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Effect of Selected Weed Control Methods for the Management of Weed in Maize in Different Agro Ecological zones of Ethiopia

Bogale Ayana*

Ethiopian Institute of Agricultural Research, Holeta Agricultural Research Center, P.O. BOX 31, Holeta, Ethiopia

Corresponding Authors:** ***Bogale Ayana, *Ethiopian Institute of Agricultural Research, Holeta Agricultural Research Center, P.O. BOX 31, Holeta, Ethiopia*

Abstract: *A significant proportion of maize is lost to weeds in the Holeta region of central Ethiopia. Weeds began to invade the fields at an early stage of growth and consume growth resources. Farmers manage their fields with cultural methods to protect crops from weeds. However, farmers' knowledge of weed control timing, which is critical for weed control, is lacking. Therefore, the use of herbicides is assumed to be necessary for corn weed control. The purpose of the experiment was to determine the appropriate herbicides to control weeds and increase corn production. The experiment was treated with different herbicides; S-Maspor 960 EC 3 L ha-1, Primagramgold SE 3 L ha-1, twice hand weeding, weed free and untreated control. Treatments were designed in a randomized complete block design with three replications. Caylusea abyssinica was found to be the most dominant weed, accounting for only 17.32% of the total weeds in the fields. The weed free treated plots outperformed the treated plots in terms of a 100% reduction in weed dry weight and a 100% increase in weed control efficiency. S-Maspor 960 EC significantly increased stand count by 63.4% and the grain yield the yield was 13 times and the yield losses were reduced by 88.7%, while no statistically significant results were obtained due to the application of the treatments for the length of ears and thousand grain weights. Thus, the application of S-Maspor 960 EC 3 L ha-1 gave better results in most of the characteristics recommended for the control of various weeds in corn.*

Keywords: *application, consistent, reduced, significantly, treated*

1. Introduction

Maize (Zea mays L.) is the most useful food in the world. It is essential for food, fodder, and is also the main raw material for several industrial products food (25%), animal feed (12%) and poultry feed (49%), starch (12%), brewing (1%) and seeds (1%) (Behera *et al*., 2018). It is one of the most efficient crops that, to its unique photosynthesis mechanism to the C4 mechanism, gives a high biological yield and grain yield in a short period of time. The average maize yield in developed countries is more than 7 t ha^{-1}, while in developing countries it is only around 3 t ha^{-1} (Harris and Kennedy, 1999; Behera *et al*., 2018).

Among the various production factors, weed control plays an important role in increasing maize productivity. Uncontrolled weed growth in the crop can result in 100% yield loss (Korav *et al*., 2018; Verma*et al*., 2018). It is known that there is a critical period of crop-weed competition with yield losses of 28-100% if weeds are not controlled (Teasdale and Mohler, 2000). Corn weed control is therefore very important to achieve higher productivity. Therefore, weed control in developed countries is done with herbicides. Weeding is an important alternative to manual weeding because it is cheaper, faster and improves weed control (Chikoye*et al*., 2005; Rana *et al*., 2017; Kumawat *et al*., 2019; Iqbal *et al*., 2020). Weed control is considered an important factor in achieving better productivity because the weed problem is more serious during continuous rains in the early stages of corn growth, which cannot be controlled by traditional and cultural methods alone due to excess moisture.

Weed control technology has evolved from manual weeding or simple cultivation to the more expensive chemical control methods we see today (McErlich and Boydston, 2014; Barla *et al*., 2016).

In modern agriculture, chemicals have become the most commonly used weed control strategy. However, environmental and economic costs and increased weed resistance to herbicides have led to a desire to reduce herbicide use on farms. Because of these potential problems and increased public pressure on conventional agriculture, interest in inorganic farming systems is growing worldwide. Therefore, the aim of the work was to find suitable weed control options against annual grasses and broadleaf weeds in maize.

2. Materials and Methods

Treatment and experimental design

The field trials were conducted in Holeta and Ejere during the main growing season of 2021 under rainy conditions where the fields were infested with many weed species. Therefore, a randomized complete block design and test herbicide S-Maspor 960 EC 3 L ha^{-1}, Primagramgold SE 3L ha^{-1}, twice hand weeded and weed free were placed in each plot of 5 m x 3 m. The fifth treatment was left untreated as a control.

Procedures and field management

To obtain a good sowing, the field was plowed three times before sowing at each location. Maize seeds were sown 75 cm x 25 cm, resulting in a plant population of 53,333/ha. All recommended agronomic practices were applied at sowing and during the growth phase of the crop. Herbicides were applied as pre emergence. The corn variety Hora was used in the experiment. Herbicides were applied as pre emergence one day after planting with a CP-15 knapsack sprayer with a nozzle calibrated to a spray volume of 200 L ha^{-1}. 150 kg ha^{-1}N and 100 kg ha^{-1}P2O5 were applied as fertilizers. Harvesting of maize was done on a net plot of 4 m^2 after the rows at the edges at both sides of the plots were discarded to reduce error. Data collection Relative density (RD) was determined by dividing the total number of individuals of a weed species in all the quadrants by the total number of individuals of all the weed species in all the quadrants multiplied by 100 (Das *et al*., 2011). Weed dry weight was done by taking weed samples at random from a 1m^2 quadrat placed randomly in each plot at harvest. Weeds were gathered together and put in a polythene bag and later oven-dried at a temperate of 80°C for 2 days to a constant weight. The oven-dried weight in grams was converted to kg/ha for each plot.

The weed control efficiency was determined $WCE\ \% = \frac{WDC - WDP}{WDC}\ X\ 100$……………1 where WCE = weed control efficiency, WDC = weed dry weight in the control plot and DWP = weed dry weight in the special treatment (Davasenapathy *et al*., 2008).

Stand count was determined by counting the total plant population at maturity in a 1 m x 1 m quadrant. Numbers of grains per plant and spike length were determined from four randomly selected plants from each plot. Thousand-grain weights were also determined by sampling and weighing the produce harvested from each plot. Grain yield was determined by weighing the harvested grain from each net area, which was calculated in kilograms per hectare using the following formula: grain yield / net plot of land x 10,000 …………………………………………2 grain yield kg/ha = net plot (m2)

Yield loss was calculated using the formula, YL % = $\frac{MGYT - GYPT}{MGYT}\ X100$………3,Where YL = yield loss, MGPT = maximum grain yield of a given treatment and GYPT = grain yield of a given treatment.

Data analysis

Analysis of variance was performed on the collected data using SAS version 9.3 Statistical Package and if the F value was significant, means were separated by LSD at 5% probability (Gomez and Gomez, 1984).

3. Results and Discussion

Weed identification and relative density

The experimental plots were infested with various weeds that are difficult for annual and perennial crops. Ten weed species were identified in the experimental areas, where all species were classified as annuals (Table 1). This result indicated that the field was heavily infested with annual weeds. The highest relative weed density (17.32%) was calculated for*Caylusea abyssinica*, while the lowest

(6.27%) was for*Plantago lanceoleta*L., indicating that annual weeds are more problematic in maize in the plots.

Table1. *Weed species, relative density and life form at experimental fields*

Weed species	Families	Weed density count m^2	Relative weed density (%)	Life form
Polygonum nepalense	Polygonaceae	200.00	13.64	Annual broadleaf
Raphanus raphanistrum	Brassicaceae	126.00	8.5	Annual broadleaf
Guizotia scabra	Compositae	112.00	7.6	Annual broadleaf
Galinsoga pulviflora	Compositae	122.00	8.3	Annual broadleaf
Corrigiola capensis	Plantaginaceae	220.00	15	Annual broadleaf
Caylusea abyssinica	Resedaceae	254.00	17.32	Annual broadleaf
Spergula arvensis	Caryophyllaceae	126.00	8.5	Annual broadleaf
Plantago lanceoleta	Plantaginaceae	92.00	6.27	Annual broad leaf
Medicago polymorpha	Fabaceae	112.00	7.6	Annual broad leaf
Phalaris paradoxa	Poaceae	102	6.95	Annual grass

Dry weight of weed

Weed dry weight was significantly affected by the use of different herbicides (Table 2). Herbicide application significantly and consistently reduced weed dry weight. Thus, the average dry weight of weeds in fields treated with S-Maspor 960 EC, Primagramgold 660 SC, twice hand weeding and weed free was reduced by 2563%, 2594%, 2546%, 2581.7%, 2544%, 2575%, 2666%. %. 2700% compared to the average dry weight of weedy check in Holeta and Ejere area respectively. The reduced weed dry mass is due to the complete removal of weeds from the fields, which resulted in a decrease in dry weed biomass. This is consistent with Nadeem *et al*. (2008) and Radheshyam *et al*. (2021) lowest dry weight was due to removal of most weeds, which reduced weed density.

Table2. *Effect of herbicides on weed dry weight and weed control efficiency in maize at Holeta and Ejere*

Weed control treatments	Weed dry weight (kg/ha)		Weed control efficiency (%)	
	Holeta	Ejere	Holeta	Ejere
S-Maspor 960 EC	103b	106b	96.3b	96.18b
Primagramgold 660 SC	120b	118.3b	95.7c	95.7c
Twice hand weeding	122b	125b	95.5c	95.5d
Weed free	0.0c	0.0c	100a	100a
Weedy check	2666a	2700a	0.0d	0.0e
LSD (5%)	128.7	85.4	0.25	0.22
CV (%)	11.34	7.4	0.17	0.15

Weed control efficiency

The effectiveness of weed control was significantly ($P \leq 0.05$) affected by the use of different herbicides (Table 2). The weed control efficiency of S-Maspor 960 EC, Primagramgold 660 SC twice hand weeded and control exceeded the average weed control efficiency of control plots by 96.3%, 96.1%, 95.7%, 95.7%, 95.5%, 95.5%,100%, 100% in Holeta and Ejere respectively. The weed control efficiency results from the complete removal of weeds from the field at all stages of the crop, resulting in a minimum dry weight of weed. Similarly, Megersa *et al*. (2017) also reported in the case of barley that the reason for the decrease in the dry weight of the weeds could be the inhibitory effect of the treatments on the growth and development of the weeds. Similarly, Stewart *et al*. (2009) and

Landau *et al*. (2021) use of pre-emergence herbicides for best weed control in a maize system increases herbicide efficacy with increasing light intensity or decreasing leaf angle.

Stand count

The use of different herbicides significantly (P≤0.05) affected the number of stands (Table 3). Weed control has significantly and consistently increased the number of stand count. Thus, the stand count of S-Maspor 960 EC, Primagramgold 660 SC, manually weeded twice, weed free exceeded the stand count produced in the weed control by 62%, 63.4%, 46.7%, 54%, 46.7% 50%, 60%, 53.4% in Holeta and Ejere respectively. The highest number of stands count that better weed control allows plants to produce more tillers, but the minimum number of stands in weed control is probably due to close weed competition. This is consistent with Brown *et al*. (2009) and Mischler *et al*. (2010) who concluded that stands count were increased in plots with few weeds.

Table3. *Effect of herbicides on stand count and ear per plant in maize at Holeta and Ejere*

Weed control treatments	Stand count m^2		Cob/plant	
	Holeta	Ejere	Holeta	Ejere
S-Maspor 960 EC	89.3a	90a	2	2
Primagram gold 660 SC	80b	80.6b	2	2
Twice hand weeding	74b	74.6c	2	2
Weed free	87.3a	88a	2	2
Weedy check	27.3c	26.6d	2	2
LSD (5%)	7.19	5.52	NS	NS
CV (%)	5.33	4.07	0.0	0.0

Cob per plant

The use of different herbicides resulted in statistically insignificant (P> 0.05) differences in corn ears at both locations (Table 3). This meant that the genetic potential of the crop had a greater effect on ears per plant than the use of herbicides. This is consistent with Khatami*et al*. (2013) and Samant *et al*. (2015) who concluded that the number of ears per plant is more influenced by genetic potential but little by other factors.

Thousand kernels weight

The use of different herbicides did not significantly (P>0.05) affect the thousand kernels weightin all tested locations (Table 4). This meant that the cultivars had a greater effect on 1000-grain weight than the treatments used. This is consistent with Muhammad *et al*. (2006) and Galon *et al*. (2018), who found that 1000-grain weight can vary between cultivars.

Grain yield

Grain yield was significantly (P≤0.05) affected by the use of different herbicides (Table 4). Weed control significantly and consistently increased grain yield. Thus, the average grain yield of S-Maspor 960 EC, Primagramgold 660 SC, hand weeded twice, weed free exceeded the average grain yield of the weedy check by 9.06, 13.84, 5.95, 9.65, 5.21 , 8, 18.13 folds in Holeta and Ejere respectively. The highest grain yield suggested that better weed control allows the plant to use more growth resources, but the lowest grain yield under weed control is likely due to abundant weed competition. This is consistent with Ali *et al*. (2011), Khan *et al*. (2012) and Shah *et al*. (2018) who reported that the highest grain yield was obtained where weed competition for nutrients and water was minimal.

Table4. *Effect of herbicides on thousand kernel weight, grain yield, and yield loss in maize at Holeta and Ejere*

Weed control treatments	100 kernel Weight (g)		Grain yield (kg ha^{-1})		Yield loss (%)	
	Holeta	Ejere	Holeta	Ejere	Holeta	Ejere
S-Maspor 960 EC	234	234	4186a	4200a	1.49e	34.5e
Primagram gold 660 SC	222	221	2894c	3016c	31.8c	29.02c
Twice hand weeding	212	214	2585d	2600d	39.17b	38.8b
Weed free	223	224	3750b	3716b	11.76d	12.5b

Weedy check	218	218	416e	283e	90.19a	93.3a
LSD (5%)	NS	NS	177.74	314.85	4.17	48.16
CV (%)	5.94	5.94	3.41	6.05	6.35	1.4

Yield loss

The use of different herbicide treatments significantly (P≤0.05) affected yield loss (Table 4). The use of herbicides significantly and consistently reduced yield loss. Thus, S-Maspor 960 EC, Primagramgold 660 SC, twice hand weeding, weed free reduced the average yield losses by 88.7%, 58.8%, 58.39%, 64.28%, 51.02. %, 54.5%, 78.43%, 80.8% as compared to control plots in Holeta and Ejere respectively. Minimal yield loss meant that minimal weed competition, which allowed plants to use more growth resources, resulted in higher grain yields, while the highest yield loss with weed control was likely due to strong weed competition. Similarly, Shah et al. (2018) reported that the lowest yield loss was achieved where weed competition for nutrients and water was minimal. Moreover, Gantoli et al. (2013) and Safdar et al. (2015) concluded that the main yield loss was due to severe crop-weed competition for growth resources.

4. Conclusion

Maize production is drastically reduced due to biotic and abiotic factors. Determining the critical competition period has a significant effect on corn yield and yield components. The use of promising herbicides improved the reduction of weed dry weight, the weed control efficiency, the number of stands, the weight of 1000 grains, the yield of grain and the minimum yield loss. Treating of fields with S-Maspor 960 EC gave excellent results in terms of stand count, grain yield and significantly reduced yield loss. The weed free application also resulted in a decrease in weed dry weight and an increase in weed control efficiency, followed by the application of S-Maspor 960 EC. On the contrary, the result further showed that number of cob per plant and thousand grain weights were shown to be statistically insignificant among all tested herbicides. In conclusion, it is recommended to treat the field with S-Maspor 960 EC for effective control of weeds in maize. Decisions to prevent corn production loss due to weeds should focus on combining an early harvest with low infestation, manipulation of planting date, using promising herbicides soon after planting or early vegetative growth of the plant, and avoiding cultivation of corn varieties that compete poorly with weeds.

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