Soil Tillage in the Tropics and Subtropics

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9.0 SPECIAL IMPLEMENTS FOR ANIMAL TRACTION

Introduction

As mentioned earlier, tillage equipment suitable for animal traction will not be examined in detail. This subject is given exhaustive treatment by Munzinger (1982) and FAO (1972) with reference to African conditions.

Two aspects do, however, justify a brief discussion of the subject in this book:

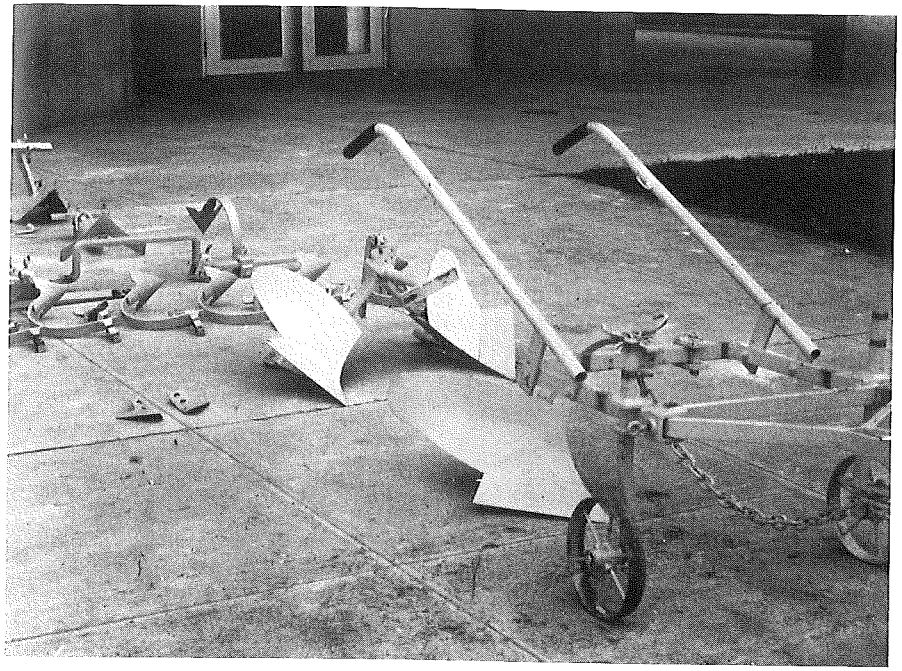
1. A large number of farms throughout the world use animals for farm-work the heaviest being the tillage operations. In Asia approximately 98% of the farms have only animal traction.
2. No dramatic change in this situation can be expected in the near future in view of the economic situation of the vast majority of the developing countries. The introduction of engines and tractors is very difficult in those countries due to the lack of capital, inadequate infrastructure, etc.

9.1 The Draught Animals

The animals used for draught farmwork are: oxen, buffaloes, horses, mules, cows and, less frequently donkeys, camels and elephants.
The choice of animals at any particular location does, of course, depend upon the climatological, ecological, sociological and historical factors. Oxen are the main source of power in Asia and the Middle East and in some parts of Latin America. Though used for draught in Western Europe, horses are employed only for riding and transport in many parts of the world; they are, however, used for draught in a few places in South America.
When it comes to using and keeping animals some major aspects which affect the available power and efficiency are:

- Health. In some cases no animal draught is available because of the presence or risk of disease, as in some African regions where the tsetse fly causes serious diseases (trypanosomiasis). Fertile areas with potential for agricultural production are not exploited because of this disease.
- Breed. Each animal has certain characteristics which determine how suitable it is for specific functions, such as milk or meat production, draught work or combinations of different purposes. Preference should usually be given to local breeds because they are accustomed to the prevalent conditions.
- Weight. This depends very much upon the type of animal, breed, age health and nutritional condition and greatly affects the potential draught power. As a rule of thumb, it can be assumed that an animal can exert 10-20% of its own body weight as draught power (see Chapter 9.2).
- Sex. Oxen are generally more suitable; bulls are often difficult to handle and train while cows are less strong (lower weight) but walk faster. Well-fed cows may be used and even dairy cows can work for a few hours a day without any serious effect upon their milk yield. The animals should not be used around calving time.
- Nutritional condition. The condition of the animals depends to a large extent upon their food both during and outside their working period. "Maintenance feeding" during the non-productive period (the dry season in semi-arid regions) is important. The food supply is often limited and the animals are weak at the start of the rainy season which is precisely when the demand for labour is greatest.
  The land required for fodder production may cause serious problems; up to 30% of the total land on a farm using draught animals is needed to grow fodder when no other (external) sources, such as forest, wild shrubs, or the banks of roads, canals or trenches, are available. Land is often expensive in irrigated regions and unexploited areas are rare; there is often competition between the production of human foods, cash crops and fodder (e.g. in Egypt). Generally speaking, 9-10% of the energy absorbed by cattle in the form of food is available for work (10-12% in the case of horses). Concentrated food is an advantage during periods of (hard) work.
- Training. After proper training animals will provide a maximum traction after about one year. Training includes the development of specific muscles which is achieved in the course of the work itself.
- Variations in the required draught. Animals tire much more quickly when pronounced variations occur in the required draught.
- Harnessing. The harnessing method is largely determined by local conditions and customs.
- Environmental conditions. High temperatures and air humidity impair the animals' performance. They often work early in the morning or late in the afternoon.
- Soil condition. When a soil is very loose or soft (muddy) much of the animals' energy will be required simply for walking so that less is available for draught work.

9.2 Tillage Equipment



The principles of tillage implements for animal traction are similar to those for motorized traction except for the following (obvious) restrictions:
- every implement is dragged or trailed and its tools are essentially passive or, in some cases, driven by the soil resistance;
- the forward speed is low (no more than 2-3 km/h);
- their size is limited by the available draught power. Under tropical conditions a pair of oxen can provide 80-140 kgf at walking speeds of 1.6-2.5 km/h. At 2.0 km/h 80 kgf is equivalent to 0.435 kW (100 kgm/s = 0.98 kW). Well-fed and correctly harnessed animals have a much better power:weight ratio. Draught animals are capable of producing considerably more power than the above figures over short peak periods.
- implements with active tools driven by the wheels cannot be used. The travel speed is too low or, when a high transmission ratio is required, the torque on the ground-drive mechanism becomes too high.

Positive factors favouring the use of these implements are that they are usually produced by local blacksmiths, are simple to handle and repair and are not dependent upon the availability or price of fuel.

The accessability of the fields, which may seriously restrict the use of tractors, causes scarcely any problems when animals are used.

Draught animals do not usually compact the soil to any harmful extent.

The range of implements available for animal traction will be discussed in this chapter but only limited details will be given.

9.2.1 Implements For Primary Tillage

Three types of implements for primary tillage can be distinguished:
1. The breaking or wedge plough, commonly known as the "ard".
2. The soil-inverting or mouldboard plough.
3. The cultivator or chisel plough.

1. As mentioned briefly in the introduction, the ard is the most basic, commonly used implement, for shallow tillage in semi-arid regions. The plough (scarcely more than a hook) does not turn the soil and therefore leaves (uprooted) vegetation on the surface to dry out.

The main parts of the plough, such as the beam, handles, and even the body, are (still) made of wood while the share or point is produced from iron or steel. Owing to its simple design the plough is easy to operate and adjust; only adjustment of the depth is possible by changing the hitch point or the angle between beam and the body. A detailed description of a large number of different ard ploughs is given by Hopfen(1969).

To achieve a satisfactory result the soil should be tilled with the ard more than once; this is usually done crossways and, where possible, with increasing depth. The depth is limited to about 10 cm and depends to a large extent upon the type and condition of the soil.

2. The characteristic features of the mouldboard plough are that it produces an open furrow and inverts the soil. The earliest types of mouldboard ploughs for animal draught were probably based on the ard. The

beam, handles and part of the body are often made of wood. Only the share and, possibly, part of the mouldboard are iron. Since the inversion and lateral movement of the soil slice results in a sideways pressure on the plough body, a landside has to be mounted, usually combined with a sole to take up the downward pressure. The hitch in front of the beam can be adjusted to find the optimum line of pull.

Ploughs made entirely of iron or steel evolved form the simple design and have become the most commonly used ploughing implements in the western (temperate) nations. Instead of a fully balanced plough (swing plough), the beam is supported in front (near the hitch) by a skid or, more often, a wheel. Further developments have been the mounting of coulters and the use of reversible bodies.

A considerable amount of research is still being carried out in many institutions to improve and adapt the design of animal-drawn ploughs, mainly with a view to reducing the energy required and partially so that one animal can be used instead of two which are often unavailable.

3. In the form used for primary tillage with tractors, cultivators and chisel ploughs are rarely animal-drawn although some modified types of the ard may be regarded as chisel ploughs. Cultivators are used for animal traction but generally for secondary or inter-row tillage (see Chapter 2.3).

(4.) It should be noted that disc ploughs are rarely used for animal traction, mainly because:
- Disc ploughs do not penetrate the soil by their own weight but need extra weights. This makes them very difficult to handle.
- The side thrust produced by the disc cannot be absorbed by a passive landside (as with the mouldboard) and so a furrow wheel would be required.
- The mounting of the rotating disc is complicated (bearing) and expensive.

9.2.2 Implements For Secondary Tillage

Harrows are also used with animal traction for tillage operations after the main tillage, as mentioned in Chapter 3.

Essentially, the same types of harrows are available, such as the spike-tooth and spring-tooth harrows.
A special type widely used in India is the blade harrow. This consists of a steel blade, 40-100 cm wide, whose sides are attached to a (wooden) beam and which is pulled horizontally through the soil a few centimetres beneath the surface. The roots of weeds are cut while the surface is scarcely disturbed. It is an effective tool in dry regions. Other types of harrows are the rake or comb harrow and the rotary harrow or hoe which is used for wet paddy cultivation; they have been described briefly in Chapter 6. Small V-type disc harrows and ridgers (mouldboard type) are also available for animal traction.

9.2.3 Multi-purpose Tool Carriers

The equipment described above includes traditional tools and implements as well as modern, improved or adapted versions. A new approach is the tool carrier (Fig. 130), a basic toolbar or frame to which various tools can be attached, such as plough bodies, cultivator tines, ridging bodies, weeders or harrows.

Extensive research into their practical applications has been carried out by a number of institutions, such as ICRISAT (India), NIAE (U.K.) and CEEMAT (France).

Quite a number of tool carriers have now been developed, ranging from very simple types consisting of a basic beam, handles and (sometimes) a support wheel, to the riding types with two wheels with pneumatic tires and quite sophisticated hitch and lift systems.

The following aspects should be considered with regard to the use of tool carriers:

- Costs. Unfortunately, the cost of many types of tool carriers still prevents their widespread use by small farmers. The carrier and a range of tools should be no more expensive than the total cost of the individual implements.
- Construction. The basic frame should be strong enough to allow the implement to be operated with the tools attached and with the maximum animal draught. This imposes heavy demands upon the materials and the design. The tool mounting system must be simple and sturdy and the tools must be arranged so that they do not produce excessive lateral forces.
- Weight. This should be kept down to a level which does not cause handling problems, especially for models with one or no wheels.

Unfortunately, these implements are sill not in common use owing to their relatively high price.

A recent review of tool carriers (including a list of manufacturers) is given by Bansal and Thierstein (1982).

Fig. 130. Multi-purpose tool carrier.

9.2.4 Literature

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10.0 ZERO TILLAGE – DIRECT DRILLING