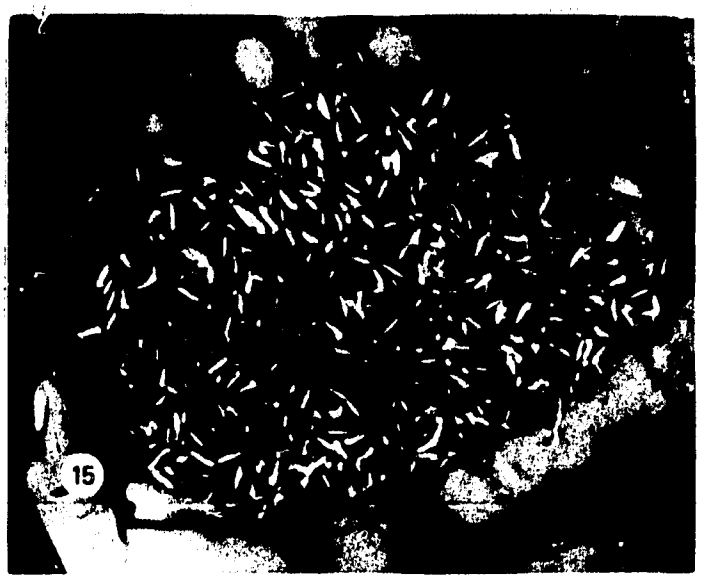
From 80 to 120 kilograms of improved variety certified seed are used per hectare. Pregerminate the seed by soaking 24 hours in water; then leave it 24 hours outside the water in the shade. Never soak a full bag of dry seed as the bag will burst when the grain swells but remove about 20 percent of the grain from a full bag before soaking. When ready for sowing the pregerminated seed root is about one mm long. (See Photo 15). One man can broadcast one hectare in less than one day. Planting may also be accomplished by airplane but it is not presently practicable because of low labor costs and because of the small three to six hectare areas that can be prepared at one time by wet land preparation.

Broadcast the seed within 24 hours after the final puddling (See Photo 16). Remove the water within 24 hours after sowing to expose the seed to the air for rapid growth. Seed in areas left flooded for several days germinate, grow slowly, and usually die. Small hand made furrows permit draining most of the field. Occasionally poorly leveled spots where the seedlings die should be transplanted with excess seedlings from other areas. In Surinam where the fields are larger, a special V-wheel is used to make drainage ruts in the field.



Leveling high spots with a blade mounted on the rear of a rototiller.

Leveling and finishing of field with the spike tooth harrow.



Pregerminated rice seed.

Weed control

Wet land preparation efficiently controls weeds for several days and pregerminated seed gives the rice seedling an advantage of several days growth. If weeds develop before the permanent flood is established and the rice is less than 10 days old, seedlings should be flooded to a 10 to 15 cm depth for two days.

Post emergence control for grasses in the two to three leaf stage involves draining the field and applying 10 liters of Stam F-34 (Propanil) and reflooding the area after two days. Alternatively six liters per hectare of Saturn (Bentiocarb) can be applied five to six days after seeding. Broad leaf weeds are controlled when necessary with 1.5 liters per hectare of 2,4-D amine, after the rice starts tillering. Because chemicals and methods change rapidly obtain other recommendations for conditions in your locale from your local rice or weed control specialist.

Hand broadcasting rice seed.

Apply herbicides in 320 liters of water per hectare with a knapsack sprayçr at a rate of one hectare per man-day. Use aerial application for fields larger than five hectares or for the minimum area per flight. Whether to use hand or air application depends upon relative cost and availability of labor and aerial services. If spots of excessive growth exist then 15 to 20 man-days of hand weeding per hectare may be economical. If large areas become uncontrollable it may be more economical to reprepare and replant the area and exercise more timely and better water and weed control.

Insect control

Obtain new detailed recommendations from your local rice specialist. At CIAT, Furadan adequately controls stem borers and leaf miners when 20 kilograms per hectare of three percent granules are broadcast into the water. One man can broadcast 2 to 2.5 hectares per day. H should carefully follow the manufacturer's precautions. Whether to use aerial services, a knapsack sprayer, or hand broadcast of granules depends upon the chemicals used and comparative costs.

Fertilizer

New areas with nitrogen-rich soils may not require fertilizer for the first planting. When preparing the fields broadcast 100 kilograms of urea and incorporate into the mud with the harrow. Forty to fifty days after planting if the plant needs additional nitrogen, apply the urea to the fields without draining to avoid weed problems, water problems, and denitrification. One man can hand broadcast 1.5 to 2 hectares per day. Photo 17 shows a well-fertilized, weed-free rice field.

Irrigation

Keep the fields completely flooded at a depth of one to ten cms. Water enters on the high side and passes to adjacent lower fields through notches in the earth leeves. Cut notches high enough to maintain the field covered with water. Approximately 200 mm of water are required for land preparation and 600 mm of water are lost in evaporation. The additional water requirements include losses through levees and canals to drains. Where possible the water entering drains should be reused on lower fields. About 2.0 lts/second per hectare of water are required to flood and prepare rice land and about 0.7 to 1.3 lts/second are needed to maintain flooded fields.

A veiw of a clean fertile rice field.

Hand harvest of rice with CIAT portable thresher.

Harvesting

Harvesting is accomplished by hand or by combine. Two men can hand harvest 420 to 600 kilograms of fresh paddy per day with sickle and thresh with a CIAT designed portable thresher. (See Photo 18). For the first two hours both men cut, thereafter one man cuts while the other threshes and bags. Present combine custom rates are one cent U. S. dollar per kilo of grain. Manual harvest competes at wage rates of two to three dollars per man-day.

California's combine rates average 3400 and 5500 kilo grams per hour for medium and large combines. Their performance in most tropical areas would probably be less because of weather, soil, and operator problems.

Future operations

After the farm is developed the sequence is as follows:

Cleaning and repair of levees

After the first crop is harvested, clean and repair the levees by repassing with the rototiller and levee builder. Remove the center blades drom the rototiller so the sides of the levees are chopped and reformed yet the center is left compact. This operation kills weeds and rats nesting in the levees. Also use hand labor as needed to close corners and bad spots.

Land preparation and leveling

All subsequent land preparations require less earth movement and tractor time is cut in half. Remove or spread excess straw in piles from the previous harvest to facilitate incorporation. The sequence is rototill, level, and incorporate the straw and weeds into the mud with the spike tooth harrow. Planting and other cultural practices are the same as described previously.