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Management of Weeds in Maize (*Zea mays* L.) through Various Pre and Post Emergency Herbicides

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Abstract

Field experiments were conducted in 2013 during main cropping season at Ambo and Guder to determine the effect of different post and pre emergency herbicides application on weed dynamics in maize (*Zea mays* L.) variety, BH-660 in randomized complete block design with three replications. Six treatments including Nicosulfuron (Arrow 75 WDG) at 0.09 $kgha^{-1}$+ silwet gold (adjuvant) at 0.10%, $_{S}$-metolachlor 290 + Atrazine (Primagram) at 3.00 $kgha^{-1}$, s-metolachlor (dual gold) 1.5 $kgha^{-1}$, hand weeding as standard check and weedy check as control were used. Effect of different herbicides on weed density was significant. The lowest weed density was recorded in plot treated with hand weeding and hoeing (3.12 m^{-2}) followed by Nicosulfuron (18.67 m^{-2}) and Primagram (3.88 m^{-2}). But, the maximum was recorded in weedy check (14.16 m^{-2}). However, no significant difference was observed between Nicosulfuron and Primagram. The minimum dry weight of weeds (0.77 gm^{-2}) was observed in hand weeding and hoeing followed by Nicosulfuron which is not significantly different from s-metolachlor. Moreover, those treatments also significantly increased the yield and yield component of maize. This is an indication of the reliability and promise as well as the exhibition of the great potential of the Nicosulfuron is the effective control of the weeds and enhancing yield of maize in Guder and Ambo, Ethiopia.

Keywords: Atrazine; Nicosulfuron; Primagram; Silwet gold; *Zea mays*

Introduction

The major constraints of maize production in Ethiopia include both biotic (weeds, plant pathogens, insect pests, rodents, wild animals) and abiotic factors (drought, hailstorm, flood, nutrient deficiency, soil type, topographic features) [1]. Weed infestation is supreme importance among biotic factors that are responsible 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 [2]. 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. Overall, weeds impose the highest loss potential (37%), which is higher than the loss potentials due to animal pests (18%), fungal and bacterial pathogens (16%) and viruses (2%) [3]. Kebede [4] reported that most farmers in Ethiopia commonly lose up to 40, 30, 35, 18 and 30% of yield in maize, sorghum, wheat, barley and teff, respectively, due to weed infestations.

Weeds have a more direct influence on human beings than any other pest in developing countries like Ethiopia. Weeds not only cause severe crop losses but also compete with farmers and their families to spend a considerable amount of their time on weeding [5]. More than 50% of labor time is devoted to weeding, and is mainly done by the women and children in the farmer's family [6,7]. In the hand hoe system, weeding alone accounts for 40-54% of the total labor input in farming in Ethiopia, Ghana, Malawi, *Nigeria, Sierra Leone, Tanzania and Zambia, requiring 300-400 man-hours per hectare [8]. In most cases, farmers are unable to do their weeding on time due to limitations on family labor.* According to Unger [9], the taller and more numerous the weeds are in relation to the crop, the stronger is the competition. Weed competition in a cereal generally reduces crop vigor, tillers, head size, kernel weight and, consequently, grain yield.

Control of weeds in the fields of maize is, therefore, very essential for obtaining good crop-harvest. Weed control practices in maize resulted in 77 to 96.7% higher grain yield than the weedy check. Different weed control methods have been used to manage the weeds but mechanical 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. In the less developed countries, the situation still exists where the peak labor requirement is often for hand weeding [10]. Herbicides weed control is an important alternative to manual weeding because it is cheaper, faster and gives better weed control [3]. Chemical control is a better alternative to manual weeding because it is cheaper, faster, and gives better control [2,11]. Weed control in maize with herbicides has been suggested by researchers [12,13]. Ali et al. [14] also reported that herbicides significantly increased maize yield and decreased the weed density. However, continuous application of currently registered herbicides caused changing weed flora, poor controlling, and evolution of some herbicide resistant weed biotypes. This necessitates the introduction of some other new herbicide options with different modes of action. Therefore, this research work was carried out to evaluate the effect of new herbicide (Nicosulfron) on weeds and yield and yield components of maize under field condition at Guder and Ambo district, West Shoa, Ethiopia.

Materials and Methods

Location of study areas

Field experiments were conducted at two different areas viz. Guder and Ambo in maize cultivated field, West Showa, Ethiopia during

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the main cropping season of 2013, for the management of weeds. The altitude of the study areas are between 1900 and 3100 m. a. s. l, geographical positions of N 08° 43.423-N 10° 12.082 and E 037° 28.902-040° 62.590. Guder and Ambo district has total geographical area of 78887 sq.km and is located at 8° 57 'North latitude and 38° 07 'East longitude at an average elevation of 1800-2300 m. a. s. l. The district lay under different climatic zones, which are 23% of highland, 60% of middle altitude and 17% is low land. In addition, the district has bi-model rainfall distribution with small amount of rainfall during autumn season and much rainfall during summer season. Heavy rain observed from onset of July to the end of August. The annual rainfall ranges from 1000 -1588.06 mm and the temperature of the district ranged between 9.44°C and 21.86°C with average of 15.65°C. The soil of the experimental site is light red in color, clay loam in texture and pH value of 6.8.

Treatments and experimental design

After determining the appropriate rate of application, field experiments were undertaken at both Guder and Ambo to compared the newly introduced herbicide (Nicosulfuron) with the traditional method (hand weeding and hoeing) and with already introduced herbicides (Primagram and s-metolachlor) and weedy check. Field experiment consists of six treatments, $_S$-metolachlor 290. + Atrazine(Primagram) at 3 kg/ha, s-metolachlor (dual gold) 1.5 kg/ha, Nicosulfuron (Arrow 750 WDG) at 0.09 kg/ha + silwet gold (adjuvant) at 0.10%, hand weeding and hoeing and weedy check were carried out and arranged in a randomized complete block design with three replications. Herbicides was applied 2 days after sowing as pre-emergence and 30 days after planting for post emergence using Knapsack/ Backpack sprayer. The spray volume was 600 L of water per ha. The size of each plot was 1.5 m×2.4 m. The distance between adjacent replications (blocks) and plots were 1 m and 0.5 m, respectively.

Agronomic practices for both locations

The experimental plots were ploughed twice to get fine seed bed, by oxen and plots were leveled manually before the field layouts were made. Variety BH-660 was used as a planting material. The maize seeds were planted manually in the month of May at both sites. During planting time, two maize seeds were placed at each hole and thinned to one plant per hill 20 days after sowing. The recommended amount of Nitrogen and phosphorus was applied. The source of nutrients was Urea and DAP, respectively. Half of N and the whole phosphorus were drilled in rows at the time of sowing. The remaining half N was applied at knee high growth stage of the plant.

Data Collected

Weeds data

Population: The weed population was counted before first 45 days after planting and at tasseling. The population count was taken with the help of 0.25 m×0.25 m quadrate thrown randomly at two places in each plot and was identified and converted to population/density per m^2.

Dry weight: While recording weed population the biomass was harvested from each quadrate. The harvested weeds were placed into paper bags separately and drying in oven at a 65°C temperature for 24 hours till constant weight and subsequently the dry weight was measured and converted in to gm^{-2}.

Weed Control Efficiency (WCE): It was calculated from weed control treatments in controlling weeds.

$$WCE = \frac{WDC - WDT}{WDC} \mathrm{X100}$$; Where WDC= weed dry matter in weedy check,

WDT= weed dry matter in a treatment

Maize data

Plant height (cm): Plant height was measured from 8 randomly selected (pre tagged) plants at the middle four rows, from the ground level to the apex of each plant at dough stage of the plant.

Number of cobs per plant: The number of productive ears was counted in each sample plants. Eight randomly selected tagged plants from the four central rows were used for counting productive ears.

Ear length (cm): The diameter of eight randomly taken ears was measured at mid length using caliper and the averages was recorded.

Hundred kernels weight (g): Thousand kernels were counted from each plot and their weight was recorded and adjusted to 12.5% moisture content.

Grain yield (kg/ha): The final produce was measured and adjusted to 12.5% moisture content with the help of formula:

$$Adjusted\ grain\ yield\left(kg\,ha^{-1}\right) = \frac{Actual\ yield\ \mathrm{X100} - M}{100 - D}$$

Where, M is the measured moisture content in grain and D is the designated moisture content.

Relative yield loss: Crop yield loss was calculated based on the maximum yield obtained from a treatment /treatment combination i.e. interaction as follows:

$$\mathrm{Re}lative\ Yield\ loss = \frac{MY - YT}{MY}\mathrm{X100},$$

Where, MY= maximum yield from a treatment, YT = yield from a particular treatment.

Statistical analysis

Population density of weed was subjected to square root transformation $\left(\sqrt{(X+0.5)}\right)$ to have data normal distribution using scientific calculator. 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.

Results and Discussion

Weed floral composition of the experimental sites

At Ambo, maize was infested with different weed species belongs to different family. 12 weeds species belongs to 8 families were identified. Out of the total weeds, 91.7% were broad leaved whereas the remaining 8.3% were grasses weeds (Tables 1 and 2). These indicate that species-rich weed community in the experimental field. Similarly at Guder site, 11 weeds species belongs to 9 families were identified. Out of the total weeds 72.7% were broadleaved weeds whereas the remaining 9.09% and 18.19% were grasses and sedges weeds respectively. This result is in agreement with Mehmeti et al. [15] who found that different weeds species in a single experimental site.

Common name	Trade Name	Rate	Time of Application
Nicosulfuron +silwet gold (adjuvant) at 0.10%	Arrow 75WDG	0.90kgha^{-1}	Post
s-metolachlor	Dual Gold	1.50 kgha^{-1}	Pre
Primagram	Primagram Gold 660EC	3.00 kgha^{-1}	Pre
Hand weeding and hoeing	-	-	Post
Weedy check	-	-	-

Table 1: Description of treatments used in the experimental sites.

S.No	Guder		Ambo	
	Botanical name	**Family name**	**Botanical name**	**Family name**
1	*Amarathushybridus* L.	Amaranthaceae	*Amarathushybridus* L.	Amaranthaceae
2	*Commelinabanghalensis* L.	Commelineae	*Bidensbiternate*	Asteraceae
3	*Corrigiolacapensis* L.	Caryophyllaceae	*Canyzaboniersis*	Asteraceae
4	*Cynodondactylon* L.	Poaceae	*Daturastramorium*	Solanaceae
5	*Cyprus esculentus* L.	Cyperaceae	*Digitariaabysinca*.	Poaceae
6	*Cyprus rotundus* L.	Cyperaceae	*Erucastrumarabicum*Fisch and May	Brassicaceae
7	*Erucastrumarabicum*Fisch and May	Brassicaceae	*Galinsogaparviflora* cav.	Asteraceae
8	*Galinsogaparviflora* cav.	Asteraceae	*Ipomeaariocarpa*	Convolvulaceae
9	*Oxalis comiculate*L.	Oxalidaceae	*Launaeacornuta*	Asteraceae
10	*Oxalis latifolia* L.	Oxalidaceae	*Oxalis comiculate*L.	Oxalidaceae
11	*Polygonumnepalense*Meisn	Polygonaceae	*Polygonumnepalense*Meisn	Polygonaceae
12			*Tribulusterrestris*	Convolvulaceae

Table 2: Weed floral composition of at Guder and Ambo study sites.

Treatment	Guder		Ambo	
	weeds Density (m^{-2})	**Dry weight(gm^{-2})**	**weeds Density (m^{-2})**	**Dry weight(gm^{-2})**
Nicosulfuron	3.68(13.33)^{d}	2.13^{bc}	5.92(34.67)^{c}	65.60^{c}
s-metolachlor	5.45(29.33)^{b}	21.33^{bc}	12.87(168.00)^{b}	105.07^{b}
Primagram	4.65(21.33)^{c}	26.67^{bc}	11.99(144.00)^{b}	93.33^{b}
Hand weeding +hoeing	0.71 (0.00)^{e}	0.00^{c}	4.90(24.00)^{c}	26.67^{d}
Weedy check	14.16(200.00)^{a}	170.93^{a}	24.24(589.33)^{a}	382.13^{a}
LSD (0.05)	0.49	25.9	2.81	26.16
CV (%)	4.6	31.1	12.4	10.3

Table 3: Effect of different herbicides on density (m^{-2}) and dry weight of weeds (gm^{-2}). Figures or numbers in the parenthesis are original value, LSD= least significant difference, CV= coefficient of variation, means within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LDS test.

Density and dry weight of weeds

Effect of different herbicides on weed density both at 45 days after planting and tasseling stage was significant. As described on Table 3, the lowest weed density (0.71) was recorded in plot treated with hand weeding followed by Nicosulfuron (3.68) whereas the maximum was recorded in weedy check (14.16 m^{-2}). Similar finding was reported Mehmeti et al. [15] who found that highest weed density in weedy check.

Moreover, the effect of herbicides application significantly affected the dry weight of weeds at both stage. The lowest of weight of weeds (0.0 gm^{-2}) was recorded in plot treated with hand weeding followed by Nicosulfuron (2.13 gm^{-2}) however, non-significant difference was existed among them, whereas the highest was observed in weedy check (170.93 gm^{-2}). These results are in agreement with those reported by Hassan et al. [16] who reported reduced weed biomass due to use of selective pre-emergence and post emergences herbicides best for controlling different maize weed species.

Weed control efficiency

Weed control efficiency at both crop stages was also significantly affected. 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 is not significantly different Nicosulfuron (98.8). This result further indicates that herbicides are more effective in reducing density and dry weights of weeds next to hand weeding and hoeing as compared to weedy check. This result was in accordance with Mehmeti et al. [15] who reported that it is evident herbicides reduced the weed infestation and control better than in the maize crop in comparison to the control plots (Table 4) [16].

Maize yield and yield components

At Guder except plant height, cobs number per plant, ear length and diameter were significantly affected by weed control methods. According the result showed in Table 5, plant height was not significantly affected. The maximum number of cobs per plant (1.9) was observed in hand weeding and hoeing followed by Nicosulfuron (1.8) however no significant were exist between them, whereas the lowest was recorded weedy check (0.47). Similarly at Ambo, effect of weed control methods was also significantly affecting the yield component of maize [17-19].

As described in Table 6, the maximum hundred seed weight was scored on combination of hand weeding and hoeing and the minimum was recorded on weedy check both at Guder and Ambo. Moreover, the highest grain yields were obtained from hand weeding + hoeing and followed by plot treated with Nicosulfuron at both study sites. While, the lowest grain yields were scored on weedy check [20-22].

Treatment	Weed Control Efficiency (%)	
	Guder	Ambo
Nicosulfuron	98.81[a]	83.02[b]
s-metolachlor	87.08[b]	72.48[c]
Primagram	83.91[b]	75.48[c]
Hand weeding + hoeing	100.00[a]	92.98[a]
Weedy check	0.00[c]	0.00[d]
LSD (0.05)	7.95	4.08
CV	5.71	3.35

Table 4: Effect of various herbicides on weed control efficiency (%). LSD= least significant difference, CV= coefficient of variation, means within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LDS test.

Treatments	Guder				Ambo			
	PH (cm)	Cobs /plant	EL(cm)	ED (cm)	PH (cm)	Cobs /plant	EL(cm)	ED(cm)
Nicosulfuron	150.47[a]	1.87[a]	18.0[a]	7.1[b]	175.5a[b]	1.9[a]	19.5[a]	7.1[b]
s-metolachlor	148.00[a]	1.20[b]	17.1[ab]	7.1[b]	160.7[ab]	1.4[b]	18.8[b]	7.2[b]
Primagram	157.00[a]	1.33[b]	16.8[ab]	7.2[b]	175.5[ab]	1.5[ab]	19.2[a]	7.1[b]
Hand weeding + hoeing	152.73[a]	1.93[a]	16.3[ab]	8.2[a]	179.1[a]	1.9[a]	19.7[a]	8.1[a]
Weedy check	147.87[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	0.29	2.28	0.8	31.39	0.42	1.90	0.8
CV	3.44	11.70	7.23	5.92	9.98	15.11	5.60	5.81

Table 5: Effect of various herbicides on plant height, cobs per plant, ear length and diameter (cm) in Guder and Ambo. PH=plant height, EL=ear length, ED=ear diameter, LSD= least significant difference, CV= coefficient of variation, means within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LDS test.

Treatments	Guder			Ambo		
	HSW	GY	RYL	HSW	GY	RYL
Nicosulfuron	41.53[a]	6883.3[a]	4.737[cd]	44.667[b]	6883.3[ab]	6.314[d]
s-metolachlor	42.633[a]	5026.4[b]	30.15[b]	41.167[c]	5026.4[c]	29.368[b]
Primagram	42.833[a]	6159.2[a]	14.519[c]	41.30[c]	6159.2[b]	11.803[c]
Hand weeding + 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

Table 6: Effect of various herbicides on 100 seed Weight (g), Grain Yield (kgha^{-1}), and Relative Yield Loss (%). HSW =hundred seed weight, GY=grain yield, RYL=relative yield loss, LSD= least significant difference, CV= coefficient of variation, means within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LDS test.

Conclusions

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. Control of weeds in the fields of maize is very essential for obtaining good crop-harvest. From the result it can be stated that effect of different pre and post emergency herbicides on weed density, weed dry weight and weed control efficiency were significant. The lowest weed density was recorded in plot treated with hand weeding and hoeing followed by Nicosulfuron whereas the maximum was recorded in weedy check. Like density, dry weight of weeds the minimum was observed in hand weeding and hoeing followed by Nicosulfuron. Moreover, those treatments also significantly increased the yield and yield component of maize. Therefore from this field experiment, hand weeding and hoeing is most effective measure of weed control and increasing yields of maize however, due to labor shortage; herbicides are the most effective in terms of time and cost. Even though herbicides are more effective in time and cost, the candidate herbicide (Nicosulfuron+silwet gold (adjuvant) at 0.10%) is the outstanding for weed control in maize as compared to the already registered herbicides (Primagram and $_{S}$-metolachlor).

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