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Effect of weed control methods on weed density and maize (*Zea mays* L.) yield in west Shewa Orimia, Ethiopia

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Field experiments were conducted during 2013-2014 crop seasons at Ambo and Guder to study the effect of weed control methods on weed dynamics in maize (*Zea mays* L.) variety BH-660 in randomized complete block design with three replications. Five treatments, including Nicosulfuron (Arrow 75 WDG) at 0.09 kg ha^{-1} + silwet gold (adjuvant) at 0.10%, s-metolachlor 290 + Atrazine (Primagram) at 3.00 kg ha^{-1}, s-metolachlor (dual gold) 1.5 kg ha^{-1}, and hand weeding and weedy check (control) were used. Effect of different herbicides on weed density was significant. The lowest weed density (0.71 and 4.99 m^{-2}) was recorded in plot treated with hand weeding followed by Nicosulfuron at 0.09 kg ha^{-1} (3.68 and 5.92 m^{-2}) whereas the maximum was recorded in weedy check (14.16 and 24.24 m^{-2}) in Guder and Ambo, respectively. Like density and dry weight of weeds, the minimum was observed in hand weeding and hoeing followed by Nicosulfuron at 0.09 kg ha^{-1} which is not significantly different from s-metolachlor at 1.50 kg ha^{-1} and the lowest dry weight of weeds (0.0 and 26.67 gm^{-2}) was recorded in plot treated with hand weeding followed by Nicosulfuron at 0.90 kg ha^{-1} (2.13 and 65.60 gm^{-2}), however, non-significant difference existed among them in Guder, whereas the highest was observed in weedy check (170.93, 382.13 gm^{-2}) in Guder and Ambo, respectively. Moreover, those treatments also significantly increased the yield and yield component of maize in both locations.

Key words: Weed, weed control methods, herbicides, maize yield.

INTRODUCTION

In Ethiopia, maize has been selected as one of the national commodity crops to satisfy the food self-sufficiency program of the country, to feed the alarmingly increasing population because maize has a great promise for higher yield and easier cultivation than any other cereal crop and if managed properly can go a long way in increasing food production in Ethiopia. Unfortunately and despite its great yield potential, the average maize grain yield (2.29 tons ha^{-1})

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Table 1. Description of treatment used in the experiment.

Chemical name	Trade name	Dosage	Time of application
Nicosulfuron + silwet gold (adjuvant) at 0.10 %	Arrow 75WDG	0.90 kg ha^{-1}	Post emergence
s-Metolachlor	Dual Gold	1.50 kg ha^{-1}	Pre emergence
Primagram	Primagram Gold 660EC	3.00 kg ha^{-1}	Pre emergence
Hand weeding and hoeing	-	-	Post emergence
Weedy check	-	-	-

in Ethiopia (CSA, 2010) is still less than that of the yield (5.14 tons ha^{-1}) in other important maize-growing countries of the world (http://faostat.fao.org/site). Weed infestation is of supreme importance among biotic factors that are respon-sible for low maize grain yield. Worldwide maize production is hampered up to 40% by competition from weeds which are the most important pest group of this crop (Oerke and Dehne, 2004). Generally, weeds reduce crop yields by competing for light, nutrients, water and carbon dioxide as well as interfering with harvesting and increasing the cost involved in crop production. Kebede (2000) reported that most farmers in Ethiopia commonly lose up to 40% of yield in maize due to weed infestations. Weeds not only cause severe crop losses but also require farmers and their families to spend a considerable amount of their time on weeding. More than 50% of labor time is devoted to weeding, and is mainly done by the women and children in the farmer's family (Ellis-Jones et al., 1993; Akobundu, 1996).

Control of weeds in maize is, therefore, very essential for obtaining good harvest. Weed control practices in maize resulted in 77 to 96.7% higher grain yield than the weedy control (Khan et al., 2003). Different weed control methods have been used to manage the weeds but mecha-nical and chemical methods are more frequently used for the control of weeds than any other control methods. Mechanical methods including hand weeding are still useful but are getting expensive, laborious and time-consuming. Chemical control is a better alternative to manual weeding because it is cheaper, faster and gives better control (Chikoye et al., 2002, 2004). Weed control in maize with herbicides has been suggested by researchers (Correa et al., 1990; Owen et al., 1993). Ali et al. (2003) also reported that herbicides significantly increased maize yield and decreased the weed density. Therefore, the present re-search work was carried out to evaluate the effect of different weed control methods on weeds and yield and yield components of maize and to assess economics of herbicides under field conditions at Guder of Toke Kutaye and Ambo district, West Shoa, Ethiopia.

MATERIALS AND METHODS

The field experiment was conducted at two different areas, Guder and Ambo in West Showa, Ethiopia during the main cropping season of 2013. Guder and Ambo district has total geographical area of 78887 km^2 and are located at 8° 57' North latitude and 38° 07' East longitude at an average elevation of 1800-2300 m. a. s. l. The annual rainfall ranges from 1000 -1588.06 mm and the temperature of the district ranged between 9.4 and 21.9°C with average of 15.7°C. The soil of the experimental site is light red in color (Guder), clay loam (Ambo) in texture and with pH value of 6.8.

The field experiment consisted of five treatments, S-metolachlor 290 + Atrazine (Primagram) at 3 kg ha^{-1}, s-metolachlor (dual gold) at 1.5 kg ha^{-1}, Nicosulfuron (Arrow 750 WDG) at 0.09 kg ha^{-1} + silwet gold (adjuvant) at 0.10%, hand weeding and hoeing at 30 days after sowing and weedy check (no weed management) plot were carried out and arranged in a randomized complete block design with three replications. Herbicides were applied at 2 days after sowing as pre-emergence and 30 days after planting for post emergence with backpack sprayer with the spray volume of 600 L of water per hectare (Table 1). The size of each plot was 1.5 x 2.4 m. The distance between adjacent replications (blocks) and plots were 1 and 0.5 m, respectively.

The experimental plots were ploughed twice by oxen to prepare and plots were leveled manually before the field layout was made. Variety BH-660 was used as a planting material. The maize seeds were planted manually in the month of May. At planting, two maize seeds were placed in each hole, at approximately 5 cm depth. The plants were thinned to one plant per hill 20 days after sowing. The recommended amount of 100 kg ha^{-1} urea and 100 kg ha^{-1} DAP as source of nitrogen and phosphorus was applied. Half of nitrogen and of all the phosphorus were drilled in rows at the time of sowing. The remaining half of the N was applied at knee high growth stage of the plant (30 days after planting).

Weed population was counted with the help of quadrate thrown randomly at three places in each plot at 45 days after planting. The weeds were categorized/classified into broadleaved, grasses and sedges and converted in to area of m^2. The total aboveground weed dry matter was also recorded from the above thrown quadrates after cutting weeds from the ground level and then oven dried at 70°C temperature till a constant weight and was converted to m^2. Weed control efficiency (WCE) was determined using the following formula:

$$WCE = \frac{WDC - WDT}{WDC} X100$$

Where, WDC = weed dry matter in weedy check, WDT = weed dry matter in a treatment

Plant height (cm), ear length (cm), ear diameter and number of cobs per plant were measured from eight randomly selected (pre tagged) plants in the middle four rows of each plot. Thousand kernels were counted from each plot and their weight was recorded. The final gran yield was measured and adjusted to 12.5% moisture content using the formula:

$$Adjusted grain yield \left(kg ha^{-1}\right) = \frac{Actual yield X 100 - M}{100 - D}$$

Table 2. Weed floral composition of at Guder and Ambo experimental site.

Guder		Ambo	
Botanical name	**Family name**	**Botanical name**	**Family name**
Amaranthus hybridus L.	Amaranthaceae	*Amaranthus hybridus* L.	Amaranthaceae
Commelina banghalensis L.	Commelineae	*Bidens biternate*	Asteraceae
Corrigiola capensis L.	Caryophyllaceae	*Canyz aboniersis*	Asteraceae
Cynodon dactylon L.	Poaceae	*Datura stramorium*	Solanaceae
Cyperus esculentus L.	Cyperaceae	*Digitaria abysinca*.	Poaceae
Cyperus rotundus L.	Cyperaceae	*Erucastrum arabicum* Fisch and May	Brassicaceae
Erucastrum arabicum Fisch and May	Brassicaceae	*Galinsoga parviflora* cav.	Asteraceae
Galinsoga parviflora cav.	Asteraceae	*Ipomoea ariocarpa*	Convolvulaceae
*Oxalis comiculate*L.	Oxalidaceae	*Launaea cornuta*	Asteraceae
Oxalis latifolia L.	Oxalidaceae	*Oxalis comiculate*L.	Oxalidaceae
Polygonum nepalense Meisn	Polygonaceae	*Polygonum nepalense* Meisn	Polygonaceae
		Tribulu sterrestris	Convolvulaceae

Table 3. Effect of different herbicides on density and dry weight of weeds.

Treatment	Density of weeds (weeds m^{-2})		Dry weight of weeds(gm^{-2})	
	Guder	Ambo	Guder	Ambo
Nicosulfuron at 0.09 kg ha^{-1}	$3.68(13.33)^{d}$	$5.92(34.67)^{c}$	2.13^{bc}	65.60^{c}
s-metolachlor 1.50 kg ha^{-1}	$5.45(29.33)^{b}$	$12.87(168.00)^{b}$	21.33^{bc}	105.07^{b}
Primagram 3.00 kg ha^{-1}	$4.65(21.33)^{c}$	$11.99(144.00)^{b}$	26.67^{bc}	93.33^{b}
Hand weeding and hoeing	$0.71\ (0.00)^{e}$	$4.90(24.00)^{c}$	0.00^{c}	26.67^{d}
Weedy check	$14.16(200.00)^{a}$	$24.24(589.33)^{a}$	170.93^{a}	382.13^{a}
LSD (0.05)	0.5	2.8	25.9	26.2
CV	4.6	12.4	31.1	10.3

Figures or numbers in the parenthesis are original value, LSD = least significant difference, CV = coefficient of variation.

Where, M is the measured moisture content in grain and D is the designated moisture content. Relative crop yield loss was calculated using:

$relativeYieldloss=\frac{MY-YT}{MY}X100$, Where, MY = maximum yield from a treatment, YT = yield from a particular treatment.

Weed density was subjected to square root transformation $\left(\sqrt{(X+0.5)}\right)$to have normal distribution. Data were subjected to the analysis of variance. Mean separation was conducted for significant treatment means using least significance differences (LSD) at 5% probability level using SAS computer software version 9.1.

RESULTS AND DISCUSSION

Weed floral composition of the experimental sites

The experimental site at Ambo was infested with 12 different weed species belonging to 8 different families. Out of the total weeds, 91.7% were broadleaved weeds whereas the remaining 8.3% were grasses weeds (Table 2). This indicated that indicating a species-rich weed community in the experimental field. Similarly at Guder, 10 weeds species belonging to 9 families were identified. Out of the total weeds 70% were broadleaved weeds whereas the remaining 10 and 20% were grasses and sedges weeds, respectively (Table 2).

Density and dry weight of weeds

Effect of different weed control methods on weed density both at Ambo and Guder were significant (p<0.05). As shown in Table 3, the lowest weed density (0.71 and 4.99 m^{-2}) was recorded in plot treated with hand weeding followed by Nicosulfuron at 0.09 kg ha^{-1} (3.68, 5.92 m^{-2}) whereas the maximum was recorded in weedy check (14.16 and 24.24 m^{-2}) in Guder and Ambo, respectively. Similar finding was reported by Mehmeti et al. (2012) who found highest weed density in weedy check.

The weed control methods significantly affected the dry weight of weeds at both locations (p<0.05). The lowest

Table 4. Effect of different herbicides on weed control efficiency.

Treatment	WCE (%)	
	Guder	Ambo
Nicosulfuron at 0.09 kgha^{-1}	98.8^{a}	83.0^{b}
s-metolachlor 1.50 kgha^{-1}	87.1^{b}	72.5^{c}
Primagram 3.00 kgha^{-1}	83.9^{b}	75.5^{c}
Hand weeding and hoeing	100.0^{a}	93.0^{a}
Weedy check	0.0^{c}	0.00^{d}
LSD (0.05)	7.9	4.1
CV	5.7	3.4

LSD = Least significant difference, CV = coefficient of variation.

dry weight of weeds (0.0, 26.67 gm^{-2}) was recorded in plot treated with hand weeding followed by Nicosulfuron at 0.90 kg ha^{-1} (2.13 and 65.60 gm^{-2}). No significant differences existed among treatments in Guder, whereas the highest was observed in weedy check (170.93, 382.13 gm^{-2}) in Guder and Ambo, respectively. These results are in agreement with those reported by Hassan et al. (2010) who reported reduced weed biomass due to use of selective pre-emergence and post emergences herbicides for controlling different maize weed species.

Weed control efficiency

Weed control efficiency at both locations was also significantly affected ($p < 0.05$). As described in Table 4 in Guder, the minimum weed control efficiency was observed in weedy check (0.00%) whereas the highest (100.0%) was recorded in a plot treated with hand weeding and hoeing which was not significantly different from Nicosulfuron at 0.90 kg ha^{-1} (98.8). Similarly, in Ambo the maximum weed control efficiency (93.0%) was recorded in hand weeding and hoeing followed by Nicosulfuron at 0.90 kg ha^{-1} (82.0), whereas the minimum was in weedy check (0.0%) This result further indicated that herbicides are more effective in reducing density and dry weights of weeds when compared with hand weeding and hoeing which are more effective than weedy check. This result was in accordance with Mehmeti et al. (2012) who reported that herbicides reduced the weed infestation in maize in comparison with the control plots.

Yield and yield components

All the weed control treatments proved significantly superior to weedy check with respect to yield attributes and yield of maize. At Guder, cob number per plant, ear length and diameter were significantly affected by weed control methods, whereas plant height was not ($p < 0.05$). The maximum number of cobs per plant (1.9) was observed in hand weeding and hoeing followed by Nicosulfuron at 0.90 kgha^{-1} (1.8); the lowest was recorded in weedy check (0.47). Similarly at Ambo site, weed control methods significantly affected the yield component of maize ($p < 0.05$).

Weed control methods also significantly affected the ear length and ear diameter of maize at both locations. The highest ear length (16.3, 19.2 cm) was in hand weeding and hoeing which was not statistically different from Nicosulfuron at 0.90 kg ha^{-1}, s-metolachlor 1.50 kg ha^{-1} and Primagram 3.00 kg ha^{-1}, whereas the lowest was recorded from weedy check (12.1, 12.9cm) in Guder and Ambo, respectively. Hundred kernel weigh, grain yield and relative yield losses were significantly affected by weed control methods. The highest thousand kernel weight was recorded with hand weeding (45.33, 49.7 g) whereas the lowest was recorded with weedy check (33.8, 29.8 g) in Guder and Ambo, respectively. These results are in accordance with work of Patel et al. (2006) who stated that all the weed control treatments proved significantly superior to weedy check with respect to yield attributes and yield of maize.

Maximum grain yield (6989.8, 7223.1 kg ha^{-1}) was recorded in plots treated with hand weeding and hoeing and Nicosulfuron at 0.90 kg ha^{-1} (6883.3, 6883.3 kg ha^{-1}). The lowest was recorded in weedy check (2312.4, 2612.4 kg ha^{-1}) in Guder and Ambo, respectively (Table 5). The efficiencies of various chemicals and other weed control practices in enhancing grain yield have previously been observed by Toloraya et al. (2001). The highest relative yield loss (63.7 and 75.7%) was recorded from weedy check whereas the lowest relative yield losses was observed from hand weeding and hoeing (0.0, 0.0%,) followed by Nicosulfuron at 0.90 kg ha^{-1} (4.7, 6.3%) in Guder and Ambo, respectively (Table 6). All yield and yield parameter of maize were best in weed control methods as compared to weed control (check), this may be due to lowest weed density and dry weight.

Conclusion

The results from both locations suggest that the density and dry weight of weeds was lower in hand weeding and hoeing followed by Nicosulfuron at 0.09 kg ha^{-1}, whereas the maximum was recorded in weedy check in both locations. Weed control efficiency was also high in these treatments. Like density, the minimum dry weight of weeds was observed in hand weeding and hoeing followed by Nicosulfuron at 0.09 kg ha^{-1}. Moreover, those treatments also increased the yield and yield component of maize in both locations.

Conflict of interests

The author(s) have declared that there is no conflict of interests.

Table 5. Effect of different herbicides on plant height, ear length and diameter in Guder and Ambo.

Treatments	Guder				Ambo			
	pH (cm)	Cobs /plant	EL (cm)	ED (cm)	pH (cm)	Cobs / plant	EL (cm)	ED (cm)
Nicosulfuron at 0.90kgha^{-1}	150.5^{a}	1.87^{a}	18.0^{a}	7.1^{b}	175.5^{ab}	1.9^{a}	19.5^{a}	7.1^{b}
s-metolachlor 1.50 kgha^{-1}	148.0^{a}	1.20^{b}	17.1^{ab}	7.1^{b}	160.7^{ab}	1.4^{b}	18.8^{b}	7.2^{b}
Primagram 3.00 kgha^{-1}	157.0^{a}	1.33^{b}	16.8^{ab}	7.2^{b}	175.5^{ab}	1.5^{ab}	19.2^{a}	7.1^{b}
Hand weeding and hoeing	152.7^{a}	1.93^{a}	16.3^{ab}	8.2^{a}	179.1^{a}	1.9^{a}	19.7^{a}	8.1^{a}
Weedy check	147.9^{a}	0.47^{c}	12.2^{c}	6.5^{b}	144.3^{b}	0.8^{c}	12.9^{a}	6.1^{c}
LSD (0.05)	NS	0.3	2.3	0.8	31.4	0.4	1.9	0.8
CV	3.4	11.7	7.2	5.9	10.0	15.1	5.6	5.8

LSD = Least significant difference, CV = coefficient of variation, EL = ear length, ED = ear diameter, PH = plant height.

Table 6. Effect of herbicides on 100 kernel weight, grain yield and relative yield loss.

Treatments	Guder			Ambo		
	HSW (g)	GY (kg ha^{-1})	RYL (%)	HSW (g)	GY (kg ha^{-1})	RYL (%)
Nicosulfuron at 0.90 kgha^{-1}	41.53^{a}	6883.3^{a}	4.737^{cd}	44.667^{b}	6883.3^{ab}	6.314^{d}
s-metolachlor 1.50 kgha^{-1}	42.633^{a}	5026.4^{b}	30.15^{b}	41.167^{c}	5026.4^{c}	29.368^{b}
Primagram 3.00 kgha^{-1}	42.833^{a}	6159.2^{a}	14.519^{c}	41.30^{c}	6159.2^{b}	11.803^{c}
Hand weeding and hoeing	45.333^{a}	6989.8^{a}	0.000^{cd}	49.667^{a}	7223.1^{a}	0.00^{e}
Weedy check	33.80^{b}	2312.4^{c}	63.655^{a}	29.80^{d}	2612.4^{d}	75.712^{a}
LSD (0.05)	5.19	921.28	9.79	3.29	812.36	5.32
CV	6.68	8.84	23.01	4.24	7.73	11.47

LSD = Least significant difference, CV = coefficient of variation, HSW = hundred seed weight, GY = grain yield, RYL = relative yield loss.

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