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Animal power for weed control: a technical review

by

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Abstract

Proper weed control is of tremendous concern to farmers in terms of labour and yields. Large gains in labour capacity are not possible from hand tools. Herbicide-based weed control offers very high labour productivity with stable yields but its economic viability at the smallholder level is uncertain. Its use requires good discipline and technical awareness from farmers. Draft animal weeding is currently one of the best answers to the needs of smallholders for improved weed control.

Widespread adoption of animal power for weeding has not taken place, often for one or more of the following reasons:

- *planting in rows is required, and farmers may lack expertise and/or suitable planters*
- *animals must be trained to follow crop rows*
- *farmers fear that animals may eat or damage the crop*
- *weeding is done by women, but men control the animals and consider weeding a light operation*
- *limited availability of suitable implements*
- *farmers lack awareness, information and training.*

It is concluded there is much potential to promote weeding with animal traction. This may involve training and the provision of information as well as stimulating the supply of suitable animal-drawn weeders.

The weeding problem

Growers of crops must exploit nature while keeping their crops one step ahead of the weeds in order to produce enough. Competing with nature involves preventing and eradicating weeds, which are the unwanted plants in the field which threaten a crop. Most farmers simply cannot cope and have to accept that the weeds get their share. That is the problem.

Proper weed control is of tremendous concern to farmers in terms of labour. This issue has been well recorded in the literature and thus there is no need to review it in detail here. Instead, this paper reviews the relevance of animal-powered weed control in farming systems.

First, the importance of weeding in farming is illustrated using examples which pertain to another struggle with nature: that against land degradation. This alarming phenomenon is perhaps recognised more by agriculturalists and environmentalists than by farmers themselves. We are now talking about soil erosion, declining soil fertility, water loss, and what can be done about them. Answers focus on improved land preparation systems like better tillage, reduced tillage and contour bunding. Such possible solutions seem unrelated to the 'traditional' view that weeding is a labour problem. In all cases the question arises: how can weeds be managed?

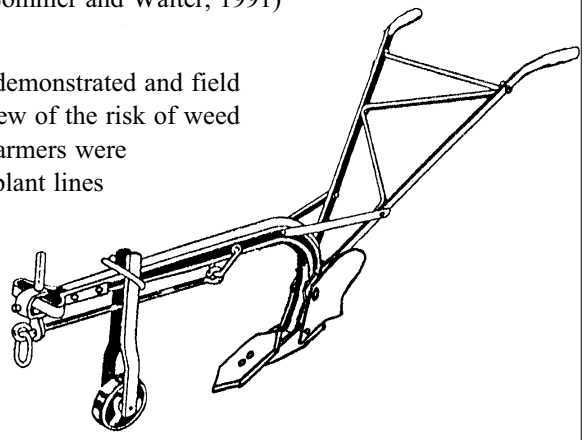
Land preparation options

Plowing

Plowing was (for genuine reasons) blamed for being a destructive factor in soil erosion. But plowing, while mostly used for seedbed preparation, is inherently an effective weeding method. Crop seedlings and young plants are no match for aggressive weeds in competition for water and nutrients. But plowing before planting severely sets weeds back so that the crop has a chance to establish before they become threatening. Meanwhile, animal-powered alternatives to plowing all require more critical and intensified weed management (Shumba, 1984; Norton, 1989; Stevens, 1989). Consequently it can be anticipated that the success of more environment-friendly tillage techniques like ripping, ridging and tie-ridging is largely determined during weeding: farmers cannot be expected to adopt a tillage system for soil and water conservation reasons if it is incompatible with their labour problem during weeding.

The Palabana Ripper Plow

The Palabana Animal Draft Power Development Programme in Zambia promotes ripping for seedbed preparation as an alternative to plowing, in particular in the drier southern part of the country. It developed a new type of ripper based on the modern ard plows (*'Arado combinado'* and *'Arado andino'*) used in Latin America (Schmitz, Sommer and Walter, 1991) and also found appropriate in Niger (Kruit, 1994).



In the introduction programme, this ripper was always demonstrated and field tested by farmers *in combination* with a cultivator in view of the risk of weed infestation that would be uncontrollable by hand. The farmers were recommended to start using the cultivator between the plant lines after having plowed these with the ripper, either just before or after the actual seeding. If, in view of the rainfall pattern at the beginning of the season, planting had to be delayed, farmers could decide to scarify the field even before ripping and planting, in order to control the emerging weeds. It was realised that in these conditions a sturdy cultivator is required as the soils are still hard at the beginning of the rainy season.

What is happening here is that the new tillage systems generally shift the labour bottleneck to a later date in the cultivation calendar, ie, into the weeding period. The solution should then be found in the combined introduction of improved tillage plus improved weeding in order to make the new systems workable. On the other hand it should be recognised that any good weed control system starts with a good tillage system. Weeds should be controlled (more or less) throughout the year.

Zero tillage

Recently, so-called zero-tillage, in which all forms of tillage are to be excluded to allow the regeneration of a healthy soil structure, is being promoted. Mulching and attempts to increase the organic matter content of the soil cannot go along with mechanical soil disturbance, including mechanical weeding. A jab planter is used to plant directly through the mulch layer, resulting in minimal soil disturbance. This appears good in theory. In practice, weed control relies on herbicides and for this reason the system has failed (Madeley, 1993).

Water harvesting

In semi-arid areas, different water-harvesting methods are being promoted. They are designed so that runoff water is concentrated near the crop plants by collecting it along predetermined slopes. Hence the crops always grow in low-lying parts, eg, in dug-outs evenly distributed over a sloping field, or in the furrows of a ridged field. These systems are highly effective in terms of water use. However, weeding remains a problem as the different layouts do not (easily) allow for mechanical weed control.

Weeding alternatives

We have seen that the weeding issue is prominent, both as a direct labour problem to farmers as well as an obstacle in the promotion of alternatives to traditional tillage systems. Most farmers weed by hand. Their problem is lack of labour. Apart from mechanical weeding with animal traction, the main choices are:

- herbicides
- alternative hand tools
- inter-cropping
- breeding for crop resistance.

Advocating herbicides

"Weed control has been described as the most daunting aspect of conservation tillage and the one most likely to deter farmers from adopting the technique. It need not be—the advent of many new herbicides and improved spray techniques has made weed control in conservation tillage relatively simple."
Representative of the chemical industry talking to commercial farmers in Zimbabwe at a workshop on conservation tillage (McConaghy, 1989).

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Herbicide-based weed control

Herbicide-based weed control offers very high labour productivity with stable yields. It facilitates mulch farming, and is compatible with minimum tillage techniques.

On the other hand, its economic viability at the smallholder level is debatable. Its use assumes good technical awareness and high levels of discipline from farmers. Even so, there is the risk that it may not be effective. Production of herbicides is a high-technology process, and a very reliable distribution network is needed. Finally, the chemicals themselves pose health risks and the danger of residual effects.

Alternative hand tools

Ergonomic improvements to hand tools are theoretically possible. They may offer less drudgery or increased comfort. Large gains in labour capacity are not possible for new hand tools, because human power is the limiting factor. Even if improved hand tools were made available, farmers might be reluctant to replace old tools that have been developed and adapted to local conditions over centuries. There are two areas where real progress might be made:

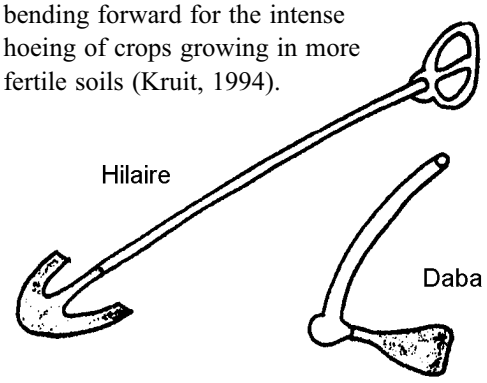
- increasing durability and strength by improving standards of production methods and materials (for example, replacing poorly mass-produced tools by high quality and well-adapted hand tools made by local blacksmiths)
- improving diversity and design through spreading traditional techniques (for example, West Africa has several types of hand tools suited for weeding in different soil conditions and these could be introduced to other parts of Africa).

Problems with herbicides and alternatives

The International Institute of Tropical Agriculture (IITA) in Nigeria virtually abandoned its interest in no-till systems relying on chemical weed control. Herbicides appeared not affordable to small-scale farmers. Its weed control research is now focusing on inter-cropping systems. Rather than killing weeds with herbicides (and leaving them as mulch), a fast-growing ground-covering crop is planted. IITA seems also to be successfully involved in breeding striga-resistant maize varieties. Traditional methods of ridging the maize and interplanting with spreading legumes further suppress striga. (Madeley, 1993).

Alternative tools for hand weeding

Examples of two traditional weeding tools from Niger. The *hilaire* is used for swift weeding in an upright position in a widely-spaced crop in very sandy soils. The *daba* is used by a person bending forward for the intense hoeing of crops growing in more fertile soils (Kruit, 1994).



Weed control in multi-cropping systems

Growing a fairly dense mixture of complementary crops, which do not compete excessively with each other, possibly in combination with a weed-smothering mulch cover, will not give weeds a chance to get established. This is a rather complex system, requiring a high level of expertise and management to maintain an acceptable level of production. It is a traditional technique, but in some areas multi-cropping systems are now discouraged and/or replaced by 'modern' cultivation methods, and so the skills may have disappeared.

The technique facilitates mulch farming, and is compatible with minimum tillage techniques to improve soil conditions. It is expected to be economical and sustainable for many smallholder farmers, and it is now gaining renewed attention from researchers.

Weed control through crop resistance

The development of new crop varieties that are resistant to certain weeds is still at the research stage. The idea seems promising, but is not yet a practical solution for promotion.

Weeding with draft animals

Compared with the weed control methods described above, weeding with draft animal is currently one of the best answers to the need of smallholders for improved weed control. It is therefore a welcome option. For many farmers, weeding with animals is the only practical solution that can be recommended for promotion.

Animal-powered weeding is characterised by:

- high labour productivity with stable yields
- well-known and straightforward techniques, adaptable to many crops and cropping systems
- some changes in cropping systems may be required
- economic at farm level
- needs healthy and trained draft animals
- requires local artisans and/or dealer network for implements and spares.

Where other approaches give at best only marginal improvements (hand tools), are not economical (herbicides) or are still at the research stage (crop resistance), draft-animal weeding addresses directly and feasibly a key problem: shortage of farm power. It deserves a firm place beside weed control through multi-cropping. The potential of the latter has attracted renewed attention from 'officialdom' and has never been completely forgotten by the farming community. However, multi-cropping is for various reasons not a simple system to promote. Animal-traction techniques may well prove to be instrumental in the (re)introduction of inter-cropping systems, for the ensuing improved timeliness of field operations.

In terms of labour productivity (time requirement) herbicides are more effective, but they are beyond the reach of most farmers. Mechanised weeding is more likely to be sustainable than the chemical strategy; it carries fewer risks (financial, health and environmental), and is easier to maintain with existing skills and facilities.

The importance of within-row weeding

Yield of early pearl millet with different weeding systems in The Gambia, 1985/86

Within-row weeding	*Between-row weeding*	*Yield increase (%)*
Late, by hand	Early, with cultivator	–
Early, by hand	Late, with cultivator	43
Early, with herbicide	Late, with cultivator	44

Source: Carson, 1987

The table emphasises the importance of early weeding *within* the crop rows: the yield increases, irrespective of weeding system used (mechanical or chemical), even with late weeding between the crop rows.

Example of the economics of weeding

Economic returns of maize weeding systems in Mbeya Region, Tanzania in 1989/90

	Weeding system		
	Hand only	*Oxen only*	*Oxen plus hand*[1]
Labour input (h/ha)	184	42	120
Yield (t/ha)	5.0	3.3	5.2
Return to labour (kg/h)	17	33	28
Return to labour (Tsh/h)[2]	182	358	290

[1] *Oxen inter-row plus hand intra-row*
[2] *The figures are in Tanzanian shillings (Tsh). In 1990 US$ 1 ≈ Tsh 100, but comparison of the treatment returns is more important than the absolute values*
Source: Kwiligwa, Shetto and Rees (1994).

The figures demonstrate the importance of weeding *within* the crop rows for high yields. Inter-row weeding with oxen only is very fast and results in a high labour productivity. However, yield drops considerably. This is undesirable if the area that can be planted is restricted. It could also lead to unsustainable exploitation of resources. As animal traction methods usually cannot control weeds within the rows at an early stage, additional hand weeding is required. Although this assures a normal yield, it affects labour requirement and potential productivity. Therefore methods of animal traction weeding are called for which can handle early weeds *within* the row as well (Loewen-Rudgers et al, 1990, 2000; Stevens, 1994). Only these would remove the drudgery of hand labour effectively. Farmers however can be expected to refrain from such methods for fear of crop damage (Schmitz et al, 1991).

Cattle-keeping farmers have known for some time that the use of animals for draft purposes offers them just the extra labour capacity they need. Weeding with draft animals would seem a fairly simple and easy-to-learn addition to already accepted techniques (plowing, transport). In addition, equipment designs and

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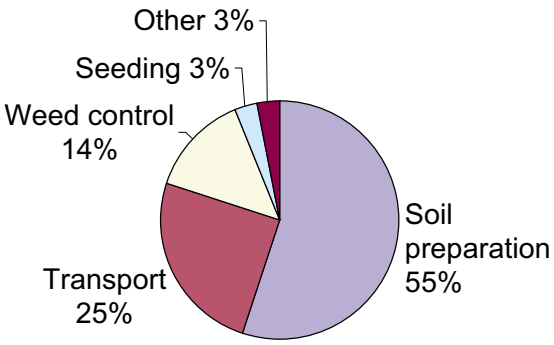
Proportion of animal traction farmers weeding with animals



This chart illustrates the results of a postal survey involving 107 returned questionnaires from 32 countries in Africa, South America and Asia. These revealed that the overall use of animal traction for weed control was low. (Schmitz, Sommer and Walter, 1991).

know-how have been widely available for decades. A manufacturing industry as well as rural repair workshops exist in most countries.

Weeding with donkeys on light soils is a technically and economically attractive option in dry regions (Stevens, 1994).

Lessons and implications

Animal-powered weed control is highly relevant in smallholder farming. Experiences with its promotion highlight the following (Stevens, 1994):

- animal-powered weeding is faster and less back-breaking than hand hoeing
- animal weeding is economic at farm level
- draft animals are little used for weeding
- weeding within the crop row is a real bottleneck.
- available animal-drawn weeders have some technical shortcomings.

Implications

Apparently, farmers can still improve a lot and benefit greatly from animal-powered weeding techniques. Why this is still not taking place on a large scale is not altogether clear. Reasons can be manifold and complex, and each one will be genuine for the farmer concerned. Many reasons have been reported or suggested by people such as Bangura (1988), Lekezime (1988), Ndiamé (1988), Schmitz, Sommer and Walter (1991) Rempel and Townsend (1993),

Reasons for not weeding with animals

Togo *(Lekezime, 1988)*

- planting in rows required
- training of animals to follow rows required
- oxen may eat crop
- long time between plowing and planting, and delayed application of fertiliser gives weeds advantage over crop; weed size makes following the crop lines difficult.

Sierra Leone *(Bangura, 1988)*

- lack of proper row planting due to poorly performing planters
- weeding done by women, while men use the animals and consider weeding a light operation
- traditional mixed farming not favourable for planting in lines.

Senegal *(Ndiamé, 1988)*

- limited availability of weeding equipment (ridging system)
- weeding restricted to experienced horses and donkeys.

Malawi *(Mwinjilo, 1994)*

- no weeder available for ridged plots.

Tanzania *(Rempel and Townsend, 1993)*

- inter-row cultivators unavailable
- reluctance to let oxen into a growing crop
- weeding with oxen requires better training (of oxen and farmer) than for plowing
- farmers are not eager to buy cultivators (the reasons are unknown: perhaps the cultivator design is inappropriate).

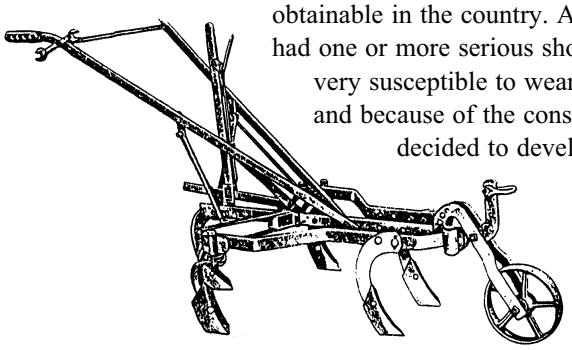
Mwinjilo (1994) and Stevens (1994). The reasons suggested include:

- planting in rows is required, and farmers may lack expertise and/or suitable planters
- animals must be trained to follow crop rows
- farmers fear that animals may eat or damage the crop
- weeding is done by women, but men control the animals and consider weeding a light operation
- limited availability of suitable implements
- farmers lack awareness, information and training.

Despite the proven advantages of weeding with animals, the adoption of animal traction has often stopped at plowing and transport. This suggests that farmers are not completely desperate when it comes to weeding. This

Need for an improved weeder

After extensive tests and field demonstrations of animal-drawn cultivators for weeding, the Palabana Animal Draft Power Development Programme in Zambia concluded that a satisfactory version was not obtainable in the country. Although several makes and types were marketed, all had one or more serious shortcomings. They were either of poor construction and very susceptible to wear and damage, or were not performing well. Therefore, and because of the considerable demand for cultivators, the Palabana team decided to develop a robust cultivator based on an existing design. This design is popular among a large number of farmers, has an excellent performance, but needs constructional adaptations for improved strength and durability (Palabana, 1993).



probably has much to do with timeliness, which is more critical (especially psychologically) at the start of the season. Weeding with animal-drawn equipment is hence more of an option for farmers with room to manoeuvre than a last resort or an imperative need. Whereas plowing enables the farmers to at least produce something, weeding with animals will increase productivity; it can intensify the farming business and be an opening to more flexibility and risk reduction. Animal-powered weeding should be seen as one of the best means currently available for smallholder agriculture to develop from subsistence farming to a profitable and more sustainable venture.

Selecting a suitable type of weeder

Soil and climatic conditions

- humid areas/heavy soils—plow
- sub-humid areas/mediumsoils—ridger
- semi-arid areas/sandy soils—sweep tines

Weed height and infestation

- low—cultivator or sweep tines
- high—ridger or plow

Crop height

- low—cultivator
- high—ridger

Inter-row distance

- large—cultivator
- average—ridger, plow, cultivator
- narrow—ripper, sweep tine

Regularity of inter-row spacing

- low—ridger, one-side-of-row cultivation
- high—inter-row cultivator

Stumps and stones

- many—ridger, plow
- few—cultivator

Conclusions

The above observations have the following major implications.

- there is ample scope for the advancement of weeding with animal traction
- there may be need to provide farmers with the necessary information
- there may be need to stimulate the supply of animal-drawn weeders
- farmers may need to adapt to the improved techniques
- there is some need for improvement in animal-drawn weeder design.

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