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Soil Tillage in the Tropics and Subtropics

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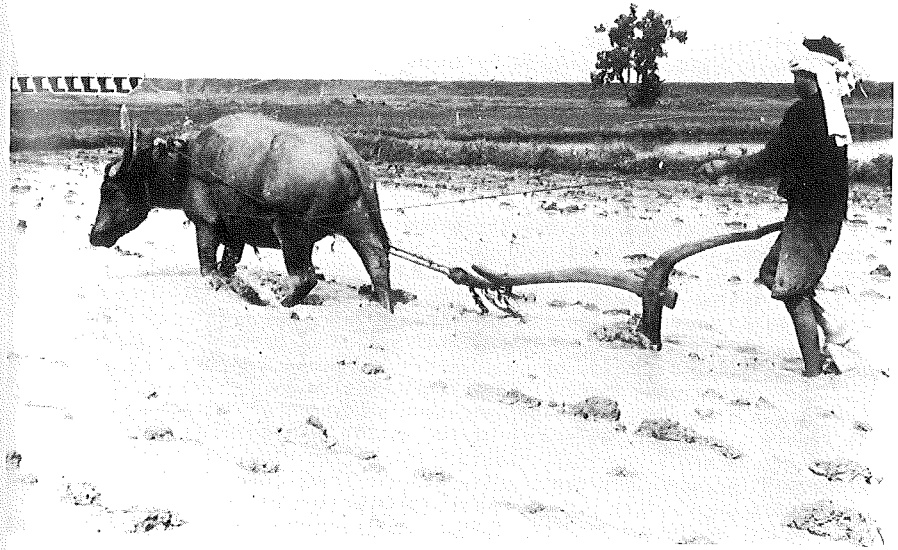
Soil Tillage in the

6.0 SPECIAL IMPLEMENTS FOR PADDY RICE PRODUCTION



Rice is the most important food crop in the tropics; in 1970 it covered 94 million ha throughout the world and produced more than 170 million tonnes. This crop is given special attention here and also in the previous chapter on irrigated agriculture because rice plants can grow in flooded soils. Not all the rice crops are produced on flooded fields: five main cropping systems can be distinguished:
Rainfed lowland - irrigated lowland - upland - deep water - direct seeded, irrigated.

Some 65% of the total rice-growing areas in the tropics apply a (rainfed or irrigated) lowland system while 25% is grown as upland rice (like other crops - without flooded fields, transplanting, etc.) and approximately 9% as floating rice in river valleys and flood plains; the remaining 1% is produced by a highly mechanized system with large tractors and equipment, often including aircraft for sowing, fertilizing and spraying. Dry soil preparation techniques are mainly used in the latter three systems.

The lowland rice production system generally assumes the following pattern: (small) level fields are bordered by dikes or "bunds" to retain water on the field surface. When the fields are flooded, the soil is ploughed mainly in order to work in the stubble and weeds. Subsequent (secondary) tillage operations consist of "puddling" which is intended to destroy the aggregates of the top soil and create a layer of fine mud. In the meantime rice seedlings are being raised on nursery beds for transplanting in the puddled fields.
Even in the case of lowland rice the primary tillage operation is not always performed on flooded land; a dry primary tillage is often followed by several puddling treatments (as in Japan) but this is suitable only for irrigated systems because, under rainfed conditions, the soil is usually in a dry workable state for too short a time.

Puddling is still a subject of controversy and not everyone is convinced that the operations improve the final yields. The main objectives of puddling (as a secondary tillage operation) are:
- to create a less permeable zone at the bottom of the arable layer;
- to create suitable physical, chemical and bacteriological conditions;
- to spread and work in organic matter in the lower zone of the puddle;
- to promote germination and subsequent destruction of weeds;
- to create conditions which favour seed germination and/or plant establishment.

After various rice production systems had been compared it was found that puddling has the most beneficial effect on well-aggregated soils where large amounts of water and, more important, nutrients would otherwise be lost. Puddling is far less effective on soils with an impermeable layer or a high groundwater table.

Puddling is a tillage operation which can be performed by nearly every type of secondary tillage equipment but some are more suitable than others, depending upon the specific conditions. An intensive form of tillage is most effective since the soil is saturated and possesses a liquid consistency.

One practical problem is the trafficability of a flooded field; its load-carrying capacity is low when the soil is fully saturated. Tractors are very likely to become stuck when the bottom of the arable layer is not firm. It may be necessary to use dual wheels or extra cage wheels.

A major aspect of tillage in rice fields is the need to keep the surface as level as possible; the growth of rice is harmed when the water layer deviates too much from the average optimum depth. Consequently, two-way (reversible) ploughs (Chapter 2.1) should be used. Disc harrows (Chapter 3.1) are also employed but use of the rotary tiller (Chapter 2.4) is widespread. The forward thrust of the driven rotor is a considerable advantage under conditions producing poor trafficability. In Asia particularly the rotary tiller is frequently used in combination with two-wheeled tractors. Since these tractors are so common, some attention will be given to special tillage equipment for them.

6.0.1 Literature

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6.1 Special Implements for Puddling

6.1.1 The Comb Harrow

The comb or peg-tooth harrow is commonly used for paddy soil in the Far East. Wooden or iron teeth (20-30 cm long at intervals of about 10 cm) attached to a wooden beam are pulled through the soil as a rake. This implement is used only with draught animals. Implements for one and two animals exist (width approx. 1 metre per animal). The depth is difficult to control because of the lack of supporting units.

6.1.2 The Levelling Board

The levelling board is an extremely simple tool consisting of a wooden board, beam or plank (dimensions varying from 1 m for animal traction to 15 m for large tractors) equipped with a pole for (yoked) animals or eyes for attaching chains or traces. When it is used with animal traction the operator usually stands on the leveller to improve its penetration and steerability (uneven spots, etc.).

Despite its simplicity this tool is often essential for obtaining a level and fine surface. Clods and aggregates are pulverized by the leveller's rubbing action (see also Chapter 4.4).

6.1.3 The Rotary Harrow

The rotary harrow discussed in Chapter 3.2 may be used for puddling. Special animal-drawn rotary harrows made (partially) of wood and based on the same principle are used in the Far East. The tine rotor may be wooden (diameter 20-25 cm) to which wooden or iron tines or lugs are attached. The working widths range up to 180 cm. The rotor is mounted by simple bearings onto a rectangular frame which acts as a skid and controls the depth. All-metal types with tine rotors, similar to the ones shown in Fig. 63, are used in Japan.

6.1.4 The Weedcutter, Stalkcutter And Mudroller

Essentially, these three types of implements have the same construction and functioning. They are all rollers with transverse knives or lugs on the circumference of a drum or open frame. The implements were originally designed for clearing operations (shrub, forest) or, in the case of smaller models, as part of roller-harrow combinations for secondary tillage. The types used for puddling are adapted models. Typical examples of these implements as used on (large) mechanized farms, are described below:
- Mudroller: weight 600 kg, working width 350 cm, diameter of the (open) roller 100 cm. The transverse bars on the circumference of the roller (at intervals of 30 cm) are 2.5 cm in height.
- Weedcutter: a closed drum, (diameter 50 cm) with 8 tranverse knives or blades about 10 cm in heigth. The weight of a section 150 cm wide is 140 kg, which may be increased to 220 kg by filling the drum with water. More sections (3 or 5) may be combined if sufficient power is available.
- Stalkcutter: an open frame with 5 knives or blades 13 cm in heigth, similar to the weedcutter, weight 450 kg, working width 180 cm.

The working depth depends upon the shape and size of the blades and the weight. The stalk-cutter is the heaviest implement and is used when large amounts of organic material are present. The weedcutter can be used under average conditions while the mudroller is more effective when the field is soft.

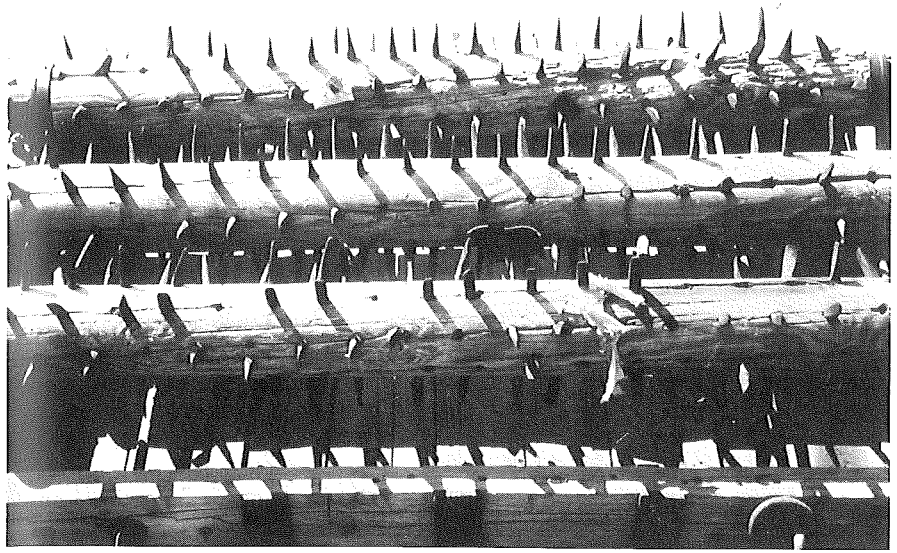

Fig. 116. Mudroller.

6.1.5 Literature

See literature for chapter 6.0.

6.2 Motor Hoes and Two-Wheeled Tractors

The small two-wheeled or walking tractors are an important group of implements used primarily for tillage operations. These implements are included in this chapter because they are developed and used extensively in paddy production systems in the Far East and especially in Japan. In 1979 330,000 of these "power tiller" units were manufactured in Japan, approximately 100,000 of them for export.

Although the tractors could be regarded purely as sources of power, they are usually very closely combined with tillage tools. Essentially, three types can be distinguished:

6.2.1 The Motor Hoe

This comprises a rotor with blades which are driven from the center by a small engine mounted on top of the rotor. The machine has no wheels but is propelled by the blades. The engine (1 - 3 kW, usually fuelled with gasoline) is operated by the two steering handles at the rear of the machine. This simple design frequently produces handling problems and the tillage action is not always satisfactory. The forward speed depends upon the condition of the soil: on hard soils penetration is very poor and the machine "walks away" while on soft soils the blades dig too deeply into the soil. The machine is tiring to operate and turning is difficult. The front of some models is fitted with a wheel for depth control, turning and transport. The rotor may be replaced by an axle with wheels for carting purposes.

6.2.2 The Single-Wheel Tractor Or Motor Hoe

This tractor is equipped with a power-driven wheel in addition to the blade rotor. This makes the rotor much more efficient since the forward speed can be adjusted independently to the rotor rpm. The rotor's working width rarely exceeds 60 cm. The width can also be reduced for inter-row tillage (crop management, weeding).

6.2.3 The Two-Wheeled Tractor Or Power Tiller

These tractors have one axle which drives two wheels. They are fitted with engines of 3 - 10 kW and the heavier ones sometimes have diesel engines. The tractor is much more of a power unit and can be used for mounting all types of agricultural machinery. The rotary tiller is still the most widely used implement for tillage but (mouldboard) ploughs, harrows, etc. are also available. In paddy fields the pneumatic tyres are often replaced by cage wheels which, with the rotary tilling, produce a dual puddling action.

A rotor hoe can be very tiring to use (especially on the soft mud of a paddy field). Ergonomically, there is much room for improvement. The more expensive models are equipped with a differential gear and a clutch to facilitate steering. A small cart is usually available for seating the driver.

The tractive power of two-wheeled tractors is generally restricted by the low ground pressure of the wheels (slippage) and not so much by the horsepower available from the engine.
Some characteristics of the different types are given in Table 11.

engine (hp)	weight (kg)	main work	characteristics
< 3	< 100	tillage, weeding and ridging with the rotary unit, carting, pest control.	management work in row crops and orchard.
3 to 5	100 to 150	ploughing, rotary tillage, puddling, ridging, weeding, crop maintenance, carting.	wide range of work, versatile.
6 to 8	150 to 250	rotary tillage ploughing, carting.	dismountable rotary unit.
9 to 12	250 to 350	rotary work.	deep tillage possible.

Table 11. Characteristics of motor hoes and power tillers.

6.2.4 Literature

See literature for chapter 6.0.

7.0 SPECIAL IMPLEMENTS FOR DRYLAND FARMING