Weed Control Systems in Maize Based on Animal Drawn Cultivators

R.M. Shetto* and E.M. Kwiligwa*

Abstract

The concept behind carrying out the weed control experiment was to develop an effective and economical weeding system based on animal drawn cultivators. Nine weeding systems were evaluated. Results from the study show that there is no difference in field capacity between the Cossul interrow cultivator and the MOP over the row cultivator. The use of animal drawn cultivators and herbicides reduced the labour input in the hand hoe weeding system by 90% and 96% respectively. However, the use of the cultivators alone failed to control weeds effectively, leading to a 44% yield reduction in maize. Weeds were more effectively controlled when these cultivators were supplemented by the hand hoe or herbicide, and yield increases of 35% were recorded. Still there was a saving in labour input of 55% for the hand hoe supplemented treatments and a 92% saving for the herbicide supplemented treatments. Generally weeding systems which controlled weeds effectively resulted in higher maize yields and consequently higher returns; although the more expensive systems such as the use of herbicides alone reduced the gross profit.

Introduction

Weeds have been a problem to man ever since he began cultivating crops about 10,000 BC (Hay 1974). They compete with crops for water, soil nutrients, light and space and thus reduce crop yields. Sankaran and Mani (1972) reported that in the first 35 days after sowing sorghum, weeds removed from the soil 46.1, 18.3, and 47.7 kg of N, P and K per ha respectively, while the crop could take up only 23.8, 9.4 and 46.8 kg/ha of N, P and K respectively. Similarly, Rao (1983) noted that weeds can deprive the crop of 30-50% of the applied nutrients and 20–40% of the soil moisture. It has been further observed that good crop husbandry practices such as use of fertilisers, good seed varieties, appropriate plant populations and insect/disease control measures rarely increase yields if weed control is not improved simultaneously (Ackland 1971; Allan 1968; Armitage and Brook 1976; Carson 1987; Compton 1982; Croon et al. 1984). A combination of fertiliser use and three hand hoe weedings has increased yields of maize by about 70-90% in the Southern Highlands of Tanzania (Annual Research Report 1972/73, 1973/74, 1974/75). Croon et al (1984) and Rain (1984) noted that poor weeding is the biggest constraint to maize production in the Southern Highlands of Tanzania.

*Uyole Agricultural Centre, Mbeya, Tanzania.

Yield losses due to weeds are less dramatic to the eye as compared to other causes like insects and diseases. However Rao (1983) showed that of the total annual loss of agricultural produce in India, weeds accounted for 45%, insects 30%, diseases 20% and other pests 5%. Table 1 shows that the yield losses from weeds alone in Africa is almost equal to that caused by pests and diseases combined.

Yield losses estimates due to weeds vary considerably world wide depending on the weed species, intensity of weed population, competitive ability of the crop, duration of weed infestation, soil fertility, climatic conditions, edaphic and management factors (Ali et al. 1984; Kondap et al. 1980; Minjas and Jana 1983; Rao 1983). Yield losses due to weeds in maize range between 20-100% in the Philippines, Brazil, America, Gambia, Sierra Leone and Nigeria (Carson 1987; Choudhary and Lagoke 1981; McEwen and Stephenson 1979; Pamplona and Imlan 1977; Starkey 1981). In Tanzania Mugabe et al. (1980) reported a loss of 61.4% in Morogoro, while losses of 70–90% were observed in the Southern Highlands (Annual Research Report 1972/73, 1973/74, 1974/75, 1988/89). Thus it can be observed that the problem of weeds in Tanzania, as elsewhere in the world, is high. Among the principle weed species in Tanzania, seven have been reported

Table 1. Estimated production losses of major cereal crops caused by weeds, pests and diseases in Africa as compared to the world average.

	% Losses due to weeds		% Losses due to pests and diseases	
Crop	Africa	World	Africa	World
Maize	35.0	13.0	36.0	21.8
Rice	13.5	10.8	20.2	35.6
Wheat	15.0	9.8	24.0	14.1
Sorghum/Millet	25.0	17.8	20.0	20.2

Source: Crammer 1976.

to be among the ten worst weeds in the world (Minjas 1978).

Apart from yield losses, weeds harbour insects and pests while some of them are allelopathic and hence harmful to the crop, human beings and livestock. Other losses due to weeds include increases in expenditure on labour and equipment in their eradication, rendering harvesting difficult and reducing the quality and marketability of agricultural produce.

Hand hoe weeding when done timely twice or thrice, or the use of herbicides have controlled weeds effectively in maize (Ackland 1971; Annual Report 1974/75, 1988/89; Fletcher 1983; Fryer 1981; Mathews 1984; Ogborn 1975; Terry 1984; Zimdahl 1983). However, for the smallholder farmer in the tropics, herbicides may be quite expensive. The lack of appropriate application equipment and technical know how may be limiting and sometimes there may be toxic effects to life and the environment. On the other hand, the use of the hand hoe is time-consuming, back-breaking and expensive too especially where labour is scarce. In the hand hoe system, weeding alone accounts for 40-54% of the total labour input in farming in Ghana, Nigeria, Upper Volta, Sierra Leone, Malawi, Zambia, Ethiopia and Tanzania, requiring 300-400 man- hours per hectare (Akobundu 1980; Annual Research Report 1985/86, 1986/87, 88/89; Starkey 1981). In most cases due to limitations on family labour, farmers are unable to do their weeding in time. A survey of 320 farmers in 20 villages in Mbeya region, Tanzania, showed that almost 90% of the farmers begin weeding when the maize crop is 30-45 cm and late weeding was mentioned as one of the main constraints to increased crop production (Loewen-Rudgers et al. 1988).

Thus the objective of this study was to develop effective and economical weed control methods based on animal drawn cultivators to reduce the labour requirement and alleviate drudgery of the hand hoe weeding system. An experiment was conducted at the Uyole Agricultural Centre in the Southern Highlands of Tanzania.

Tanzania has a population of about 23 million people out of which 80-90% depend on agriculture. There are 2.25 million farm families cultivating 6.2 million ha of the 39.5 million arable ha. The total land area is about 89 million ha (Croom 1982; Economist Intelligence Unit 1987). The major food crops are maize, paddy, wheat, sorghum/millets, pulses, cassava, bananas and potatoes. The cashcrops include coffee, cotton, tea. tobacco, pyrethrum, sisal and cashewnuts. More than half of the Tanzanian farmers produce maize which is the major staple food. The maize production stands at about 1.3 million tonnes annually. The national cattle herd is about 12.3 million, out of which 600,000 – 800,000 are oxen. These are employed for draught work, ploughing 12-15% of the total cultivated land (Tanzania National Agricultural Policy 1982) . Oxen are extensively used for ploughing and to a limited extent for transportation using wooden sledges and a few wheeled ox carts. The use of animals in weeding is negligible, although the Cossul interrow cultivators had been introduced within the country as early as the mid-60s.

Materials and Methods

A field experiment was conducted at the Uyole agricultural centre in 1988/89 season on a young volcanic gravelly silt loam soil of pH 6.5. The total rainfall in the 1988/89 season was 1363 mm (Table 2) falling between October and May. The site ia at an altitude of 1800 m.

The important weed flora during the growing season comprised *Nicandra physalodes, Sommelina benghalensis, Galinsoga parviflora, Eleusine indica and Digitaria spp.* The treatments included 9 different weeding regimes, replicated 3 times in a randomised complete block design, which included

Table 2. Monthly rainfall, temperature and wind speed at Uyole in 1988/89 season.

	Rainfall			Temp.		Pan	Wind
Month	1988/89 (mm)	No of days it rained	30 years Average (mm)[1]	Max Mean	Min Mean	Evap.1 (mm)	Speed (km/hr)
Aug.	Nil	Nil	2	24.0	8.4	192	6.3
Sept.	Nil	Nil	3	25.8	9.6	240	5.2
Oct.	36.2	5	14	26.9	11.9	233	10.2
Nov.	83.4	8	50	24.9	12.5	180	7.4
Dec.	232.4	21	143	24.0	12.5	155	7.4
Jan.	226.4	25	195	22.4	12.8	121	4.5
Feb.	133.2	16	165	23.1	12.8	182	4.2
March	237.6	22	161	23.7	12.1	124	4.6
April	320.8	17	118	22.2	11.9	129	5.4
May	92.5	7	17	22.1	9.9	121	5.1
June	0.5	Nil	Nil	21.4	6.7	131	6.0
July	Nil	Nil	Nil	21.4	5.7	159	6.7
Total	1363.0		868				

1. Recorded at Mbeya Airport, about 9 km from Uyole.

an unweedy check. The plot size was 30m x 3m with five rows each. Primary tillage was done by using a single furrow mouldboard plough pulled by oxen, while harrowing was done by using a hand hoe and rope at a spacing of 75 cm x 30 cm. Two seeds were planted per hole and later thinned to the recommended plant population. Two types of fertilisers were applied: Triple super phosphate (P_2O_5) at 20 kg P/ha at planting time and calcium ammonium nitrate 26% N at 100 kg/ha split application. Endosulfan (Thiodan) was sprayed to control stalkborer *(Busseola fusca)*. The 10 weeding regimes tested were the following:

- No weeding (NW)
- Weeding with hand hoe 10-15cm, 45 and 90 cm of maize height (HH).
- Weeding with Cossul interrow cultivator at 10–15 cm followed by hand hoe in maize rows, Cossul cultivator at 45 cm again followed by hand hoe, and ridging at 90 cm of maize height (CH).
- Weeding with Cossul interrow cultivator at 10–15, 45 and ridging at 90 cm of maize height (CC).
- Weeding with hand hoe at 10–15 cm and mouldboard plough at 45 cm of maize height (HP).
- Preemergence herbicide (Gesaprim), Cossul interrow cultivator at 45 cm and ridging at 90 cm of maize height (GC).
- Weeding with MOP over the row cultivator at 10-15 cm, MOP cultivator at 45 cm and ridging at 90 cm of maize height (MM).
- Preemergence herbicide (Gesaprim), MOP cultivator at 45 cm and ridging at 90 cm of maize height (GM).
- Weeding with MOP over the row cultivator at 10-15 cm followed by hand hoe, MOP cultivator at 45 cm followed by hand hoe and ridging at 90 cm of maize height (MG).
- Preemergence herbicide (Gesaprim) and postemergence herbicide (Gramoxome) at 90 cm of maize height (GG).

Herbicides were applied at the recommended rate for the southern highlands of Tanzania. The preemergence herbicide applied was an atrazine (Gesaprim) at a rate of 5 l/ha while paraquat

(Gramoxome) at 2.5 l/ha was used as a post emergence herbicide. Atrazine was applied within 2-4 hours after planting and paraquat was applied at 90 cm height. Spraying was done by using a lever hand operated knapsack sprayer with a fan type nozzle in 200 L/ha of water. Mechanical weeding either by hand or draught animals was carried out at the stipulated plant height. Two animal drawn cultivators were used, i.e. the Cossul interrow cultivator and the MOP over the row cultivator. During each operation the starting and finishing time was recorded, as was the number of people involved. A 0.25m^2 quadrant was used to assess the weed infestation. The quadrant was thrown randomly in each plot and all the weeds harvested within the frame. Two samples were taken in each plot. Weed harvesting was done at 65days after planting. Based upon the costs of herbicide, hand hoe labour and animal drawn cultivators, the total cost for weed control for each weeding regime in the experiment was calculated. Finally, yields for each treatment were recorded. In each plot maize was harvested on the two middle rows. Four samples were taken each, one metre long. Prior to harvesting the total number of plants and cobs to be harvested was recorded. The results were analysed statistically.

Results and Discussion

Weeding using an ox plough gave the lowest field capacity (Table 3). This is because two interrow passes are required for effective weed control. There was no marked difference in field capacity between the Cossul interrow cultivators and the MOP over the row cultivator. For both cultivators higher field capacities were recorded at 45cm maize height. This is probably because the animals could move easily and quickly in well established rows of maize.

The use of herbicides decreased the weeding labour requirement in the hand hoe system by 96% while the animal drawn cultivators reduced the labour input by about 90% (Table 4). When the animal drawn cultivators are supplemented by either herbicide or hand hoe the reduction is 92% and 55% respectively. Akobundu (1980) reported a labour reduction of 97% when herbicides were used in controlling weeds in maize in Nigeria. Starkey (1981) working in Sierra Leone reported a 35% saving in labour when ox weeding was supplemented with hand hoe in maize, an 81% reduction in groundnuts and 52% in cowpeas.

The weeding systems involving combinations of herbicides and animal drawn cultivators (GC and GM) gave the lowest weed fresh weight biomass (Table 5). However, it was not significantly different to that of the hand hoe (HH) and herbicide alone (GG). The same trend was observed by Bridgemohan (1989). Treatments involving animal drawn cultivators which were not supplemented by either hand hoe or herbicide (CC and MM) gave a high weed biomass, although the differences were not significant with the treatments which were supplemented by the hand hoe (CH and MH).

Chemical weed control (GG) gave the highest yield (table 6), but it was not significantly different to either the hand hoe system or treatments of animal drawn cultivators when supplemented by the hand hoe or herbicide i.e. CH, GC and GM (Miller et al. 1980).

It should be noted that the hand hoe system (HH) did not significantly outyield the animal drawn cultivators treatments CH and MH (Fisher et al. 1980; Pamplona and Imlan. 1977; Santos et al. 1980). However, the use of animal drawn cultivators alone (CC and MM) recorded significantly low yields. There was a yield reduction of about 35% and 44% compared to the supplemented treatments and pure hand hoe system respectively. Probably this is because of poor weed control within the maize rows. Numerous researchers have reported similar yield reductions in maize. Among them are Fisher et al. (1980) who reported a reduction of 26%, Pamplona and Imlan (1977) a reduction of 23%, Scolari and Young (1977) a reduction of 36% and Thomas and

Table 3. Average effective Field capacity (EFC) for animal implements in the various weeding systems.

	EFC ha/h									
Weeding height	NW	HH	CH	CC	HP	GC	MM	GM	MH	GG
10–15 cm	–	–	0.15	0.15	–	–	0.15	–	0.17	–
45 cm	–	–	0.18	0.15	0.09	0.15	0.18	0.18	0.18	–
90 cm (Ridging)	–	–	0.14	–	0.14	0.14	0.15	0.15	0.14	

Table 4. Labour input for the various weeding systems.

Weeding system	Oxteam hours/ha	Ox-operator man-hours/ha	Handhoeing[1] man-hours/ha	Total Labour man-hours/ha
UN				
HH			413	413
CH	19	38	153	191
CC	20	40	–	40
HP	11	22	185	207
GC	13	26	8	34
MM	19	38	–	38
GM	12	24	7	31
MH	19	38	145	183
GG	–		14	14

1. Represents spraying man-hours for GC, GM and GG treatments.

Allison (1975) a reduction of 22–46%. They suggested, to improve further weed suppression and crop yields, animal drawn cultivators should be combined with herbicide or hand hoe.

The use of herbicides increases tremendously the operational costs (Table 7). The results show that it is even cheaper to weed by hand hoe than using chemicals. However, the weeding regimes which gave the highest yields also had the highest gross profits as indicated in Table 8.

Conclusion.

It seems essential to control the weeds within the maize rows if yields are to be maximised. The use of animal drawn cultivators reduces tremendously the labour input in weeding. However, when these cultivators are used alone, they do not control weeds effectively and hence record reduced yields. Thus supplementing animal drawn cultivators with hand hoe or herbicide is essential. Systems which controlled weeds effectively resulted in higher maize yields and subsequently higher returns.

This information, however, is based on one season's data. Further work is required to confirm these findings. Moreover, research emphasis should be on design of cultivators, frequency of cultivation and good land preparation with a goal of reducing supplementation of the animal drawn cultivators.

Table 5. Weed Fresh weight under different weed control methods.

Weeding system	Weed biomass (gm/m^2)
UN	642.9
HH	202.3
CH	271.6
CC	423.3
HP	307.0
GC	99.9
MM	365.0
CM	100
MH	276.8
GG	139.2
LSD 5%	168.4

Table 6. Yield of maize under different weed control methods.

Weeding system	Plant Population	Yield tonnes/ ha
UN	44919	0.6
HH	44030	6.2
CH	43758	5.9
CC	44032	3.6
HP	43908	4.8
GC	44464	5.9
MM	44007	3.4
GM	44418	5.0
MH	44385	4.8
GG	44028	6.4
LSD 5%		1.5

Table 7. Operational costs in weeding for the varius systems.

Weeding system	Oxteam hours/ha	Handhoeing man-hours/ ha	Implement use cost 1 TShs/ha	Herbicide cost TShs/ha	Labour cost TShs/ha	Total cost TShs/ha
UN						
HH		413	72.0		3713.00	3785.00
CH	19	153	1212.0		1377.00	2589.00
CC	20		1200.0			1200.00
HP	11	185	754.0		1665.00	2419.00
GC	13	811	48.0	5000.00	72.00	6220.00
MM	19		1140.0		1140.00	
GM	12	7	1042.0	5000.00	63.00	6105.00
MH	19	145	1212.0	1305.00	2517.00	
GG		14	644.0	7200.00	126.00	7970.00

1. Implement use cost includes: Fixed cost hand hoe =72.00/ha, Fixed cost for cultivator =2.00/hr; fixed cost for plough =4.00 hr. and the ox team cost (1 pair +2 operators) is 58.00/hr. Costs based at Uyole Institute for 1988/89 season.

Source: Annual Research Report 1988/89.

Table 8. Comparison of costs and profits in maize production under the different weeding methods.

Weeding system	Yield kg/ha	Revenue TShs/ha[1]	Total weeding Cost TShs/ha.	Gross Profit TShs/ha[2]
UN	0.62	6820.00	0.00	6820.00
HH	6.20	68200.00	3785.00	64415.00
CH	5.93	65230.00	2589.00	62641.00
CC	3.63	39930.00	1200.00	38730.00
HP	4.83	53130.00	2419.00	50711.00
GC	5.87	64570.00	6220.00	58350.00
MM	3.40	37400.00	1140.00	36260.00
GN	5.00	55000.00	6105.00	48895.00
MH	4.80	52800.00	2517.00	50283.00
GG	5.37	70070.00	7970.00	62100.00

1. The cost of maize is TShs. 11.00/kg

2. Excludes all other costs e.g. inputs, land preparation and insect control. Land preparation cost: 2095.00/ha and inputs =7390.00/ha*

* Thus gross profit obtained by subtracting 9485.00/ha from each system.

Source: Annual Research Report 1988/89.

Résumé

Des essais de lutte contre les mauvaises herbes ont eté réalisés afin de mettre au point un système efficace et économique de désherbage fondé sur l'utilisation de cultivateurs à traction animale. Neuf systèmes ont été évalués. Il ressort des résultats des essais qu'il n'existe pas de différence de capacité au champ entre les terrains désherbés au moyen de cultivateurs types Cossul et MOP travaillant en interlignes et de la bineuse à plusieurs rangs. L'utilisation d'une sarcleuse à traction animale et de produits herbicides a permis une réduction de 90% et de 96% respectivement de la main-d'oeuvre requise pour le sarclage à la houe à bras. Toutefois, l'utilisation du seul cultivateur ne permettait pas un désherbage efficace et se traduisait par une perte de rendement du maïs de 44%. L'utilisation combinée du cultivateur et de la houe à bras ou d'herbicides permettait une meilleure lutte contre les adventices, entraînant des augmentations de rendement de 35%. Par ailleurs, les traitements complétés par un binage manuel ont engendré une réduction de 55% des besoins en main-d'oeuvre, et ceux complétés par l'application d'herbicides, une réduction de 92%. D'une manière générale, les systèmes autorisant une lutte efficace contre les mauvaises herbes conduisaient à une augmentation des rendements du maïs et donc à un accroissement des revenus, encore que les plus coûteux d'entre eux, tels ceux fondés sur la seule utilisation d'herbicides, faisaient tomber les bénéfices bruts.

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