Animal-drawn weeders for weed control in India

by

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Abstract

The status of animal-drawn weeders available and used in India is highlighted in this paper. Traditional animal-drawn weeders are used widely for mechanical control of weeds. Implements with straight or triangular blades are made by blacksmiths and village artisans.

Prototype animal-drawn cultivators with shovels, sweeps or duckfoot sweeps have been introduced by several research centres. One weeder–mulcher made use of four straight blades. Wheeled toolcarriers with pneumatic and steel wheels were introduced for tillage, sowing and interculture operations, but their uptake was very small. Use of rotary tools such as discs and rotating rods is limited. There has been growing emphasis on integrated weed management in farming systems.

The Central Institute of Agricultural Engineering (CIAE) recommended the use of a V-shaped blade for the conventional bakhar or blade harrow. Studies on four basic shapes of weeding tools (straight blade, curved blade, triangular blade and sweep) were undertaken at CIAE in order to optimise tool parameters for minimum draft force in black soils. A triangular blade hoe was developed and introduced by the Agricultural Tools Research Centre, Bardoli, for secondary tillage and weeding operations.

Future emphasis should be on the adaptation, manufacturing, promotion, training and demonstration of animal-drawn weeders that reduce the cost of weeding.

Introduction

Animal power plays an important role in mechanical methods of weed control in India. Traditional animal-drawn hoes made by village artisans from locally available materials (usually wood for the framework and steel for the soil working components) are used widely by farmers. 'Improved' animal-drawn weeders developed and introduced by various research centres have not been adopted widely, but they are gradually becoming more popular. The major constraints have been the quality of production of these implements and their limited availability in remote villages.

About 85 million draft animals are available in India, and almost all tillage and sowing is still carried out using animal power. For weeding and interculture operations, however, animal power is not used so extensively. Manual weeding can give clean results, but it is a slow process and acute labour shortages in the peak season mean that weeding is delayed. Animal-drawn weeding is faster, and usually cheaper, than manual weeding. For some crops, weeding by animal power is supplemented by manual weeding within the crop rows.

Studies in various parts of the country showed that weeds cause substantial (up to 60%) reductions in crop yields. Integrated weed management, comprising mechanical, chemical and biological control, combined with crop rotation and crop competition methods, has been suggested by research workers. The use of pre-emergence herbicides to control weeds for about four weeks, followed by one mechanical weeding by manual or animal-operated weeders, is used by some people during the peak season.

Mechanical methods will remain by far the most widely used means of weed control in the country for years to come. Animal power will play a key role in weed control in upland crops. Efforts should therefore be made to develop, evaluate, modify and introduce improved animal-drawn weeders in the region.

This paper reviews the status of development of animal-drawn weeders in India and the related research studies conducted at CIAE.

Review of animal-drawn weeders

Research into the development of improved animal-drawn weeders was carried out at several research centres in India. However,

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adoption by farmers has been limited. Biswas (1980) surveyed and reported details of 14 animal-drawn weeders used in India. Traditional hoes and improved traditional hoes are used in large numbers by farmers.

The blade hoe (Figure 1) is a traditional animal-drawn weeder that is widely used for weeding and intercultivation operations. Use of a single blade is very common although double blades are also used.

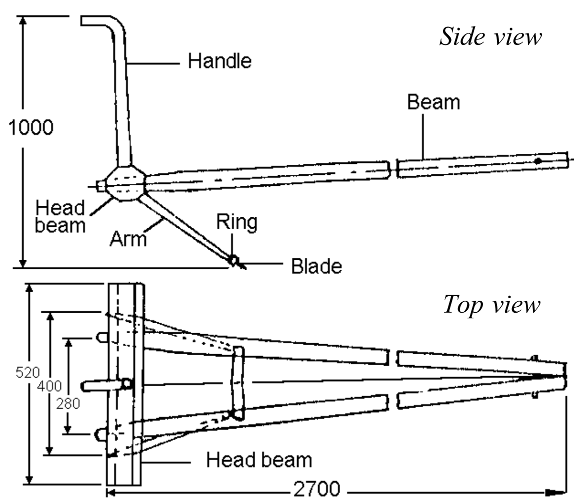
The *bakhar* (blade harrow) is a traditional implement used for primary and secondary tillage, weeding and soil mulching in black soil regions of the country. It makes use of a straight or slightly curved blade. A V-shaped blade (Figure 2) that could be fitted onto a traditional *bakhar* was developed by CIAE (1980). It was reported to suffer less from clogging and to have a lower draft force requirement, than the traditional blade.

A patella harrow (Figure 3) with a lifting arrangement of hooks was developed at CIAE (1980). This was used after primary tillage for levelling, breaking soil clods and collecting trash and weeds for removal from the field.

Yadav and Anderson (1980) describe a serrated blade for hoe and harrow, bullock-drawn blade-cum-tine hoe and bullock-drawn ridger hoe for weeding and intercultivation operations in dryland farming. The serrated blade (Figure 4) which comes in different sizes may be fitted into the traditional blade hoe or blade harrow (*bakhar*). The serrated blades easily penetrate the soil and help in moisture conservation.

The bullock-drawn blade-cum-tine hoe (Figure 5) is an improvement over the

Figure 1: Blade hoe from central India



All dimensions in millimetres

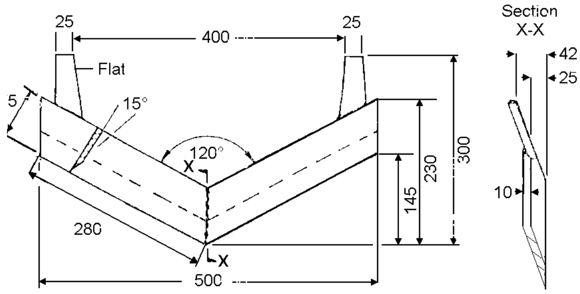


Figure 2: V-shaped blade for Bakhar (CIAE design)

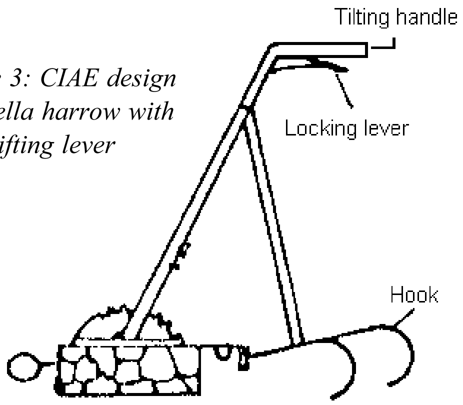


Figure 3: CIAE design of patella harrow with lifting lever

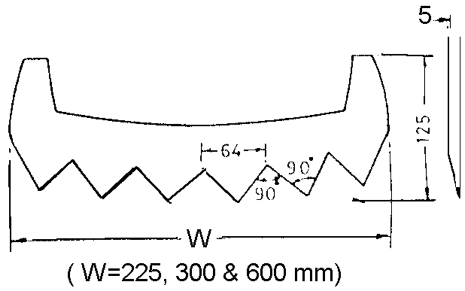


Figure 4: Serrated blade for hoe and harrow

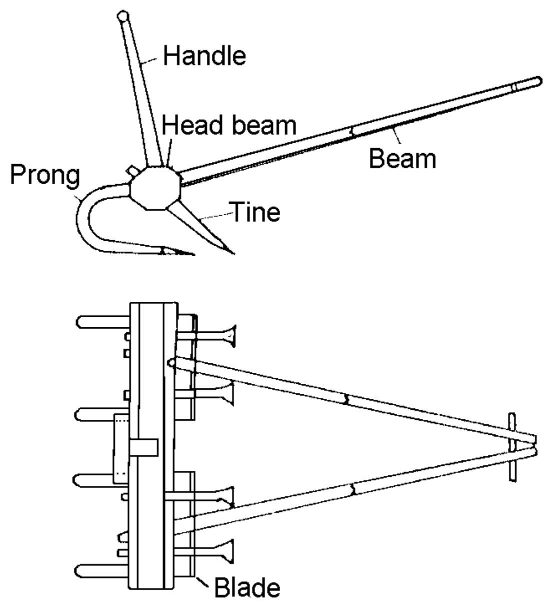


Figure 5: Animal-drawn blade-cum-tine hoe

traditional blade hoe. It has two straight blades in the hoe, with two tines in front of each blade to loosen the soil.

The bullock-drawn ridger hoe (Figure 6), which makes use of two ridger bottoms on a traditional wooden frame with row-to-row adjustments, is useful for weeding and earthing-up.

Triangular-blade hoes are popular in some parts of the country and one such hoe developed by the Agricultural Tools Research Centre (ATRC), Bardoli is shown in Figure 7. Wedges have

Figure 6: Animal-drawn ridger hoe

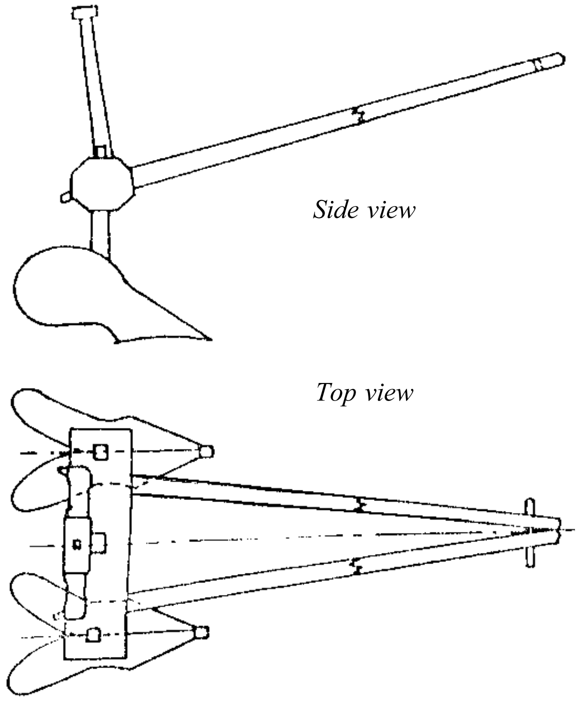
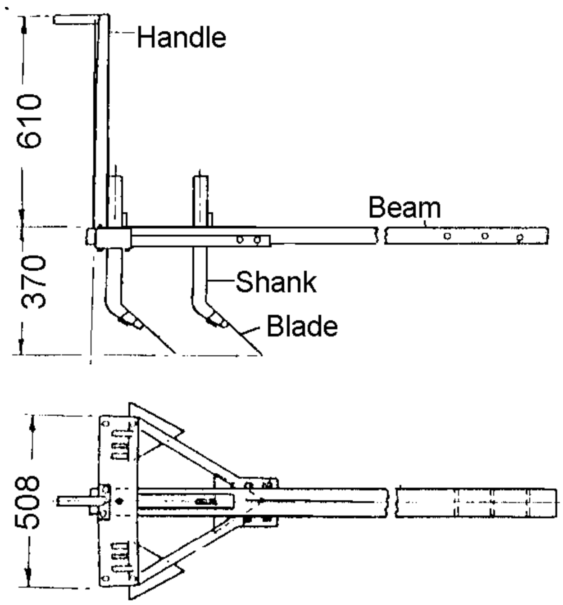


Figure 7: ATRC triangular blade hoe



been used for fixing the tines and blades to enable ease of adjustment in the field. The triangular blades easily penetrate the hard soil and clogging of the blade is minimal. The hoe is used for secondary tillage and weeding operations.

Prototype animal-drawn cultivators making use of shovels, sweeps and duckfoot sweeps have been introduced by several research centres including:

- Indian Agricultural Research Institute (IARI), New Delhi
- Allababad Agricultural Institute (AAI)
- Panjabrao Krishi Vidyapeeth (PKV), Akola
- Tamil Nadu Agricultural University (TNAU), Coimbatore (Figure 8)
- CIAE, Bhopal (Figure 9).

Figure 8: TNAU animal-drawn cultivator

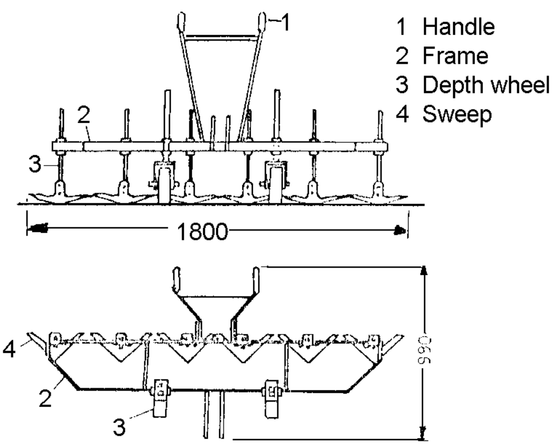
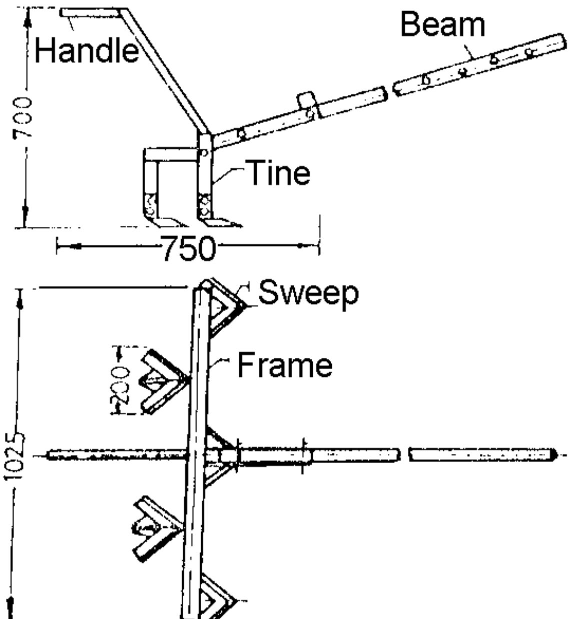


Figure 9: CIAE animal-drawn cultivator



All dimensions in millimetres

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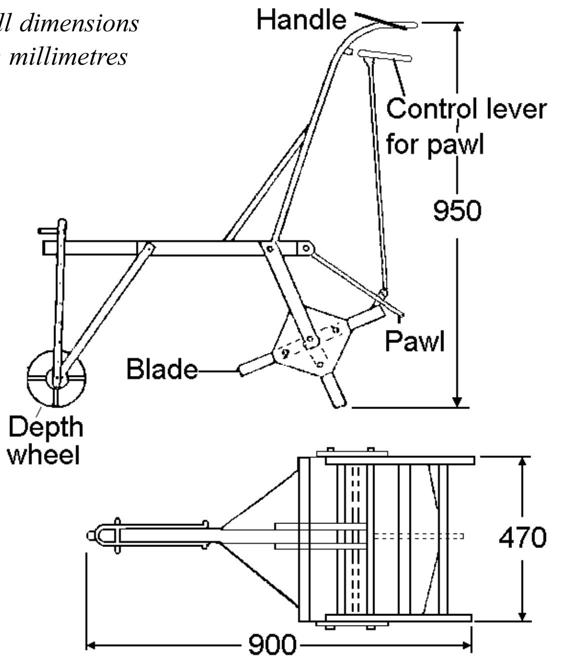


Figure 10: IISR-Lucknor weeder-mulcher

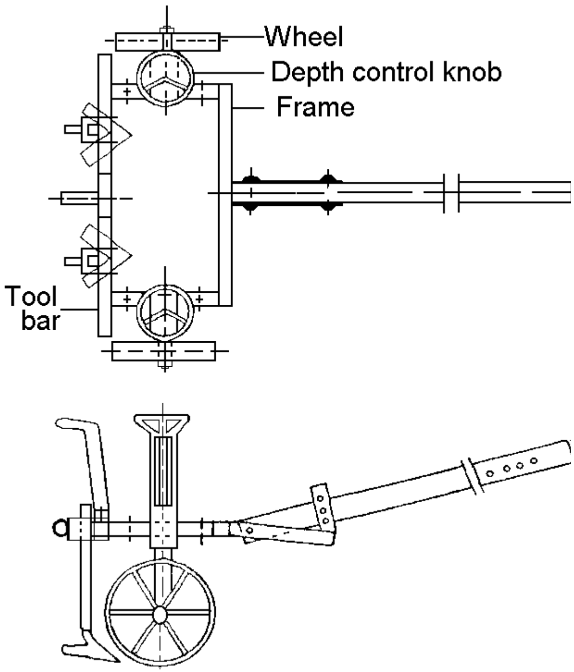


Figure 11: CIAE toolframe with steel wheels

The weeder mulcher (Figure 10) developed at the Indian Institute of Sugarcane Research (IISR), Lucknow, makes use of four straight blades in the form of a cage. During operation only one blade works in the soil as the cage is held by a pawl mechanism. When the blade is clogged by weeds, the operator releases the pawl by means of a lever and the cage turns through 90º and is locked again by the pawl. This brings a new blade into working position. The weeder mulcher (Figure 10) is useful for weeding in sugar-cane and other widely-spaced row crops.

Use of rotary tools such as discs and rotary rods is limited. However, animal-drawn disc harrows are available for secondary tillage and weed control. A weeder making use of a ground-powered square rod was developed at the Andhra Pradesh Agricultural University (APAU), Hyderabad.

Animal-drawn toolcarriers with pneumatic and steel wheels were introduced from different research centres for tillage, sowing, weeding and intercultivation operations. Work at the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad and CIAE, Bhopal showed the benefits of the toolcarriers for various farm operations. They have high field capacity compared with traditional tools. Rajput (1987), in his study on toolcarriers from 1981–87 in CIAE, Bhopal, reported the following field capacities: plowing 0.065 ha/h, blade harrowing 0.106–0.220 ha/h and weeding/intercultivation 0.287 ha/h. Unfortunately the high cost of the toolcarriers with pneumatic wheels (eg, Nikart and Tropicultor) is prohibitive for most farmers.

Garg and Devnani (1982) developed a toolcarrier with steel wheels (Figure 11). Biswas (1990) developed a mobile toolcarrier with instrumentation (Figure 12) for evaluation of different shapes of weeding tools. In this a four-channel mechanical strain-gauge recording unit measured the draft forces acting on three blades at a time and the forward speed was recorded through a centrifugal system on the fourth channel.

Studies on animal-drawn weeders

Animal-drawn weeders work between crop rows; weeds left within the rows may be removed manually. The straight blades of traditional hoes can remove weeds within the working width of the blades, but straight blades tend to become clogged with soil and weed debris, which reduces their efficiency. There is therefore a need to develop and use improved blades.

The field performance of animal-drawn blade hoes and triangular-blade hoes was evaluated on a soya bean crop at CIAE during 1980. The triangular blade hoe worked deeper (6.3 cm compared with 5.5 cm for the blade hoe) requiring higher draft force (415 N compared

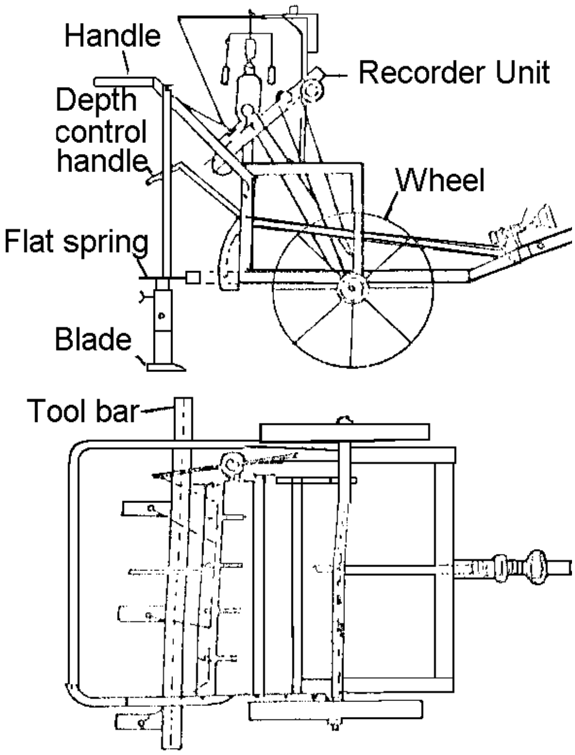


Figure 12: CIAE wheeled toolcarrier unit with instrumentation

with 330 N for the blade hoe). However, weeding efficiency was higher for the triangular-blade hoe (78% compared with 75% for the blade hoe). Weeding with the triangular-blade hoe was slower (one hectare taking 8.2 hours compared with 7.7 hours for the blade hoe).

Four shapes of weeding tools were tested during 1988–90 under laboratory and field conditions. These were straight blade (Figure 13), triangular blade (Figure 14), curved blade Figure 15) and sweep (Figure 16). A laboratory test apparatus was developed for testing the tools in a small soil bin at a constant speed and at different depths. Strain gauge transducers were developed and used along with strain indicators and a two-channel oscillographic recorder. The mobile toolcarrier unit with instrumentation (Figure 12) was used for field testing. The critical dimensions of the tools were optimised based on the minimum draft force required per unit working width during operation.

For straight blades the following optimum values were obtained: rake angle (ranging from 20.6º to 22.5º, blade width (B) as small as possible in the range 15–50 mm, blade thickness (t) as small as possible depending upon the mechanical strength and blade sharpness angle) of 15º or less. For curved

All dimensions in millimetres

Figure 13: Straight blade

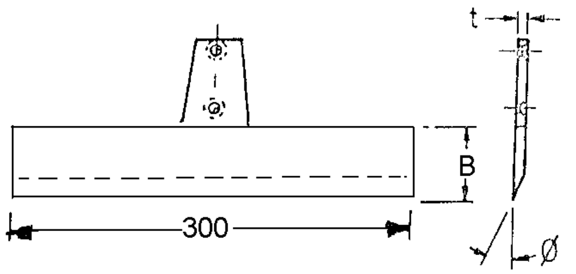


Figure 15: Curved blade

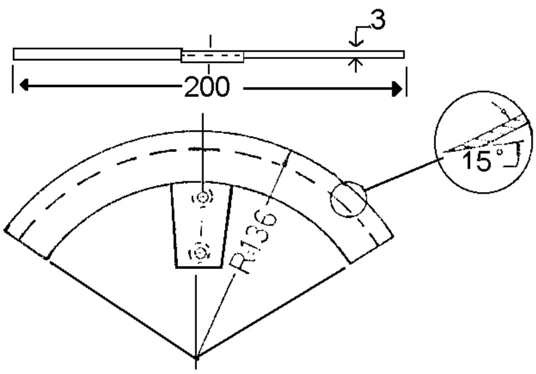


Figure 14: Triangular blade

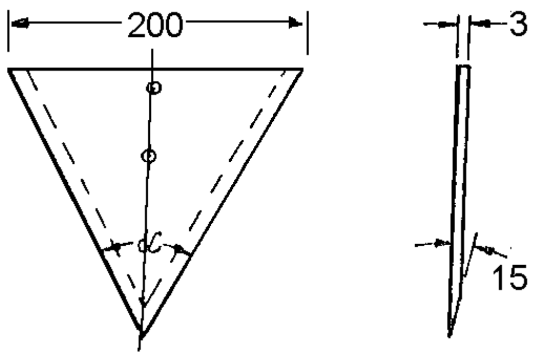
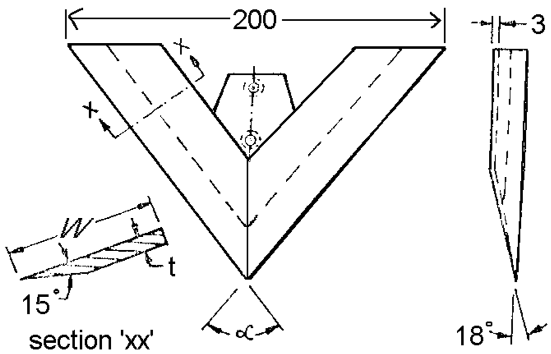


Figure 16: Sweep blade



blades of 200 mm working width, optimum value of radius of curvature (R) was 136.4 mm and rake angle (ranged from 22.0º to 22.4º.

For triangular blades, the optimum value of rake angle (ranged from 21.6º to 21.9º and approach angle ( ) ranged from 76.9º to 81.6º

For sweeps, the following optimum values were obtained: approach angle ( ) in the range 74.7° to 75.0°, wing width (W) 50 mm or less and blade thickness (t) less than 4 mm. Wing width and blade thickness should be minimal depending on the mechanical strength of the sweep. High grade steel may be utilised to obtain these minimum values.

Field performance of weeding tools was assessed by calculating the performance index (P), as suggested by Gupta (1981).

$$P \quad \frac{a \quad q \quad e}{p}$$

where:
a = output (ha/h)
q = (100 – % plants damaged)
e = weeding index (%)
p = power input

The weeding index e is given by:

$$e \quad \frac{w_1 \quad w_2}{w_1} \quad 100$$

where:
w_1 = weed count before weeding
w_2 = weed count after weeding

Optimised blades, one of each of the four shapes, were tested under field conditions on the animal-drawn mobile toolcarrier unit with instrumentation. The highest performance index was obtained for the sweep (8940) followed by the triangular blade (7690), curved blade (7230) and straight blade (3780).

For straight blades, draft force and power requirement were high and weeds clogged the cutting edge. Plant damage was also greater. Soil manipulation was high in the case of the triangular blade.

An animal-drawn cultivator (Figure 17) was developed using improved sweeps and one triangular blade. Performance of the cultivator and a traditional *bakhar* (blade harrow) was evaluated under field conditions. Performance indices were 2020 for the animal-drawn cultivator and 1280 for the *bakhar*. The animal-drawn cultivator could cover about 53% more area than the traditional *bakhar*.

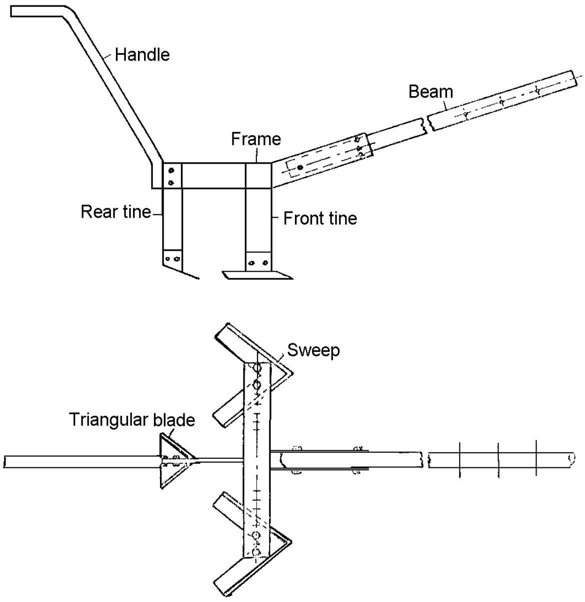


Figure 17: CIAE animal-drawn cultivator

Conclusions

Animal-drawn weeders play an important role in the mechanical control of weeds. Due to high output, animal-drawn weeders help in the timeliness of operations compared with manual methods and are cheaper. Within the crop rows weeds may be removed manually. Other weed control methods such as chemicals, crop competition or crop rotation may be utilised for effective weed management.

Various improved animal-drawn weeders have been developed but new designs have not been adopted easily by farmers for a number of reasons:

- difficulty in development of manufacturing technology by village artisans and small workshops
- inadequate extension facilities for demonstration, training and popularisation
- non-availability of designs of improved weeder for different locations or crop-specific agro-climatic conditions.

Concerted efforts are therefore required from research and government organisations in the design and development of improved weeders, demonstration and popularisation, training of extension workers and farmers in the use of improved weeders and industrial liaison for quality production of improved weeders. The transfer of available technology to the farmers could reduce yield loss due to weeds and increase agricultural production.

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