Animal power for weed control: experiences and challenges

by

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Abstract

The paper highlights the status and trends of draft animal power utilisation in weeding operations in sub-Saharan Africa. It is estimated that about 20% of the cultivated land area is plowed using animal power and about 5% of farmers use animal-drawn weeders.

It is well known that using draft animal power for weed control reduces human drudgery and allows increased production to take place through area expansion and improved timeliness. Social and economic benefits are enhanced through increased yield if work animals are used for weeding. However, in the past there have been limited efforts to promote animal-drawn weeding systems.

To get maximum output from working animals, appropriate harnesses and implements have to be used, and the animals must be well trained, fed, cared and managed. This is the challenge to researchers, extension staff and farmers.

Introduction

Agriculture in most developing countries is predominantly subsistence, dominated by smallholder farmers. Over 80% of the arable land falls into this sector. Human power is still the biggest power source used in crop production in most of these countries (Table 1). For example, out of the 6.5 million hectares under cultivation in Tanzania, 70% is cultivated with human power, 20% by animal power and only 10% by mechanical power (Starkey and Mutagubya, 1992).

Under smallholder farming, the hand hoe is still the dominant tool and because of its limited capacity, delayed weeding in planted crops is common. A survey in Mbeya Region of Tanzania showed that more than 50% of smallholder farmers weeded later than the critical growth stage when crops are most susceptible to weed infestation (Loewen-Rudgers et al, 1990; 2000).

In most of the sub-Saharan region, cattle are the main work animals. Oxen are the animals of choice but cows are being used increasingly as work animals, reflecting a world-wide trend in intensifying smallholder production systems. Donkeys are also being used increasingly for transport, tillage and weeding operations (Makwanda et al, 2000). They are easily trained and reliable and can survive well in drought conditions and may thrive more than cattle in tsetse-infested zones. Table 2 gives estimates of the number of cattle and donkeys employed in eastern and southern African countries.

In almost all sub-Saharan countries, weeding has been cited as one of the major constraints in crop production for resource-poor farmers. Crop losses of 30–70% have been recorded because of poor weeding (Croon et al, 1984; Madata and Mkuchu, 1992). Most farmers experience a serious labour shortage during the time of weeding and the most detrimental effect of weeds, which compete with crops for nutrients and water resources, is the decrease of crop yield (Armitage and Brook, 1976; Rao, 1983; Kwiligwa et al, 1992).

Alstrom (1990) has reported yield losses in cereal crops ranging from 0.4 to 15% in crops

Table 1: Sources of farm power used in developing countries (% contribution)

Area	*Human*	*Animal*	*Tractor*
North Africa	69	17	14
Sub-Saharan Africa	89	10	1
Asia (excl China)	68	28	4
Latin America	59	19	22
Overall	71	23	6

Sources:
FAO, 1987 as cited by Panin and Ellis-Jones, 1994

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Table 2: Estimates of draft cattle and donkeys used in eastern and southern Africa

Country	*Cattle population (000s)*	*Donkey population (000s)*	*Employed cattle (000s)*	*Employed donkeys (000s)*
Zambia	2 700	2	240	1
Zimbabwe	5 950	104	500	70
Malawi	1 400	2	70	1
Tanzania	12 000	175	800	130
Uganda	3 900	17	600	13
Kenya	12 000	30	700	20

Source: FAO, 1991

weeded manually, from 1 to 32% with chemical weed control and from 17 to 57% in unweeded conditions as compared to completely weed-free crop conditions. Cramer (1986) estimated that production losses caused by weeds are 35% in maize and 25% in sorghum and millet.

In the hand-hoe-based farming system, weeding can take up to 50% of the available season time per hectare and accounts for 40–55% of the total labour input. In Zambia, for example, it has been reported that weeding in maize consumes 65% of the time required to produce the crop, while in Malawi and Zimbabwe the recorded times are 57% and 45% respectively. (Akobundu, 1990; 1992).

Draft animal power weeding systems can play a very important role in improving agricultural productivity and alleviating the labour shortages experienced during weeding operations.

The role of draft animal power in weed control

Weeding with draft animal power is a much faster and less tiring operation compared with hand weeding. It allows farmers to weed more often and/or over a wider area saving both time and labour. As a result, a farmer can improve the timeliness of weeding which, in turn, can lead to better yields per hectare (Kwiligwa et al, 1992). It has also been shown that weeding with draft animal power gives a better tillage effect with deeper loosening of soil leading to better infiltration of rain (Stevens, 1994; Kayumbo, 1994).

On-farm trials in Mbeya, southern Tanzania, have recorded an average time for hand-hoe weeding as 230 work hours per hectare as against 50 working hours per hectare when weeding with oxen (Kwiligwa et al, 1994). It has also been shown by Roeleveld and Wella (1994) that when weeding with *Cossul* inter-row cultivators in western Tanzania, the time spent on ox-weeding was about one third of the time required for hand weeding. Weeding with oxen may also result in significant saving in monetary terms.

In trials in Zimbabwe it took 60–130 work hours per hectare to weed using draft animal power (Chatizwa and Nazare, 2000). Similar observations have been noted elsewhere although there can be wide variations (FAO, 1990; Mungroop, 1991). In general, there is an overall reduction of working hours of 20–70% when weeding with animal power compared to hand weeding. Therefore, the use of draft animal power for weeding can considerably alleviate the labour constraint faced in hand-hoe-based farming systems.

Many studies and reports have shown that, although animal-drawn weeders are available in many African countries, the adoption rate among smallholder farmers has been very low (Anderson, 1985; Loewen-Rudgers et al, 1990; 2000). Starkey (1988) estimated that only 5% of farmers utilising animal traction for plowing used animal-drawn weeders. Similar results have been shown by a study carried out in ten regions of Tanzania which revealed that all the 100 farmers interviewed used work animals for plowing, 85% used their animals for transport and only 16% and 5% used them for planting and weeding respectively (Mgaya et al, 1994).

In an attempt to explain the reasons for the low rate of adoption of animal powered weeding technologies, Loewen-Rudgers et al (1990;

2000) cited some of the major constraints which were based on the experiences of the Mbeya Oxenization Project in Tanzania. Similar constraints have been observed in Zimbabwe and reported by Chatizwa and Nazare (2000). They include:

- non-availability and poor quality of implements
- inadequate knowledge/information about alternative animal-drawn weeders
- inadequate training of animals
- poor dissemination of the weeding technologies
- inadequate repair services at village level
- fear of crop damage by animals and implements.

Review of animal-powered weeding systems and practices

Generally, all crops can be weeded using oxen or donkeys provided the inter-row spacing allows passage of the implement without causing damage to the roots and stems of the crop plants. It is generally recommended that for easy weeding, crops should be planted in parallel rows, or parallel contours across the slope, at least 45 cm apart. Animal power can also be used to weed along and across rows of fruit trees and plantation crops such as citrus, banana, coffee, tea, sugar cane and vines.

The normal practice is to weed maize crops two to three weeks after germination and then once or twice during the growing stage depending on the rainfall pattern of the area and the level of weed infestation. Field observations have shown that cultivators perform better when weeds are short and the soil is not too wet. When it is too wet, the soil and the uprooted weeds tend to clog the tines making the cultivator act like a rake with minimal penetration of the soil.

Weeding is generally recommended when the maize plants are 5–10 cm, 45 cm and 90 cm high. An alternative approach is to kill the weed population before planting. In other farming systems, intercropping of sunflower and soyabeans have been used specifically to control weeds.

Successful and effective weeding using animal power depends on adequate preparation both of animals and the cropped land. Animals must be adequately trained by making them walk in straight lines. This is best accomplished by first passing the animals between rows of sticks and then between rows of a short crop while muzzled.

During weeding operations precautions should be taken by using muzzles or halters to prevent animals from grazing the crop.

All animal-drawn weeders which are currently in use are for row crop work and are mainly used for inter-row cultivation. An attempt to introduce over-the-row cultivation by the Mbeya Oxenization Project (MOP) in Tanzania and elsewhere has not been accepted fully by farmers. Some of the reasons as highlighted by Loewen-Rudgers et al (1990; 2000), Kwiligwa et al (1992) and Rempel and Townsend (1993) include:

- affordability: the construction of these cultivators depended on imported steel (thick hollow rectangular) which pushed the price up
- the wheels were quite small (220 mm diameter) so transport was only possible over short distances
- due to the size of the implement, over-the-row weeding was not possible after the crop had reached a certain height. The cultivator is effective only for early weeding at plant heights of not more than 45 cm
- failure to eliminate the weeds within the rows meant that farmers had to supplement it with hand weeding.

Preconditions for successful weeding

For successful weeding using draft animals, there are preconditions which must be fulfilled. These include: good field preparation, selection of appropriate yokes and harnesses, well-trained animals, planting crops in rows and at correct spacing relative to weeding yokes and harness, and the use of appropriate implements.

Field preparation

The field should be well plowed and possibly harrowed to minimise clods and trash. To facilitate ease of turning, marking of headlands is recommended.

Appropriate yokes

As a rule of thumb, yokes should be selected which are twice the row width. For example: if a crop is planted at 75 cm width spacing, then a suitable yoke should be 150 cm long. For a breast-band harness in a 75 cm width spacing, a swingle tree 60 cm long would be suitable.

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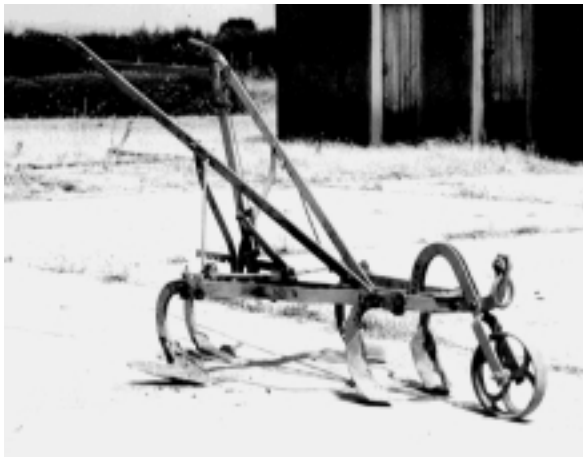


Photo: A K Kayumbo

Figure 1: A cultivator with reversible teeth and rear sweeps for inter-row weeding

Animal training

Well-trained animals are necessary. The animals should be made to walk in straight lines as described above. Training to walk in straight lines is normally accomplished in two weeks.

Planting crops in straight lines

Weeding with draft animals is easily done when the crops are planted in straight lines or parallel to contours and at the correct spacing.

Appropriate weeding implements

In general, selection of implements for weeding will depend on: crop type, stage of crop, type of land (whether flat or ridge cultivated), soil condition and stage of weed growth.

Kayumbo (1994) used the following headings to categorise the range of animal-drawn weeders and options available for use in different farming systems in Tanzania.

Implements that cut weed roots between rows

Two implements fit this category:

- a cultivator fitted with reversible tines and sweeps. Two or four tines in front and three sweeps on hind tines (Figure 1).

Figure 2: A sweep fitted to a ridger beam for inter-row weeding

Photo: A K Kayumbo

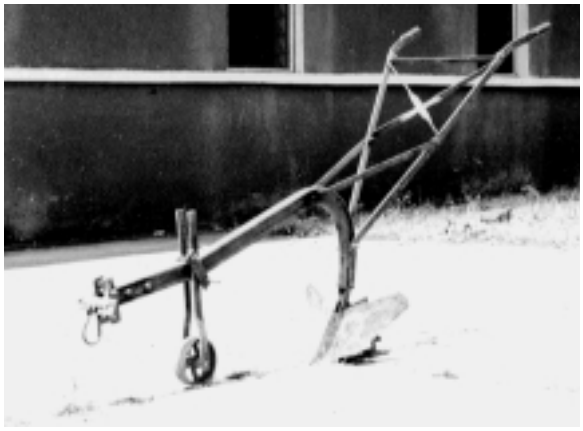


Photo: A K Kayumbo

Figure 3: A hiller fitted on a ridger beam for earthing-up

- a sweep (the size of which depends on inter row spacing) fixed onto the beam of a plow by a bracket (Figure 2).

Implements for earthing-up

Hillers attached to the steel beam of a plow or ridger or to the rear of a cultivator can be used for earthing-up to bury weeds (Figure 3).

Implements for cutting weed roots and earthing-up in one operation

A five-tine cultivator fitted with two reversible tines in the front, a pair of hillers and a sweep tine at the rear is one such implement suitable for inter-row weeding and earthing-up to bury the weeds along the crop rows (Figure 4).

Alternatively the tie ridger blade can be fixed on the rear tine instead of the hiller to produce the same effect.

Some farmers also use the ordinary mouldboard plow for inter-row weeding and earthing-up.

Implements in ridged cultivation systems

Ridged cultivation systems can be weeded using a tie-ridger/weeder (Figure 5). The implement can be used for weeding between the ridges and for tying the ridges, all in one operation. Re-ridging is another method practised by farmers for weed control.

Implements for weeding with donkeys

Most of the conventional implements have been designed for ox- and cow-traction. In recent years, efforts have been made to develop light implements suitable for donkey traction. A donkey-drawn hoe, the HATA (Houe à traction asine), has been developed for mechanised weeding on sandy soils (Figure 6; Emhardt and Kutzbach, 2000).

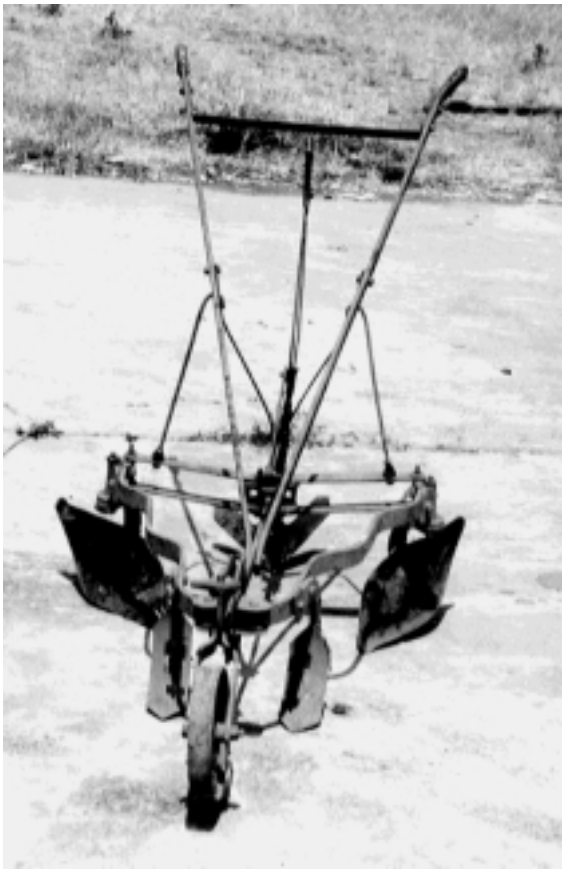


Photo: A K Kayumbo

Figure 4: Cultivator fitted with reversible front tines, hiller blades and rear sweep

On-farm experiments conducted in Niger, showed a remarkable decrease in labour time with the HATA compared with traditional hand tool weeding. Trials indicated that using the HATA reduced the labour requirement from 41 h/ha for manual weeding to 18 h/ha (Emhardt, 1994).

Photo: A K Kayumbo

Figure 5: A tie ridger

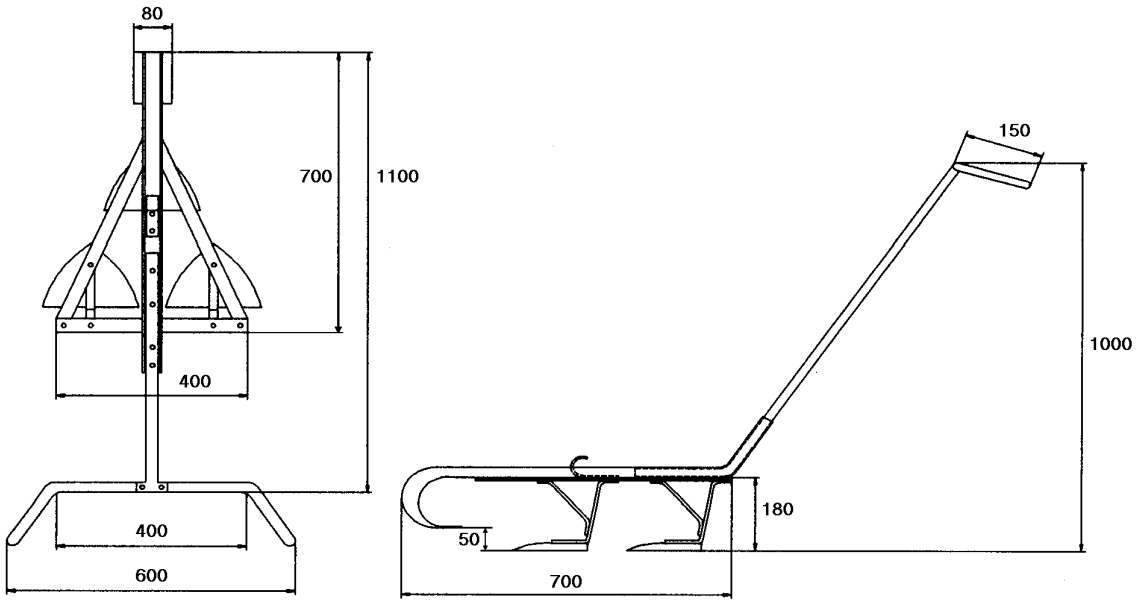
Although the HATA can be made and maintained in the country's rural areas, the fabrication of a durable model is very dependent on the abilities of the village blacksmith. Farmers also need training on how to use the implement and how to harness the animals properly.

Dissemination of weeding technologies

Studies on the development of effective and economical weed control systems based on animal-drawn implements have been conducted over the last decade in several different countries in east and southern Africa.

In Tanzania, studies started as early as 1987 when the then Mbeya Oxenization Project

Figure 6: HATA, a donkey-drawn weeder (dimensions in mm)



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(MOP), in collaboration with Uyole Agricultural Centre, initiated an extensive programme of promoting animal-drawn weeding technologies in three regions of the Southern Highlands of Tanzania. Through these efforts, the number of animal-drawn cultivators in Mbeya Region increased from 11 in 1988 to 865 in 1993.

Also in Tanzania, work on weeding with animal power has been undertaken by the Farming Systems Research Lake Zone Project and the response has been very impressive (Roeleveld and Wella, 1994; Wella and Roeleveld, 2000). In another project in Tanzania, the Tanga Draft Animal Project initiated weeding with donkeys and similar positive results have been documented (Makwanda, Shemdoe and Msagusa, 2000).

Among the weeding implements which have been tried in the field and/or promoted in the region are: *Houe Sine, Houe occidental* and *Ariana* toolbars from Senegal*, Cossul* cultivators from India, *Agro-Alpha* cultivators from Mozambique, *Zimplow* and *Bulawayo Steel* cultivators from Zimbabwe and *UFI* cultivator, *Mkombozi (Pecotool)* cultivator by SEAZ (MOP) and the MOP over-the-row cultivator from Tanzania. Characteristics of some of these implements and the field observations are shown in Table 3.

During an ATNESA workshop on weed control, held in Tanga, Tanzania in 1993, it was observed that the inter-row tine weeders were preferred by farmers in the region. Previous efforts to introduce over-the row weeding implements had not led to wide adoption. Available designs were functional although they were generally too heavy, particularly for donkeys. It was also agreed that tine points were suited for early cultivation of crops such as maize, while hillers were useful for later weeding.

Implement recommendations

The main recommendations relating to weeding implements, based on the 1993 ATNESA weeding workshop, are summarised below.

Technique

Emphasis should be on between-row weeding implements as these are likely to be preferred by farmers. Although over-the-row weeding can be effective and used in some parts of the world, trials in Tanzania and elsewhere in Africa have not led to adoption.

Adjustments

Simple adjustments should be promoted. The use of bolts requiring spanners is not favoured, particularly if more than one size is required. The use of tommy bars and ring bolts/nuts is preferred. Lever-operated width adjustment is preferred as it allows instant adjustment without tools. Depth adjustment is necessary and can be achieved through hake plate or depth wheel.

Control height adjustment (handle height) is necessary for an operator to work comfortably. The choice of one or two handles is determined by farmer preference, tradition and the level of animal training.

Tine type

Ducksfoot tines are preferred for general weeding. Narrow reversible tines are suitable for early weeding at the weed seedling stage. Hiller bodies are only useful for earthing-up taller crops, such as maize at 30 cm.

Ridgers

Ridgers are preferred for weed control in ridged tall crops (eg, maize) and for incorporating fertiliser applied alongside the crop row in flat or ridged tall crops. Ridgers can be used for earthing-up tall crops planted on the flat.

Table 3: Characteristics of some weeding implements and field observations of their use

Implement	*Major features/characteristics*	*Observations*
Houe occidental	Short, rigid tines with low ground clearance (10 cm)	Unsuitable for heavy soils
Houe Sine	Spring tines	Expensive (US$ 125)
Ariana	Spring tines	Too heavy and expensive (over US$ 150)
Cossul	Low clearance (22 cm)	Frequent breakage of cast iron brackets and bending of hillers
Mkombozi	Over-the-row cultivator, rigid tines with high ground clearance (45 cm)	Expensive (US$ 130) frequent breakage of pins

Other designs

Spring tines are generally expensive and are not effective at the slow speeds of oxen and donkeys. Spike tooth harrows are mainly suited to the higher speed and power of draft horses. Tie ridgers are water conserving tools and will only be appropriate where this is a specific requirement.

Weight and ergonomics

Weeders currently available are generally too heavy. Lighter weeders are easier to control. Current designs are rarely suited to donkey draft. Weight and cost are also related: heavy implements may be unnecessarily expensive, but lightweight, strong materials may also be expensive.

Challenges in promoting animal power weeding technologies

While everyone seems to agree that weeding is the major bottleneck in agricultural production, very little has been done to promote alternative systems to alleviate the problems for smallholder farmers. It is generally agreed that animal-drawn weeding systems provide the best alternative. However, key issues have to be resolved by both researchers, extension staff, manufacturers and entrepreneurs.

- How can we increase the availability of implements (supply and repair side) and at affordable prices?
- Can we develop suitable implements for donkeys?
- How can we make the information on the range of implements and techniques available readily accessible to farmers?
- How can we solve the dilemma of weeding using animal-drawn systems when most small-scale farmers practise intercropping?

We can identify the following five major areas of challenge concerning the promotion of animal-drawn weeding technologies.

Social and economic factors

Can we make animal-drawn weeders available at prices affordable to farmers? The current low income of most smallholder farmers, which is partly attributed to poor pricing policies and marketing strategies, is one of the hindrances faced by most small-scale farmers in investing in agriculture.

Traditional and cultural beliefs and attitudes hindering adoption should also be dealt with through dialogue and training. Farmer-to-farmer exchange visits should be encouraged whenever possible to break down some of the traditional barriers to using animals for weed control.

Implement availability

Most weeders in the region are produced by large factories and workshops which concentrate on plow production. For example, in 1994, Bulawayo Steel Products in Zimbabwe made and sold only 1927 cultivators and 54 ridgers, compared to 12 667 plows. Such production levels are low compared to the potential demand from the one million smallholder farmers in Zimbabwe.

In recent years in Tanzania, most of the weeders have been imported and assembled by the state-owned factory UFI. As it receives government subsides, UFI distorts the market price of weeders. Another company, SEAZ, based in Mbeya in Tanzania has imported *Agro-Alpha* weeders from Mozambique and *Cossul* cultivators from India.

Equipment and spares availability at affordable prices is still a major challenge to widespread use of animal-drawn weeders.

The use of donkeys for weeding is likely to increase, particularly if encouraged and if appropriate weeding equipment and harnesses are made available. If we are to promote weeding technologies, a major challenge ahead will be to ensure the availability of implements.

Information, training and extension

In eastern and southern Africa, specific market analyses of the requirements of farmers have not been undertaken and the actual demand for weeders has not been properly quantified.

There is inadequate information for farmers on the range of weeding implements available. Many farmers in the region do not know about animal-drawn weeding technology. Others do not know how to train their animals to walk in rows.

An important means of increasing the animal draft power available is to make more efficient use of animals by having well-trained handlers and well-trained animals. Therefore, there is much scope for good training and extension targeted at both men and women. In Tanzania, coordinated farmer-based testing and extension programmes on weeding technology have been tried by using the 'contact farmer' and 'farmer training groups' approach. Considerable success has been achieved with this strategy of

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participatory dissemination which enables one to incorporate farmer perceptions, preferences and responses to technology at an early stage. Other methods which have been tried include organising weeding competitions and use of radio programmes.

Research and development

Technical investigations into design changes and materials are not the main priority, but may be needed in specific circumstances. Some research and development possibilities include:

- lightweight weeders for donkeys and oxen
- spike tooth weeders
- tied ridgers
- herbicide application with animal power.

Animal availability, health and harnessing

Health and general draft animal management are of extreme importance for ensuring good performance of animals. It has been reported that the main plowing and weeding season corresponds to a period of high challenge from ticks and diseases (Ngendello, 1991). It is also possible that the stress of work makes draft animals more susceptible to disease, and that the challenges of diseases and parasites reduce work performance.

Well-designed yokes and harnesses are essential to allow an animal to transmit forces to the implement efficiently. Harnessing requirements are specific to each draft species and it is essential that correct forms are used to ensure that the animals are not injured and that optimum work output is achieved.

Conclusions

Draft animal power has a big role to play in alleviating drudgery, making farm work attractive and improving the social status and income of resource-poor farmers. Weeding using animal draft power can improve agricultural production and alleviate the labour shortages experienced during weeding.

Given all the advantages of weeding with animal power, the low rate of its adoption poses a challenge to extensionists and to scientists to ensure that farmers take full advantage of their resources. It is important to remember that the weeding technology appropriate for a particular country or area can only be determined by analysis of the local farming systems, their unique combination of soils, climate, crops and animals and the requirements, resources and potential of the farm families.

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