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Evaluation of Broad Spectrum Herbicides for Control of Annual Broad Leaf Weeds in Wheat

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Abstract – **Wheat is one of the most important food crops of the world. However, its production and productivity has been limited due to various abiotic and biotic factors including weeds. The aim of this study was to investigate the effects of post emergence broad leaf herbicides application on management of weeds and increasing productivity of wheat. Treatments consisted of three post emergence broadleaf herbicides; Weedban 40 % WDG @ 75g/ha, Agro 2,4-D 720 g/L @ 1L ha^{-1}, Pallas 45 OD @ 0.5L ha^{-1} along with weed free and a weedy check that were laid out in RCBD with three replications. The field was infested with eight weed species in which six species were annual broadleaf weeds and two species were annual grasses. The tallest plants were recorded from weedy check plots while shortest plants were recorded at Agro 2, 4-D amine salt 720g/l. Results also showed all traits were significantly affected by application of different weed control treatments. There was no dry weed biomass at weed free plots and also the highest weed control efficiency (99.89%) was recorded from application of weed free while no weed control at weedy check. Maximum stand count and thousand grain weight recorded from application Pallas 45 OD and weed free while lowest values were obtained at weedy check. The maximum numbers of tillers per plant were recorded at all treatments other than Agro 2, 4-D 720g/l and weedy check. Moreover, the maximum number of spike length (9.25cm), seeds per spike (72.33), thousand grain weight (47.00g), grain yield (4873.30kg/ha) were recorded from Weed ban 40% WDG while the lowest values were observed from the weedy check. Therefore, it can be concluded that application of Weedban 40% WDG effectively managed weeds and gave better grain yield which could be recommended for the test environment.**

Keywords – **Broadleaf, Effect, Herbicides, Maximum, Minimum.**

I. INTRODUCTION

Wheat (*Triticum aestivum* L.*)* is one of the most important food crops of the world and a member of the family Poaceae that includes major cereal crops of the world such as maize, wheat and rice (Bekele *et al*., 2018). Ethiopia is the largest wheat producer in sub-Saharan Africa. In Ethiopia, wheat is the most important cereal crop in terms of the area of land allocated, volume produced and the number of farmers engaged in its production (Luchia *et al*., 2018). Proper weed control measure at optimum growing period could increase the productivity of wheat. Kamrozzaman *et al.* (2015) found that weed control efficiency depends on weed control method, time of weeding and nature of weeds and crops. High weed infestation may cause complete crop failure. Moreover, Sarfadar *et al*., (2013) investigated that the cost of removing weeds adds to the cost of production of crops thus producers losses part of their investment and the country suffers a reduction in agricultural products.

Various production constraints among which weeds are frequently occurring as production constraints in which its effect is aggravated by traditional cultural methods that the farmers are practiced. Weeds have strong competition with the wheat crop for light, nutrients, and moisture which adversely affect the wheat production. Therefore, continuous effort is needed to keep the weed population under control (Shah *et al*., 2018).

Weeds can be suppressed in wheat through variety of techniques as single method of weed control is not sustainable in our country (Shigute *et al*., 2019). However, due to ignorance and lack of knowledge the farmers carelessly apply herbicides without considering its economics, resistance health and environment. However, herbicides are generally over used and the rather indiscriminant use of herbicides has led to health and environmental concerns (Haile and Girma, 2010). Various methods that are most widely used in the country for controlling weeds are physical, mechanical, cultural and chemical (Muhammad *et al*., 2014). Current weed control practices suggested that herbicide control is now the merely option in many situations because of the high level of infestation and the scarcity and cost of labor for hand rouging. Continuous use of herbicides with similar mode of action may create persistent and herbicide résistance weeds. However, it is necessary to evaluate new herbicides product against various weeds in wheat. Therefore, this study was designed to investigate the effects of post emergence broadleaf herbicides application for management of weeds and increasing productivity of wheat.

II. Materials and Methods

2.1. *Description of the Study Area*

Field experiment was conducted during the 2020/2021 main cropping season under rain fed conditions at Holeta Agricultural Research Center and Medegudina locations. Holeta is located 33km west of Addis Ababa at an elevation of 2400 m.a.s.l and within the geographic coordinates of 9^{o} 00′N and 38^{o} 30′E. The area receives annual rain fall of 1144 mm with mean minimum and maximum temperatures of $6^{o}C$ and $22^{o}C$ respectively (EIAR, 2018). The soil of the experimental field is clay loam with p^{H} of 6.65, organic carbon (2.26%), available Phosphorus (14.17mg kg^{-1}), total nitrogen (0.12%) and cation exchange capacity of (17 Cmol kg^{-1}) (EIAR, 2018). The edaphic and climatic conditions observed during trial period were favorable for the growth of numerous weed species that competed with the crop. The climatic conditions observed during the trial period mean rain fall of 1114.5 mm relative humidity 78.8% with mean minimum and maximum temperatures of $8^{o}C$ and $25.2^{o}C$, respectively. Medegudina is located 5km from Holeta main station which received almost similar agro ecology with Holeta.

2.2. *Treatments and Experimental Design*

The treatments comprised of four types post emergence herbicides Weedban 40% WDG 75 g/ha, Agro 2, 4-D amine 720g/L 1L/ha, Pallas 45 OD 0.5 L/ha, weed free and weedy check. The experiment was laid out in a Randomized Complete Block Design with three replications in which tested locations were used as replications.

2.3. *Experimental Procedure and Crop Management*

The experimental fields were ploughed twice with tractor followed by harrowing to make fine seed bed. Plot sizes of 5m x 4 m (20 m^2) were used as the experimental unit accommodating 20 rows of each 5m long. Well known bread wheat variety (*Dendea)* was used as a test crop. Seeds were drilled in well prepared rows at 20 cm spacing between rows on July 1^{st}, 2020. Fertilizers were applied based on recommended rate of 55 kg ha^{-1} of N and 182 kg ha^{-1} of P_2O_5 that were applied in the form of Urea (46% N) and NPS (19% N, 38% $P_2O_{5,}$ 7% SO_2) respectively. Nitrogen fertilizer was applied at two doses (split application) i. e 1/3 of it was applied at time of sowing by mixing with full dose of Nitrogen and the remaining 2/3 was applied at tillering stage. All herbicides were applied as post emergence stage (30 DAE) with the help of knapsack sprayer nozzle size of 350um while the volume of water was 200L/ha^{-1} pressurized at 40psi. All other management practices were uniformly applied to all plots as per the recommended practices.

2.4. *Data Collection*

Weed species identification was done by comparing individual species with predetermined weed species in the herbarium. The aboveground dry biomass of weeds was done by cutting weeds from each quadrat placed into paper bags and then oven dried at a 65^{0}C for 48 hours and finally the dry weights were measured. Weed control efficiency (WCE) was determined by the following formula $\text{WCE}\ (\%) = \frac{\text{WDC}-\text{DWP}}{\text{WDC}} \text{X}100$, where, WCE = Weed Control Efficiency, WDC=Weed Dry weight in Control Plot and DWP = Weed Dry weight in Particular treatment (Davasenapathy *et al*., 2008).

Plant height was taken with a meter from 4 randomly taken and pre-tagged plants in each net plot area from the plant base to the tip of the spike excluding of awns at physiological maturity and the average was used for the analysis. Spike length was taken with a ruler from 4 randomly selected plants in each net plot area from the base of the spike to the tip of the spike excluding of awns at physiological maturity and the average was used for the analysis.

Stand count was performed by counting total number of plants in quadrat and calculated on m^2 area basis. Number of fertile tillers were counted from five rows with the length of 1 m randomly taken in each net plot area and was converted into m^2 at harvest. Number of seeds per spike was determined from randomly selected 4 spikes per plot and their average calculated. Thousand grain weights were counted from the bulk of threshed produce from the net plot area and their weight recorded. Grain yield was measured after threshing the sun dried plants harvested from each net plot and the yield was adjusted at 12.5% grain moisture content (Amare *et al.*, 2014).

2.5. *Statistical Analysis*

Data of each parameter was summarized and arranged before subjected to SAS software. The means of each data was checked by the normality test depending on Shapiro test (Pr < W) before analysis of variance using the GLM procedure of SAS (SAS 9.3 version).When the treatment effects were significant, means were compared using Fisher's LSD test at 5 % level of significance (Gomez and Gomez, 1984).

III. Results and Discussion

3.1. *Composition of Weed Flora*

The experimental field was infested with different weed species that were categorized under five major families. Out of total identified weed species, six species were annual broad leaf weeds but only two species were annual grasses which showed that the field is dominated by annual broadleaf weeds (Table 1).

Table 1. Weed species, families and life form in the experimental field.

Weed Species	Families	Life Form
Polygonum nepalense L.	Polygonaceae	Annual (broadleaf)
Galinsoga pulviflora Cav.	Compositae	Annual (broadleaf)

Weed Species	Families	Life Form
Guizotia scabra (Viz) chiov	Compositae	Annual (broadleaf)
Spergula arvensis L.	Caryophylaceae	Annual (broadleaf)
Cotula australis (Sieber ex spreng.) Hook. f. APNI	Asteraceae	Annual (broadleaf)
Anagalis arvensis L.	Caryophylaceae	Annual (broadleaf)
Phalaris paradoxa L.	Poaceae	Annual (grass)
Setaria pumila L.	Poaceae	Annual (grass)

3.2. *Dry Weed Biomass*

Dry weed biomass was significantly affected by application of different broadleaf herbicides (Table 2). There was no dry weed biomass was recorded from application of Weed free plots at both locations while the maximum weed dry weight (2251.67 kg/ha) was recorded from weedy check plots at all tested locations. There is no statistically significant differences was observed due to application of Agro 2, 4-D amine salt 720g/l and Pallas 45 OD at both locations. The minimum dry weed biomass from application of Weed free implied that complete removal of weeds from plots consequently resulted in reduced dry weed biomass. Megersa *et al*. (2017) reported in barley that the lowest dry weight recorded was due to removal of most of the weed plants there which suppressed density of weeds and resulting into a lower competition between the crop and weeds for resources.

3.3. *Weed Control Efficiency*

Weed control efficiency was significantly affected by application of different weed control treatments (Table 2). The maximum weed control efficiency (100%) was recorded from application of Weed free but no weed control efficiency at weedy check plots at all tested locations. There is no statistically significant differences was observed due to application of all weed control treatments other than weed free and weedy check at both locations. The maximum weed control efficiency from application of Weed free plots due to minimum weed dry biomass. Megersa *et al.* (2017) also reported in barley that the reduction in weed dry weight might be due to the inhibition effect of treatments on growth and development of weeds.

Table 2. Effects of broad leaf herbicides on dry weed biomass and weed control efficiency.

Weed Control Treatments	Dry Weed Biomass (kg/ha)		Weed Control Efficiency (%)	
	Holeta	Medegudina	Holeta	Medegudina
Weedban 40% WDG	106.67c	16.67c	95.29a	99.25a
Agro 2,4 - D amine salt 720g/l	220.00b	220.00b	90.22a	90.22a
Pallas 45 OD	200.00b	200.00b	91.11a	91.11a
Weed free	0.00d	0.00c	100b	100b
Weedy check	2251.67a	2251.67a	0.00c	0.00c
LSD (5%)	50.34	61.80	0.04	1.12

Weed Control Treatments	Dry Weed Biomass (kg/ha)		Weed Control Efficiency (%)	
	Holeta	Medegudina	Holeta	Medegudina
CV (%)	4.81	6.10	0.03	0.02

3.4. *Plant Height*

Plant height was significantly affected by application of different weed control treatments (Table 3). The maximum plant height (111.67cm) was recorded at weedy check while the minimum plant height (85.42cm) was recorded from application of Agro 2, 4-D amine salt 720g/l. at Holeta. The result also showed that statistically no significant difference was observed due to application of Pallas 45 OD and weed free at both locations. This indicated that plant height was more influenced by genetic than weed control treatments. Bekele *et al*. (2018) investigated that the increased plant height with the weedy plot might be due to the effect of severe competition among plants which make them elongated in search of light and lack of availability of plentiful of growth encouraging factors in weedy plot that allowed the plants to increase in height, the competition between weeds and crop for sun light and space in un weeded plots resulted in taller plants.

3.5. *Stand Count*

Crop stand count was significantly affected by application of different weed control treatments (Table 3). The maximum stand count (528m$^{2)}$ was observed from application of Pallas 45 OD and Weed free plots at both tested locations but the minimum number (144.67m^2) was recorded from weedy check plots. There is no statistically significant differences were observed between application of Weedban 40% WDG, Pallas 45 OD and weed free at all locations. The maximum stand count from application of Pallas 45 OD and Weed free implied that better weed control that enable the plants to produce more number of tillers but the minimum number of stand count at weedy check probably due to severe competions of weeds.

Table 3. Effect of broad leaf herbicides on plant height, stand count, number of fertile tillers and spike length.

Weed Control Treatments	Pant Height (cm)		Stand Count (m^2)	
	Holeta	Medegudina	Holeta	Medegudina
Weedban 40% WDG	102.50b	102.50c	493.33a	493.33a
Agro 2,4 - D amine salt 720g/l	85.42c	95.33b	317.33b	317.33b
Pallas 45 OD	108.75a	108.75b	528.00a	528.00a
Weed free	108.75a	108.75b	528.00a	528.00a
Weedy check	111.67a	113.33a	144.67c	144.67c
LSD (5%)	3.32	2.87	36.02	36.03
CV (%)	1.71	1.44	4.75	4.75

3.6. *Tillers per Plant*

Tiller per plant was significantly affected by application of different weed control treatments (Table 3). The maximum number of tillers was recorded from application of all weed control treatments other than Agro 2, 4-D amine salt 720g/l and weedy checks at all tested locations while the minimum number of tillers (4.00) was recorded from weedy check plots at Holeta and Medegudina. There is no statistically significant differences was observed due to application of Weed ban 40% WDG, Pallas 45 OD and weed free at all locations. The maximum number of tillers from application of Weed ban 40% WDG, Pallas 45 OD and Weed free implied that better weed control that enable the plants to utilize more growth resources but the minimum number of tillers at weedy check probably due to severe competions of weeds for growth resources. Bekele *et al*. (2018) stated that the production of more total tillers at weed free plot might be attributed to better access of space, nutrient, water and light that enabled plants to produce more tillers m^{-2} and reduction in tiller number m^{-2} was probably the increased weed population and continuous competition reduced access to different resources.

Table 4. Effects of broad leaf herbicides on tillers per plant and spike length.

Weed Control Treatments	Tillers Per Plant		Spike Length (cm)	
	Holeta	Medegudina	Holeta	Medegudina
Weedban 40% WDG	7.75a	7.75a	9.25a	9.25a
Agro 2,4 - D amine salt 720g/l	5.83b	6.00b	7.75a	7.75a
Pallas 45 OD	7.75a	7.50a	8.00a	8.00a
Weed free	7.75a	8.08a	8.00a	8.00a
Weedy check	4.00c	4.00c	4.50b	4.50b
LSD (5%)	1.01	1.09	1.62	1.63
CV (%)	8.07	8.64	11.52	11.52

3.7. *Spike Length*

Spike length was significantly affected by application of different weed control treatments (Table 3). The maximum spike length (9.25cm) was recorded from application of Weed ban 40% WDG but the minimum number (4.5cm) was recorded from weedy check plots. There is no statistically significant variation was observed due to application of all weed control treatments except for weedy check at all tested locations. The maximum stand count from application of Weed ban 40% WDG implied that better weed control that enable the plants to utilize more growth resources but the minimum spike length at weedy check probably due to severe competions of weeds. Bekele *et al.* (2018) concluded that this longest spike length could be due to the lower dry weight of weeds at treated plots that probably led to better resources (water, light, nutrients) and enhanced spike length.

3.8. *Seeds Per Spike*

Seeds per spike were significantly affected by application of different weed control treatments (Table 4). The maximum number of seeds per spike (72.33) was recorded from application of Weed ban 40% WDG while the minimum number (22) was recorded from weedy check plots at all locations. There is no statistically significant differences was observed due to application of Agro 2,4 - D amine salt 720g/l and Pallas 45 OD at both locations. The maximum seeds per spike from application of Weed ban 40% WDG implied that better weed control that enable the plants to utilize more growth resources but the minimum spike length at weedy check probably due to severe competions of weeds. Kamrozzaman *et al*.(2015 determined that lowest grain per spike might be due to severe infestation of weeds and lower amount of assimilate production by this treatment resulting in lower availability of resources and yield.

Table 5. Effects of broadleaf herbicides on seeds per spike, thousand grain weight and grain yield.

Weed Control Treatments	Seeds Per Spike		Thousand Grain (gm.)		Grain Yield (kg/ha)	
	Holeta	Medegudina	Holeta	Medegudina	Holeta	Medegudina
Weedban 40% WDG	72.33a	72.33a	46.66b	47.00a	4856.70a	4873.30a
Agro 2,4 - D amine salt 720g/l	64.00c	64.00c	40.26b	40.26b	3015.10b	3011.30c
Pallas 45 OD	63.00c	63.00c	46.80a	46.80a	3362.00b	3362.00bc
Weed free	68.66b	68.67b	46.80a	46.80a	4008.00b	4354.00b
Weedy check	22.00d	22.33d	24.26c	24.27c	102.70c	1102.70d
LSD (5%)	3.51	3.51	1.42	1.14	1304.40	1233.30
CV (%)	3.21	3.21	1.86	1.47	21.19	19.60

3.9. *Thousand Grain Weight*

Thousand grain weights were significantly affected by application of different weed control treatments (Table 4). The maximum thousand grain weights (47.00g) were recorded from application of Weedban 40% WDG at Medegudina whereas the minimum values (24.26g) was recorded from weedy check plots at both locations. The maximum thousand grain weight at Weedban 40% WDG treated plots implied that better weed control that enable the plants to utilize more growth resources but the minimum spike length at weedy check probably due to severe competions of weeds. Muhammad *et al*. (2006) identified that the probable reason for higher grain weight in plots where weed control practice was carried out was due to lower weed density which reduced the competition between wheat plants and weeds for nutrients, light, moisture and space relating in maximized utilization of resources by crop plants.

3.10. *Grain Yield*

Grain yield was significantly affected by application of different weed control treatments (Table 4). The maximum yield (4873.30kg/ha) and 4856.70 kg /ha were recorded from application of Weed ban 40% WDG at Medegudina and Holeta respectively while the minimum values (102.70 kg/ha) was recorded from weedy check plots. There is no statistically significant variation was observed due to application of all other weed control treatments except for Weed ban 40% WDG and weedy check at Holeta. The maximum Grain yield from application of Weed ban 40% WDG implied that better weed control that enable the plants to utilize more growth resources but the minimum grain yield at weedy check probably due to severe competions of weeds. Shah *et al*.(2018) reported that the maximum grain yield was obtained where minimum weed crop competition for nutrients and water was existed.

IV. CONCLUSION

Wheat is one of major food grains that can be cultivated from small to large scale farms in Ethiopia. Weed management practices such as post emergence herbicides are among the important methods for the management of weeds to improve wheat production and productivity. Therefore, this study was designed to investigate the effects of post emergence broadleaf herbicides application for the management of weeds and increasing productivity of wheat.

All of the traits studied were significantly affected by different weed control treatments. The result also revealed that application of weed free caused better performance on dry weed biomass and weed control efficiency but no weed control at weedy check. The maximum number of spike length, seeds per spike, thousand grain weight and grain yield were obtained from application of Weed ban 40% WDG whereas the maximum plant height was recorded at weedy check. Broad spectrum herbicides more advantageous than narrow spectrum herbicides for better weed management and gaining maximum yield. Therefore, application of all Weedban 40% WDG 75g/ha is recommended for controlling various broadleaf weed species in wheat field at tested locations.

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Bogale Ayana, was born on 12th November, 1988 G.C in Oromia region, South West Shewa Zone, Weliso woreda. I started primary school in Maru Korme and Dilela primary Schools from 1998 to 2005 G.C. and also went to Dejazmach Geresu Duki Comprehensive Secondary High school and Preparatory school at Weliso town from 2006-2009 G.C. I also attended higher education from 2010-2012 G.C at Ambo university and graduated with bachelor of science degree in plant science from faculty of agriculture in 2012 G.C. He has been employed at Ethiopian Institute of Agricultural Research at Holeta Agricultural Research Center and served at various capacities from May, 2014 G.C. to September, 2018 G.C. as junior and assistance researcher for three years and five months. I got the chance learning to pursue MSc. d--egree in plant protection at Jimma University, College of Agriculture and Veterinary Medicine in October 2018 G.C. Now days, I am working as Researcher and weed science research programs coordinator at Holeta Agricultural Research Center.