Cotton [*Gossipium hirsutum*] and maize [*Zea mays*] yield losses due to weeds in Muzarabani, Zimbabwe.

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Abstract

In an experiment to assess the weed-flora and the effect of additional weeding on *Gossipium hirsutum* (*L.*) (cotton) and *Zea mays* (*L.*) (maize) yields in Muzarabani, paired plot experimentation on farmers' fields was used. One of the plots was farmer managed while the other was researcher managed. The participatory approach was used to select the farmers from the four different resource groups in the area. A comparative analysis was done on the weed flora and crop yields for farmer managed and researcher managed plots. A partial budget was used to analyse the effects of extra weeding. The following weed species were common to all sites *Ocinum canum* (*L.*,) (Wild basil), *Trichodesma zeylanicum* (Burm.f.) (Late weed), *Eragrostis aspera* (Jacq) Nees (Rough love grass), *Cochorus olitorius L.*, (jute) and *Ceratotheca sesamoides* Endl. Extra weeding in cotton and maize plots increased yields by 52 and 117 kg/ha, respectively. Economic benefits of additional weeding were greatest for households with average resources as indicated by the marginal rate of return (Z$ 1.4 and Z$ 1.1) for maize and cotton, respectively. It can be concluded that extra weeding is beneficial for an average resource endowed household particularly for maize. It can be recommended that weed management for the average resourced farmers, can be improved and labour costs reduced by use of band application of pre-emergence herbicides.

Keywords: cotton, maize, weed flora, yield loss

Introduction

Maize and cotton are both important cash crops grown in Muzarabani, however, the yields have been quite low averaging 1 t/ha and 0.7 t/ha for cotton and maize, respectively (Agritex, 1989). Participatory rural appraisals in Muzarabani identified excessive weed growth as a major problem limiting yield per unit area and the total area cultivated (Chatizwa et al., 2000). Weeds have been reported to be notorious yield reducers that are, in many situations, economically more important than insects, fungi or other pest organisms (Savary et al., 1997).

Weeds compete with crops for nutrients, soil moisture and sunlight (Zimdhal, 1980). As a result weeds can cause 15 - 90 % crop losses (Maina, 1997). Most of the farmers in Muzarabani are unable to control weeds efficiently on all their cotton land during the critical period. Most smallholder farmers use an ox-cultivator and ox-plough for weeding but amongst the poorer groups a hoe is used which is very labour intensive. Hoe weeding requires 200 - 400 person-hours/ha to weed (Mashingaidze and Chivinge, 1995). Farm labour is also both expensive and scarce during peak periods of crop growth. This leads to poor weed control which results in substantial crop losses (Chui, Kahumbura and Kusewa, 1997). Some farmers end up abandoning more than 20 % of their crop area because of weeds (Ellis-Jones et al., 2001).

Most farmers in Muzarabani face an acute labour constraint, which is seasonal. This constraint affects the timeliness of weed control, especially during the initial stages of crop growth. Yet this is the stage when weeds cause great crop loss than later in the season (Keely, Thullen and Carter, 1986). This study was therefore developed to assess the yield losses farmers are incurring due to weeds because there has not been any quantification of yield losses caused by weeds in Muzarabani under farmer conditions. Studies have been done elsewhere to determine yield losses in maize and cotton but yield losses are variable among locations (Cowan et al., 1998 and Jasieniuk et al., 1999). The objective of this study was to assess the weed flora in Muzarabani and the level of yield losses caused by these weeds in cotton and maize for households within different economic starta.

Materials and methods

Study site

The study was carried out in 3 villages (Gutsa, Muringazuva and Mufudzi) in Muzarabani District (S16°20' E31°15'). The area is characterised by deep alluvial loam to clay soils that are derived from sandstone and quartzite. Mean annual rainfall is 450-650 mm, periodic seasonal droughts and severe dry spells characterises the rainy season. Temperatures are usually high, mean temperature 21 °C and a maximum of 40 °C during the crop-growing season.

Sampling, Data Collection and Analysis

During the 1999/00 season, stratified sampling (household resources endowment) was used to select a total of 12 farmers growing maize (4 farmers in each of Gutsa, Muringazuva and Mufudzi) and 15 farmers growing cotton (5 farmers in each of Gutsa, Muringazuva and Mufudzi), to participate in the study to determine the potential yield gains obtainable from improved weeding. Participating farmers were selected during focus group discussions from four different resource categories as shown in Table 1.

Table 1: Resource groups (RG) of farmers in Muzarabani

Indicator	RG1 Well resourced	RG2 Average resourced	RG3 Poorly resourced	RG4 Very Poorly resourced
Size of arable land	4.86 ha plus Borrows extra land from farmers who can't utilize all their land	4.86 ha	4.86 ha Land sometimes lent to others	0-2.2 ha
Livestock				
Cattle	>20	5-15	Nil	Nil
Goats and sheep	>30	5-15	Nil	Nil
Poultry	Plenty	Many	A few	Nil
Implements	Tractor, full range of implements	Full range of animal drawn implements	Hoe, sprayer	Hoe only
Yields achieved				
Cotton (bales)	>20	5-15	0-4	0-1
Maize (bags)	>20	5-20	1-5	1-3
Groundnuts (bags)	>10	10	1-5	1-3
Labour utilization	Hires labour and permanent workers	Hires labour Works for others	Hires out labour Nil	Hires out labour
Other Business	Larger stores	Some small stores	1-2 meals per day	Nil
Food consumption	>3 meals per day	2-3 meals per day	20-30 %	1 meal per day
% Households in each category	5-10 %	30-50 %		10-20 %

Two plots (35 x 10 m) were marked out in maize and cotton stands planted and managed by farmers. Participating farmers weeded the farmer-managed cotton plots 4-6 times and therefore kept the farmer managed plots virtually weed-free similar to the weed free treatment. For maize, farmers weeded the crop an average of only once. On farmer-managed plots the farmer determined the timing and frequency of weeding while the second was kept weed free throughout the season by hand hoe weeding. Weed species abundance was recorded in January in five random square metre quadrants across four farmer-managed fields in each of three areas, which were selected according to the different soil types and period of settlement. Weed counts were square root ($(x+1)^2$) transformed prior to analysis using analysis of variance (ANOVA). Genstat statistical package version 8 (Windows) was used to analyse the data.

Labour costs of extra weeding, above that undertaken by the farmer to keep the clean weeded plots weed-free throughout the season, were recorded and used to calculate the marginal return to the extra weeding. The labour was calculated from cost of weeding per hectare. Net return was calculated by subtracting total costs from gross returns per hectare. Marginal rate of return was calculated as net return divided by total costs for extra weeding. Maize and cotton yields were subjected to analysis of variance. Maize yield was adjusted to 12.5 % moisture content, the moisture content for dry maize in Zimbabwe. Farms were used as blocks in a factorial ANOVA, with the two factors being site (three sites of Gutsa, Mufudzi and Muringazuva) and weed treatment (farmer managed versus clean weeded).

Results

Distribution and abundance of weeds

The abundance of weeds averaged across farmers was different in all the three sites as shown in Table 2. More weeds (80 %) were found in Gutsa, than in Mufudzi and Muringazuva. There was no significant (P > 0.05) difference in the distribution of *Ocinum canum L.*, (Wild basil), *Trichodesma zeylanicum (*Burm.f.) (Late weed), *Eragrostis aspera (*Jacq) Nees (Rough love grass), *Cochorus olitorius L.*, (Jute) and *Ceratotheca sesamoides* Endl. In Gutsa, the most abundant weed species were *Vernonia poeskana* Vatke & Hiderbr., *Eragrostis aspera* and *Boerria scabra* (Schumach and Thom K Schum). In Mufudzi, *Eragrostis aspera, Ocimum canum* and *Panicum maximum* Jacq., (Guinea grass) were the most abundant weeds. In Muringazuva *Panicum maximum, Eragrostis aspera* and *Ocimum canum* were the most abundant weeds.

The most abundant weed, which was present in all three sites, was *Eragrostis aspera. Sphaeranthus flexuosus* (L.) was the second most abundant weed. Similarly, *Vernonia poskeana,* which was only present in Gutsa, was the third abundant weed species.

Effect of additional weeding on yield

Raw data showed no statistically significant effects (P > 0.05) for either weeding or resource category or their interaction for cotton and maize yields. Transformation of the data using a $\log_{10}$ scale stabilized the variation and some significant effect of weeding was shown for maize but not for cotton (Table 3). Clean weeding in maize increased yield by 117 kg/ha over normal farmer practices and cotton yield was increased by 52 kg/ha.

Economic analysis

Additional weeding of cotton and maize, over that undertaken by the farmer was most advantageous for households in RG 2 (Table 4). For this group the additional expenditure incurred resulted in a marginal rate of return per labour hour of Z$1.1 for cotton and Z$1.4 for maize (Table 4). However, costs exceeded the additional benefit achieved by resource category 1, while for the poorest households in resource category 3 the net benefit and marginal rate of return was negative.

Table 2. Distribution and abundance of weed species in three areas of Muzarabani.

Weed species	Site 1	Ranking	Site 2	Ranking	Site 3	Ranking	Total	Ranking	P Value	S.E.D
Boeeria scabra	3.32 (10.52)	3	1.28 (1.14)	7	0.71 (0)	9	5.31	5	***	0.4
Ocinum Canum	1.82 (2.81)	5	2.16 (4.17)	3	1.01 (0.52)	7	4.99	6	Ns	***
Trichodesma zeylanicum	1.83 (2.85)	4	0.98 (0.46)	1	1.62 (2.12)	5	4.43	7	Ns	Ns
Eragrostis aspera	4.33 (18.25)	2	3.51 (11.82)	1	3.80 (13.94)	2	11.74	1	Ns	Ns
Cochorus oritorius	0.94 (0.34)	9	1.40 (1.46)	6	1.03 (0.56)	6	3.37	9	Ns	Ns
Vernonia	4.93 (23.80)	1	0.84 (0.21)	10	0.81 (0.16)	8	6.58	3	***	0.59
Boerhivia Erecta	0.71 (0)	10	1.27 (1.11)	8	1.80 (2.74)	4	3.78	8	***	0.27
Sphaeranthus flexuosus	1.78 (2.67)	6	2.68 (1.32)	2	2.68 (6.68)	3	8.92	2	*	0.46
Panicum maximum	0.71 (0)	10	1.89 (3.07)	4	3.93 (14.94)	1	6.53	4	***	0.59
Ceratotheca sesamoides	0.94 (0.38)	8	1.07 (0.64)	9	0.74 (0.05)	1	2.75	11	Ns	Ns
Celosia trygna	0.95 (0.40)	7	1.58 (1.96)	5	0.71 (0)	9	3.24	10	***	0.47
Total mean	64.62		6.51		4.57				***	1.22

*=P<0.05, **= P<0.01,*** =P<0.001, Ns = Not significant, Site1=Gutsa , Site 2= Muringazuva, Site 3= Mufudzi [1]Numbers in brackets in each column represent untransformed weed numbers/m^{-2}

Table 3: Effect of additional weeding compared to farmer practice on yield (kg/ha) of farmer managed cotton and maize.

Resource category (n)	Cotton			Maize		
	Average yield (Farmer management)	Yield increase resulting from clean weeding kg/ha	% Increase resulting from clean weeding	Average yield (Farmer management) kg/ha	Yield increase resulting from clean weeding kg/ha	% Increase resulting from clean weeding
RG1	454	71 ns	16%	764	139 ns	18%
RG2	715	150 ns	21%	1596	275 ns	17%
RG3 and RG4 combined	517	-5 ns	-1%	865	-41 ns	-5%
Overall average	566	79 ns	14%	1001	189 ns	19%
Adjusted averages	588	52 ns	9%	971	117	12%
Log_{10} scale values	2.77	2.73	-	2.99	2.93	-
S.E.D	-	0.018	-	-	0.017	-
P value	-	0.054	-	-	0.012*	-

ns- Not significant, *P<0.05, RG-Resource group RG1-Well resourced, RG2- Average resourced, RG3 poorly resourced.

Table 4: Effect of additional weeding on returns from cotton and maize.

Resource category	RG1		RG2		RG3 and RG4	
COTTON	Clean weeded	Farmer weeded	Clean weeded	Farmer weeded	Clean weeded	Farmer weeded
Yield kg ha^{-1}	525	454	865	715	512	517
Gross benefit $ ha^{-1}	8453	7309	13927	11512	8243	8324
Additional weeding cost $ ha^{-1}	1820	-	1750	-	1773	-
Net benefit $ ha^{-1}	1144	-	2415	-	-81	-
Marginal rate of return	0.6	-	1.4	-	-0.05	-
MAIZE						
Yield kg ha^{-1}	903	764	1871	1586	824	865
Gross benefit $ ha^{-1}	6788	5730	14033	11970	6180	6488
Additional weeding cost $ ha-	1456	-	1848	-	1729	-
1Net benefit $ ha^{-1}	1058	-	2063	-	-308	-
Marginal rate of return	0.7	-	1.1	-	-0.2	-

RG-Resource group

Discussion

Eragrostis aspera is a shade tolerant grass (Drummond, 1984), being found in abundance at all three sites under the cotton canopy late in the season. Although the inflorescence can contaminate lint during harvesting, adversely affecting the cotton grade and price, it was not mentioned as a problematic weed during the farmer focus group discussions.

Vernonia poskeana and *B. scabra* were confined to the medium textured black alluvial soils of Gutsa and absent from the red fersiallitic and light sandy soils of Muringazuva and black heavy alluvial clays of Mufudzi. Although *T. zeylanicum* and *C. olitorius*, the leaves of which are harvested for consumption, were nominated as troublesome weeds in all three areas during focus group discussions, these species were present in very low densities in farmer managed fields. This suggests that these troublesome species are currently controlled by the combination of hoe weeding and ox-cultivation that is used for weed control by many farmers in the valley.

Cotton yields under farmer management in Muzarabani averaged well below one tonne ha^{-1} showing the need to improve the yields. The yield gap due to weeds at current levels of management average 14 % but are as high as 21 % for the 30-50 % of households with average resources. This is probably due to the planting of larger areas by this group than can be managed adequately. The absence of a demonstrable yield gap in cotton crops of poor households (RG 34) may reflect the smaller area planted. Poor households have also limited resources available to purchase seed and insecticides and as a result the benefit of weeding is overshadowed by losses due to pest damage. The results also showed that farmers tend to concentrate labour resources on cotton to the detriment of maize, which is their staple food. A significant yield gap averaging 12 % was recorded for cotton. Practices, which reduce the labour requirement for weed control in cotton, could allow additional resources to be invested in the maize crop, which could improve food security in the area. Although the yield increases following additional weeding on the observation plots set up in cotton were not large, farmers have reported that they regularly abandon areas of the crop due to weed infestation, a factor not included in the analysis reported here.

Conclusion

Economic benefits of extra weeding were significantly higher for maize production for all the resource groups than for cotton production. Thus farmers should commit more resources to maize, which is their staple food. Farmers should cultivate manageable areas which they are able to weed, in order to avoid the losses they are incurring, thereby negating the time, labour and inputs previously committed to the crop. Farmers who are well resourced (RG1) can make use of a pre-emergence herbicide, which could offer an option to relieve the weeding labour constraint during the critical period of weeding.

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