Research on weed control using animal power undertaken by the Institute of Agricultural Engineering, Zimbabwe

by

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Abstract

Research on mechanical weed control for small-scale farmers, carried out by the Institute of Agricultural Engineering in Zimbabwe, is discussed. A survey revealed that hand tools and, to a lesser extent, animal-drawn equipment are the predominant means of weed control in the small-scale farming sector in Zimbabwe. Most weeding is carried out by women and children and weed control is a major constraint in crop production.

A literature review indicated that within-row weed control in a maize crop is essential. This implies that weeding systems based on animal draft need to be complemented by within-row hand weeding.

Six weeding implements were tested during the research programme: plow without a mouldboard, cultivator with tines, cultivator with hillers, spring-tine cultivator, sweep-tine cultivator and triple-tine cultivator. The use of these implements reduced the total labour requirement for weeding by 50–70% compared with weeding entirely by hand. The total time required was about 30–70 hours per weeding run per hectare (10–20 hours for animal-drawn weeding and 20–60 hours for additional hand-weeding). During wet seasons weeding generally takes more time. Timing of the operation and overall crop/weed management practices have a significant influence on the total time required for weeding.

Farmers who own a mouldboard plow can adopt animal-drawn weeding quite cheaply. Farmers and rural artisans can play an important role in the development of weeding devices.

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Introduction

A survey was carried out by Agritex (Department of Agricultural, Technical and Extension Services) and the Institute of Agricultural Engineering (IAE) in Zimbabwe in 1990 to look at weeding practices and investigate weeding-related constraints experienced by smallholder farmers. The results of the survey formed the basis for weed-control research at the IAE.

On-station trials were then carried out with the aim of testing various hand tools and animal-drawn weeding implements. The results of these tests are presented in this paper. At the same time an on-farm research programme was implemented with the aim of complementing the findings of the on-station research.

Weed control practices and constraints

The survey was carried out by Agritex extension workers based in various communal areas of Zimbabwe. About 100 questionnaires (78% of the total distributed) were returned to the IAE and subsequently analysed.

It was found that weeding in the smallholder sector was carried out mainly using hand tools and to a lesser extent animal-drawn equipment. Weeding with motorised equipment was virtually unknown and the use of herbicides was limited to fewer than 5% of the farmers (mainly those growing cash crops such as cotton and tobacco). Most of the weeding work was carried out by women and children. Similar findings have been obtained from other African studies (see Figure 1).

Weeding was considered a major constraint in crop production. Most farmers experienced a serious labour bottleneck at weeding time. Extension workers considered that competition from weeds led to major losses and they estimated the yield reduction was over 10%.

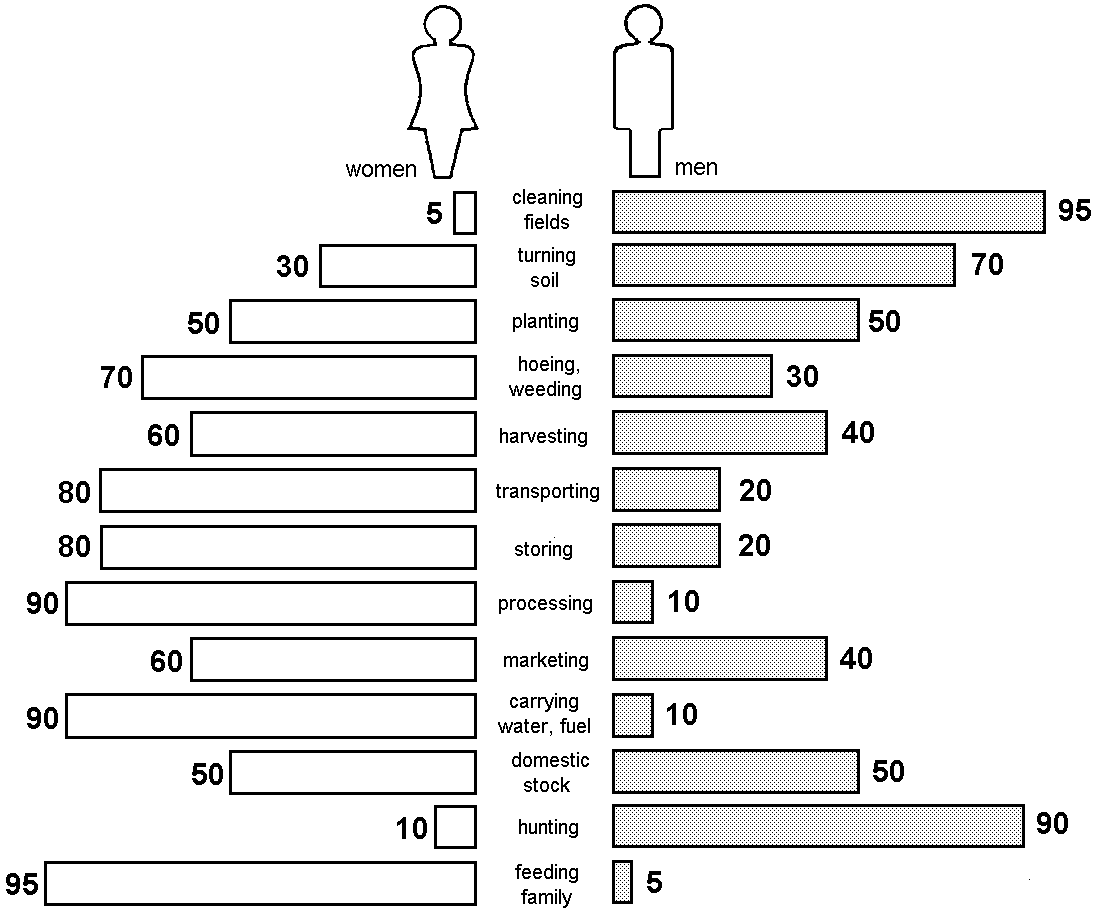

Figure 1: Agricultural labour division (% total labour) between men and women in sub-Saharan Africa (Okigbo, 1989)

In addition to the survey a literature review was carried out to identify relevant research work being undertaken in the region. The literature study underlined the findings of the survey. At the Agronomy Institute in Zimbabwe it was concluded that excessive weed growth is one of the most important factors limiting crop production on small-scale farms within the communal areas of Zimbabwe (Chivinge, 1984). It has been reported that weeding in maize consumed 65% of the time required to produce that crop in Zambia, and 57% in Malawi (Akobundu, 1980). The average time requirement for hand-hoe weeding of a crop was estimated at 140 hours per hectare (FAO, 1990), but wide variations may occur.

It was concluded that there was an urgent need to find means to reduce both the time required for weeding and the yield losses due to weed competition, and IAE began a research programme aimed at achieving these ends.

On-station research

Materials and methods

The survey had indicated the need for research on testing and modifying existing hand and animal-drawn weeding equipment. Herbicides and motorised weeders were considered inappropriate and not cost-effective for small-scale subsistence farmers. Furthermore, from discussions with farmers and extension workers it became obvious that weeding tools and implements to be promoted should not only be effective in weed control, but also fairly cheap, durable, locally repairable and easy to use. The technology related to the use of the implements should be in line with farmers' knowledge levels and aspirations. During the selection of the various cultivators only locally available and/or proven designs were taken into account.

The following animal-drawn weeding implements were selected (see Figure 2):

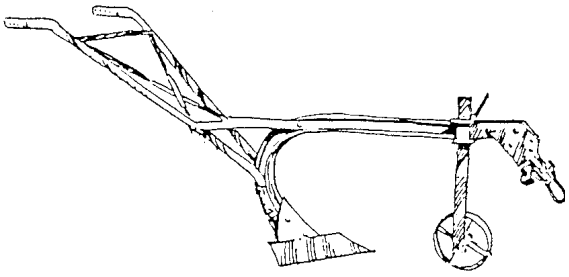

Figure 2a: Plow without mouldboard

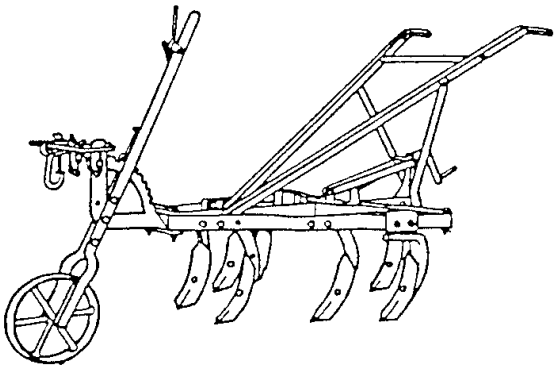

Figure 2b: Cultivator with tines

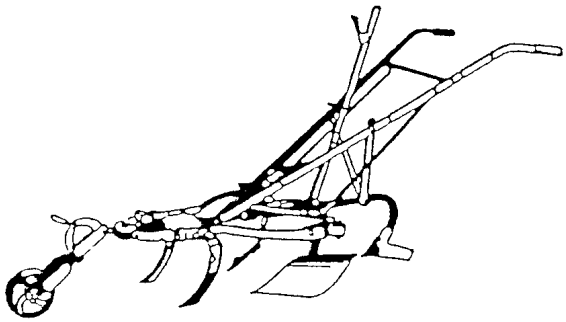

Figure 2c: Cultivator with hillers

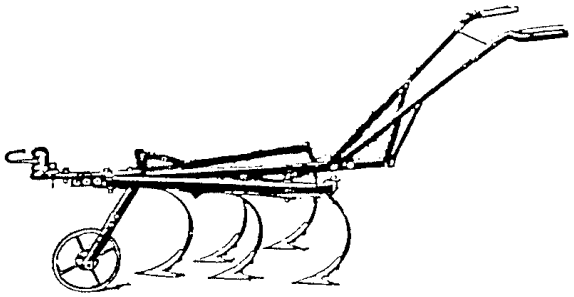

Figure 2d: Spring-tine cultivator

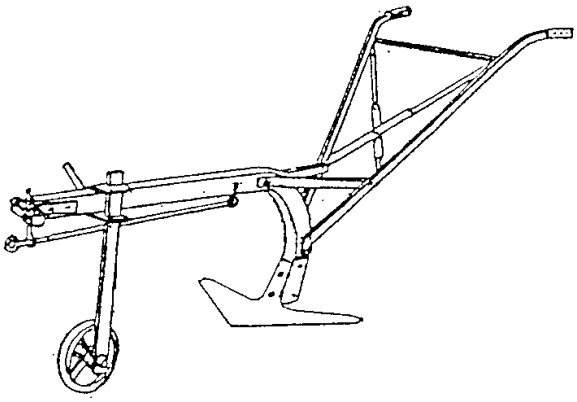

Figure 2e: Sweep-tine cultivator

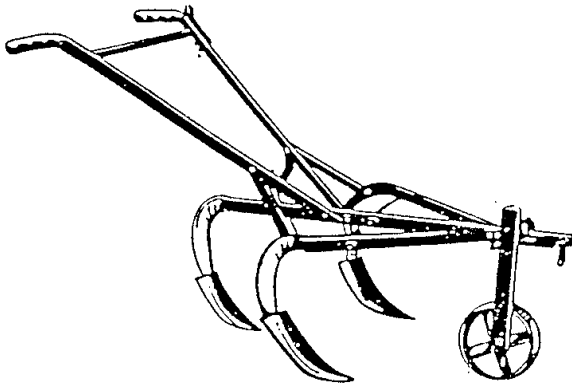

Figure 2f: Triple-tine cultivator

- plow without mouldboard
- light cultivator
- light cultivator with hillers
- spring-tine cultivator
- sweep-tine cultivator
- triple-tine cultivator.

Research in Tanzania (Shetto and Kwiligwa, 1989) and in Zimbabwe (WRT, 1984) revealed that when animal-drawn cultivators are used alone, they do not control weeds effectively. It was found that the control of weeds within maize rows is essential, thus necessitating additional in-row hand weeding or band application of herbicides. It was decided to test the six types of weeders in combination with within-row hand weeding (by traditional hoe). No herbicides were applied.

The on-station research was carried out at the Domboshawa Experimental Fields located 30 km north of Harare in agro-ecological zone 2a at an altitude of 1500 m above sea level. The soil is sandy to sandy loam and of granitic origin. Average rainfall is 700–800 mm per year. The recorded rainfall during the 1991/92 season was 380 mm and during 1992/93 about 800 mm.

Each implement was tested on a rectangular field (60 x 16.2 m) with 18 crop lines. Both maize (hybrid R201) and sunflowers (cv Peredovic) were planted in lines 0.9 m apart, to give a maize density of 30 000 plants/ha and a sunflower density of 40 000–50 000 plants/ha.

Animal weeding was carried out with a standard team of two trained oxen and two

Table 1: Results of weeding trials, 1991/92 season, IAE-Domboshawa, Zimbabwe

	Time for first weeding (h/ha)			*% weeds killed*	*Time for second weeding (h/ha)*			*% weeds killed*	***Total time (h/ha)***	*Mean % weeds killed*	*Yield (kg/ha)*
	Oxen	*Hand*	*Total*		*Oxen*	*Hand*	*Total*				
Plow without mouldboard											
Maize	16.8	20.6	37.4	89	20.2	25.0[1]	45.2	70	**82.6**	79	2300
Maize	18.5	17.5	36.0	90	17.5	22.6	40.1	62	**76.1**	76	2200
Sunflower	19.2	34.8	54.0	93	21.3	27.6	48.9	77	**102.9**	85	1290
Light cultivator											
Maize	8.9	36.0	44.9	83	9.3	25.0[1]	34.3	92	**79.2**	87	1500
Sunflower	9.3	18.0	27.3	88	11.3	23.8	35.1	80	**62.4**	84	1070
Light cultivator with hillers											
Maize	10.3	20.6	30.9	75	11.0	25.4	36.4	62	**67.3**	69	2400
Sunflower	11.0	31.2	42.2	91	12.0	21.4	33.4	80	**75.6**	86	1200
Spring-tine cultivator											
Maize	8.9	25.7	34.6	89	10.3	25.0[1]	35.3	69	**69.9**	79	2000
Maize	9.3	40.1	49.4	62	11.3	24.6	35.9	68	**85.3**	65	1600
Sunflower	10.3	18.0	28.3	87	12.0	25.7	37.7	71	**66.0**	79	1030
Sweep-tine cultivator											
Maize	16.0	38.5	54.5	93	18.8	25.0[1]	43.8	80	**98.3**	86	2300
Triple-tine cultivator											
Maize	8.6	39.0	47.6	76	11.3	28.8	40.1	74	**87.7**	75	1800

1) Estimated value

Table 2: Results of weeding trials, 1992/93 season, IAE-Domboshawa, Zimbabwe

	Time for first weeding (h/ha)			*% Weeds killed*	*Time for second weeding (h/ha)*			*% Weeds killed*	***Total time (h/ha)***	*Mean % Weeds killed*
	Animal	*Hand*	*Total*		*Animal*	*Hand*	*Total*			
Plow without mouldboard										
Maize	22.5	50.1	72.6	85	18.5	48.5	67.0	89	**139.6**	87
Light cultivator with hillers										
Maize	13.3	56.5	69.8	92	12.8	40.2	53.0	91	**122.8**	92
Sweep-tine cultivator										
Maize	22.0	56.2	78.2	80	18.3	33.6	51.9	84	**130.1**	82

men, one guiding the oxen and the other controlling the implement. Hand weeding was carried out with a traditional hoe.

The work rates recorded during the research are shown in Tables 1 and 2. The times shown do not include time spend on collection of the animals, harnessing, transport to the field, etc, but do include time for resting, turning at headlands and repair/adjustment time.

A weed count (not biomass assessment) was carried out shortly before and after the weeding operation (implement + hand). A counting frame (62 x 30 cm) was used and eight counts were carried out per treatment. Yields were recorded by taking four samples per treatment.

Results

The 1991/92 season was extremely dry and weed growth was less prolific than usual. Thus hand-weeding time was fairly low compared with the 1992/93 season. Satisfactory weed control was achieved with all treatments. In adjacent fields weeding completely by hand

required about 200–300 working hours per hectare, depending on weed infestation and soil moisture content. The introduction of animal-drawn weeders reduced the weeding time to 60–130 working hours per hectare, a reduction of 50–70% (excluding off-field time requirements for harnessing, feeding, care, etc).

Weeding efficiency can be defined as the number of weeds per unit area destroyed divided by number of weeds per unit area present before operation x 100 (RNAM, 1983). In the trials, this averaged about 75–85%, although there was substantial variation. The weeding requirement for maize was about 45% of the total cropping labour requirement.

The plow without mouldboard and the sweep-tine cultivator had to make two passes for every row: the other implements required only one pass. Weeding time with the former two implements was thus roughly double that with the other cultivators (18–20 versus 9–11 hours per hectare). The time requirement for additional hand weeding varied between 17 and 60 working hours per hectare. In general additional hand weeding (within-row weeding) doubled or even trebled the required weeding time compared with implement weeding alone. Climate has a dramatic influence on within-row weeding times: in dry years two weeding runs are considered sufficient, while in wet years three weeding runs might be necessary.

The timing of the weeding operation was seen to have a considerable influence on the effectiveness, and labour requirement, of the operation. During the first six weeks after germination of the maize crop weeds are very competitive. It was found that three weeks after germination there were on average 55 weed plants for every maize plant.

It is interesting to note that satisfactory weed control was achieved with all treatments. If farmers own a plow, they can easily and cheaply modify it into a weeding implement (eg, by removing the mouldboard or attaching a sweep tine). Removing the mouldboard will require the purchase of a spanner and some bolts and nuts (US$ 5–10), while buying the sweep tine attachment and spanner is expected to cost US$ 25–35. Purpose-built cultivators cost about US$ 60–100.

It is argued that introducing animal-drawn weeding, in a situation where draft animals and a mouldboard plow are available, requires little additional investment.

On-farm research

During the on-farm research the IAE teamed-up with local Agritex extension officers and a regional rural development project. During field days discussions were held with farmers and a number of weeding tools and implements were demonstrated. The participating farmers, mostly organised in groups, expressed interest in obtaining and using some of the demonstrated equipment. In consultation with local counterparts the IAE decided to provide some of the selected tools and implements for on-farm testing and evaluation.

At the same time the IAE was involved in a programme aimed at upgrading the skills of local artisans, focusing on the production and repair of agricultural equipment.

The on-farm research yielded information on the appropriateness and acceptability of the implements, but also provided the IAE with specific suggestions for modifications. These suggestions were incorporated in the later models. More important, however, was the fact that farmers decided to discuss the production and modification of some of the hand tools with rural artisans. As a result local variations of introduced tools were developed.

It appears that the production of the sweep tine, and in general most animal-drawn equipment, does not match the level of production facilities available to local artisans. This heavier type of equipment requires a more industrial environment for its production. Bridging the distance between farmers and industrialists is considered an important element in the production of appropriate equipment that addresses farmers' needs. If one goes beyond the technology transfer objective and aims at strengthening the innovative capacity of producers and users, 'full-fledged' participation may be the only way (van der Bliek and van Veldhuizen, 1993).

Transfer of weeding technology and local technology development

One of the problems facing the IAE and many other research institutions in their developmental work is the fact that they generally have neither the means nor the mandate to market their own innovations. In this respect a World Bank report states; "the process of adaption and innovation of agricultural equipment can best be fostered by the private sector" (Binswanger, 1987). "The

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emphasis both in research and in extension [related to animal traction] should be on the exchange and on-farm testing of equipment already fully accepted by farmers in similar environments" (Starkey, 1986). In general it is considered that research and extension organisations should concentrate their efforts on providing an enabling environment for technology development and technology transfer to take place.

The major actors in the development of agricultural equipment are manufacturers, rural artisans and metal workshops and farmers. Agritex and the IAE have made efforts to facilitate contact between these entities, not only during field days, agricultural shows, workshops and conferences, but also by providing information via extension services, radio broadcasting, brochures and catalogues. The IAE fosters links with manufacturers by providing them with designs and technical expertise, and is also involved in a training programme for rural artisans. Initiating interactions and enhancing the links between the various actors in a participatory manner is considered by the IAE an important element in achieving sustained agricultural mechanisation.

Conclusions

The IAE carried out a comparative test of six animal-drawn cultivators. It was concluded that animal-cultivator weeding has to be complemented by within-row (hand) weeding in order to achieve acceptable weed control.

The cultivators reduced the labour hours required for weeding by 50–70% compared with hand weeding alone. The time required per weeding run for animal-drawn weeding varied between 10 and 20 hours per hectare, while additional (in-row) hand weeding varied between 20 and 60 hours per hectare. During wet seasons more time was generally needed for weeding.

From the experiments, it was difficult to select the best animal-drawn weeder. The light cultivator, the light cultivator with hillers and the spring-tine cultivator seemed to require the least labour. The plow without mouldboard and the sweep tine was the cheapest option for farmers who already possess a plow.

It was observed during the trials that the timing of the operation and the management practices of the farmers had a marked influence on the time required for weeding. In a hand-weeding trial overall weeding time increased by 40%, if the weeding operation was postponed by two to three weeks.

In collaboration with farmers, weeding tools and implements were tested on-farm. This has led to farmer-initiated design modifications and participation of rural artisans in the development and manufacturing process.

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