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Evaluation of Sequential Application of Herbicides for Broad and Grass Weed Management in Durum Wheat, Ethiopia

Zahara Mohammed[1], Shugute Addisu[2]

[1]Ethiopia Institute of Agricultural Research, Debre Zeit Agricultural Research Center, Debre Zeit, Ethiopia

[2]Department of Crop Protection, Debre Zeit Agricultural Research Center, Debre Zeit, Ethiopia

Email address:
zehara2008@yahoo.com (Z. Mohammed), ashugute@yahoo.com (S. Addisu)

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Abstract: Studies were carried out on the evaluation of Sequential Application of herbicides for broad and grass weed management in durum wheat at Debre Zeit, Akaki and Alem Tena Districts, Oromia Regional State, Ethiopia under main season condition, during 20012-14 for two years to evaluate the efficacy of different post emergence herbicides on weeds. The experiment was laid out in Randomized Complete Block design (RCBD) with three replications, with plot size of 3.60m x 4m ($14.4m^2$). Four different herbicides were applied as post emergence via: 2, 4-D and Flurasulam (75g/L, Flumelsulam (100g/L) (Derbi175 SC) herbicides were applied at 28days after crop emergence with rate of (1 L/ha and 0.06L/ha) respectively, Pyroxsulam (Pallas*45 OD) and Mesosulfuron methyl+Iodosulfuron methyl sodium (Atlantis 37.5 OD) at 35days after crop emergence with rate of (0.45 L/ha and 1 L/ha). Twice hand weeding as standard check and an untreated control was also included in the trial. All herbicides significantly decreased weed population over control and maximum grain yield were recorded from sequential herbicidal applications of 2, 4-D and Pyroxsulam, followed by Flurasulam (75g, Flumelsulam (100g/l) (2849 and 2818 kg/ha) respectively. All the herbicidal applications out yielded the control. It is thus recommended that an integration of Pyroxsulam (Pallas*45 OD) and (Mesosulfuron methyl+Iodosulfuron methyl sodium) Atlantis 37.5 OD and 2, 4-D and Flurasulam (75g/L, Flumelsulam (100g/L) (Derbi175 SC) for offering control of broad leaf and grassy weeds and increase grain yield of wheat.

Keywords: Weed Control, Broadleaf and Grassy Weeds, Herbicides

1. Introduction

Ethiopia is major producer of wheat in East Africa (>700,000 ha) accounting for over 70% of total wheat area in the region. The most important wheat growing areas are located in the highlands (i.e.,>2000 m.a.s.l.) characterized by a mean annual rainfall>1000 mm, mean annual temperatures between 16 and 200C of wide range of soil condition in Ethiopia. The temperature, rainfall and altitude hospitable to wheat production are located in the south-eastern highlands of Ethiopia that shares 75% of the total wheat production area of Ethiopia. In recent years, wheat became one of the most important cereal crops in Ethiopia ranking 3rd in total grain production (17.02%) next to tef. Durum wheat (*Triticum turgidum* L. var Durum) is the second most cultivated wheat species in the world, next to common wheat (Woyema., et al).

Weed infestation has been reported as a major constraint to wheat production in Ethiopia in both the peasant and the state farm sectors. One of the earliest surveys found that in peasants' wheat fields in Arsi region the weed population reached 743 weeds per square meter in contrast to a crop stand of only 149 wheat plants per square meter. The peasant sector has been almost entirely dependent on cultural practices for weed control, while the state farms consider herbicides an essential component of wheat production. Research in weed control methods in wheat production at Kulumsa Research Center in Arsi region, in 1969 at the Holetta Research Center in western Shewa and in 1970 at the Debre Zeit Agricultural Research Center. Minor emphasis

was given to screening broadleaf herbicides in the first decade of research, as the phenoxy compounds provided adequate control. Subsequent to the shift in the weed spectrum towards phenoxy-tolerant broadleaf species, broadleaf herbicide screening increased in the early 1980s (Tanner and Giref, 1991).

Bekele et al (2000) study on Wheat Technologies shown that both adopters and non-adopters reported that broadleaf and grassy weeds were equally important in their wheat fields. About 95% of adopters and 93% of non-adopters controlled weeds by hand, whereas 87% of adopters and 61% of non-adopters used herbicides. The average number of hand weeding was 1.7 and 1.8 for adopters and non-adopters, respectively. While only 18% of adopters and 5% of non-adopters hand weeded on the basis of the Oromia Agricultural develop Bureau recommendation, 42% and 33%, respectively, were aware of the recommended weeding frequency. The main constraints to frequency of hand weeding for adopters were labor shortage (74.5%) and lack of cash to hire labor (59.6%). Similarly, the main constraints for non-adopters were labor shortage (68.2%) and lack of cash to hire labor (60.6%).

Responses by the farmers to weed infestation cover different approaches, including hand weeding, although it is highly demanding for time and labor. Some researchers have mentioned the use of herbicides also influence on seed number and species composition of the seed bank such that depending on the herbicide under use while certain species in the seed bank decrease others may increase (Robert and Neilson, 1981).

In addition hand weeding is the most common weed control method used by small-scale farmers. It usually requires no capital outlay. This is a major advantage when cash is not readily available and labour is provided from the farmer's immediate family or through non-cash exchange. However, it is time and labour-consuming. Therefore, to increase agricultural production and to reduce the time and cost of weeding operations, there is an urgent need to reduced hand-weeding dependency and develop Herbicide application methods at the correct time. Hence this study is a meant to enlighten the potential of combined herbicides on broad and grass weeds management and compare the effect of herbicide against hand weeding on common weed species of Durum Wheat to enhance durum wheat yield by reducing weed infestation level using appropriate weed management options.

2. Materials and Methods

An experiment was laid out at Debre Zeit, Akaki and Alem Tena Districts, Oromia Regional State, Ethiopia under main season condition, during 20012-14 for two years, to study the effect of herbicides against broad leave and grassy weeds. The experiment was laid out in Randomized Complete Block Design having three Replications with a total area of 16.80m x 32m (537.6 m^2) with Plot size of 3.60m x 4m (14.4m^2) and footpaths of 0.5 between plots and 1m between replications was used. The wheat variety was ude at the rate of 150kg per hectare. A recommended dose of DAP and Urea fertilizers were applied. Nitrogen fertilizer was applied in two splits; two-third Urea & whole of DAP were applied at the time of seedbed preparation seedbed preparation and was thoroughly mixed into soil by ploughing. The 2^{nd} (1/3) of Urea was applied at 25 days after planting. All other cultural practices were kept according to Departmental recommendation, during the course of studies for all the treatments. The treatments were consisted of three types of herbicide application and hand weeding. Flurasulam (75g/L, Flumelsulam (100g/L) i.e. Derbi 175Sc herbicides was applied at 35 after crop emergence as post herbicide with rate of (60ml/ha), Pyroxsulami.e. Pallas*45 OD at 35 DAE (0.45L/ha), 2, 4-D at 28 DAE ((1 L/ha), Mesosulfuron methyl + Iodosulfuron methyl sodium i.e. Atlantis 37.5 OD at 35 DAE (1 L/ha) with manually pumped Knapsack sprayer. Twice hand weeding as standard check were done at 30 and 55 days after crop sowing and weedy check as control. The detail of treatments applied was discussed in Table-1.

The treatments were applied 30-35 days after sowing and the weed dynamics data were recorded at 30 days and 30 days after treatment. The data were recorded on weed infestation using quadrant size 0.5 x 0.5mand growth and yield parameters of wheat like number of weeds before and after spray of herbicides, weed dry and green biomass plant height (cm), crop biomass and yield (kg ha^{-1}). The data for each parameter were individually subjected to analysis of variance (ANOVA) version 9.5 at probability significance level of α=0.05 and means were separated by using least significance difference (LSD) Test.

Table 1. *Detail of post emergence herbicidal treatments used in wheat experiment.*

No	Trade name	Common name	Dose ha^{-1}
1	Agro-2,4-D amine 720g/l A. E*	2,4-D	1L
2	Derby 175 SC	Flurasulam 75 G/L+flumetsulam 100 G/L SC	0.06L
3	Pallas 45 OD	Pyroxsulam	0.45L
4	Atlantis 37.5 OD	Mesosulfuron methyl + Iodosulfuron methyl sodium	1L

3. Result and Discussion

Results of the combined analysis of variance for all measured parameters are summarized in Table 3. Data on the general revealed that for both broad and grass weed species shows significant difference (P<0.05) across all experimental plots of each site after treatment application. However, the test herbicides including the standard check treatments showed high differential response for the general weed control scores, density of individual weed species, and biomass weight of weed species. The least significant crop density was recorded from the weedy check plots where the weed population stand was the highest. There were significant differences (P<0.05) in crop biomass and grain

yield of wheat among the herbicide treatments but yield in the weedy check treatment was significantly reduced (P<0.001). More or less there were no site (location) variations observed on the efficacy of the test herbicides and the standard check treatment against broad and grass weed species.

3.1. Visual Observation

Table 2. *The major problematic (infesting)broad leaf and grass weed species observed through the experimental season at study area.*

No	Botanical Name	Family	Local name
1	*Convolvulus arvensis*	Convolvulaceae	*Tatu*
2	*Cichorium intybus*		-
3	*Setaria pumila*	Poaceae	yewusha sindedo; metene
4	*Cyperus esculentus*	Cyperaceae	Ingicha
5	*Argemon aurculutes*	Papaverceae	Abba kore
6	Sorghum *arundinacensis*	Poaceae	-
7	Eragrostis cilianensis	Poaceae	-
8	*Phalaris paradoxa*	Poaceae	asendabo
9	Raninculus arvense	Asteraceae	

Plots treated by sequential herbicides were free from most problematic weed species mentioned above and others however; to some extent *Convolvulus* and *Cichorium were* escaped and lately emerge since these weeds are hard and perennial characteristics so it needs further study for these individual species.

3.2. Number of Weeds Before Spray

The examination of data in Table-1show that the experiment was infested with several broad leaf and grass weed species. The family Poaceae pre-dominated the other families having 4 species viz. *Setaria pumila*, *Phalaris paradoxa*, Eragrostis cilianensis, and Sorghum *arundinacensis*. The rest all families were represented by single species each. Data concerning number of weeds before spray m^2 showed least significant differences among the different treatments (Table-3). Comparative study of the means showed that maximum number of weeds before spray (19.27 m^2) were counted in Flurasulam (75g, Flumelsulam (100g/l) @ 1l ha-1 was going to be applied followed by Mesosulfuron methyl+Iodosulfuron methyl sodium@ 1l ha-1 (17.05), as compared to control where least number of weeds before spraym^2 (14.30) were recorded. There was a arbitrary variability among the remaining treatments (Table-3).

3.3. Weed Density (m^2)

Data concerning number of weeds after spray m^2 showed significant differences among the treatments under study (Table-3). As study of the means revealed that minimum number of weeds after spray (4.7m^2) were counted in treatment twowere2, 4-D+Pyroxsulam @ 1Land 0.45Lha-1 was applied, respectively followed by treatment 3 (6.18m^2) where Mesosulfuron methyl+Iodosulfuron methyl sodium was applied @ 1L ha-1 as compared to control (48.5m^2).

3.4. Weed Score

The analysis of variance indicated that weed count after spray and weed infestation level were significantly (P<0.05) suppressed by all sprayed combined herbicide to all locations during the cropping season (Table 3).

3.5. Crop Height (cm)

The analyses of data regarding crop height showed highly significant differences among the treatments (Table-3). The study of the means showed that maximum crop height (72.8cm) was achieved in weedy check. There was least significance among herbicidal treatments.

3.6. Grain Yield (kg ha^{-1})

The analysis of data concerning grain yield revealed significant differences among the different treatments as presented in Table-3. The study of the means showed that maximum grain yield (2849 kg ha-1) was achieved in treatment one where Flurasulam (75g, Flumelsulam (100g/l)+Pyroxsulam@1l and 0.45l ha-1 was applied, respectively. It was however, statistically comparable with all treatments particularly (Mesosulfuron methyl+Iodosulfuron methyl sodium @ 1l ha-1) and Mesosulfuron methyl+Iodosulfuron methyl sodium with grain yield of 2818 kg, 2796kg ha-1, respectively except weedy check.

Minimum grain yield of 1200kg ha-1 was obtained from weedy check where no herbicide was applied (Table-3). The percentage increment (57.88, 57.088, 54.94, 49.48,, and 53.74%) in grain yield was observed in Flurasulam (75g, Flumelsulam (100g/l)+Pyroxsulam, Mesosulfuron methyl+Iodosulfuron methyl, 2, 4-D+Pyroxsulam, Twice Hand weedingandFlurasulam (75g, Flumelsulam (100g/l)sodiumtreatments, respectively over control (Table-4).

3.7. Biomass

The other influenced weed parameters by herbicidal treatments in addition to above parameters were the green and dry biomass of the weeds. That means, the overall weed count means of herbicidal treatments were significantly lower than the controls (weedy check), the highest weed suppression were from Pyroxsulam+2, 4-D and twice hand weeding followed by Flurasulam (75g/L, Flumelsulam (100g/L)+Pyroxsulam herbicide; and the highest was from weedy check and single herbicide application either for grass or broad leaf purposes (Figure 1).

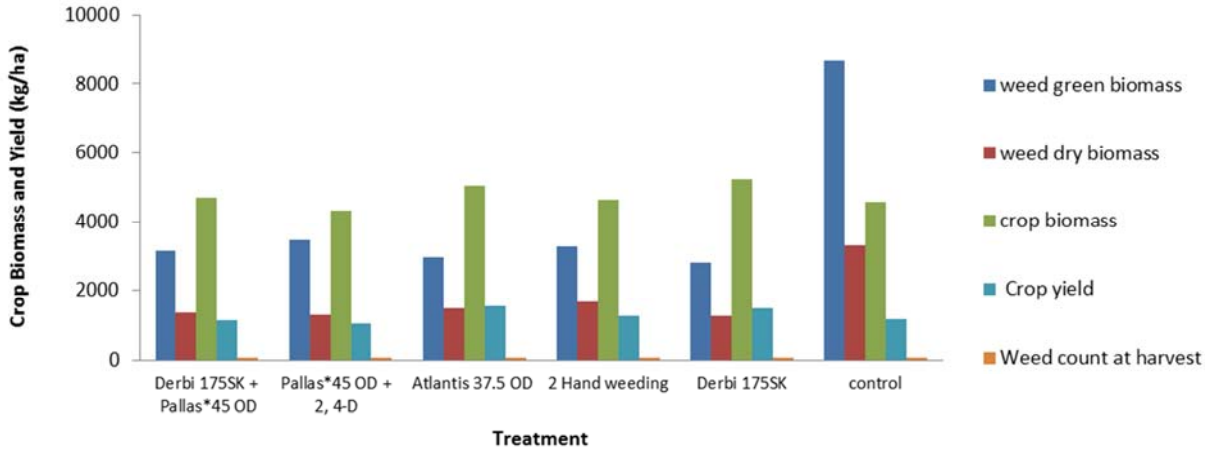

Figure 1. *Comparison of herbicidal effect with hand weeding and weedy check on different growth parameters.*

Table 3. *Main effect of herbicides on weeds and crop growth parameters (2012/13-2013/14)at Debre Zeit, Akaki and Alem Tena Districts, Oromia Regional State, Ethiopia.*

treatments	wbs	was	wi	wh	wg	wd	cb	ch	gy
Flurasulam (75g, Flumelsulam (100g/l)+Pyroxsulam	16.056b	6.5cb	1.66b	67.22a	821b	372.96b	7972a	66.852bc	2849.7a
2, 4-D+Pyroxsulam	16.222b	4.7c	1.66b	67.778a	816b	305.48b	7695a	64.259c	2663.6a
Mesosulfuron methyl+Iodosulfuron methyl sodium	17.05ab	6.167cb	2.127b	79.44a	1103b	362.04b	11513a	67.593bc	2796.3a
Flurasulam (75g, Flumelsulam (100g/l)	19.278a	10.944b	2.1b	76.1a	1053b	316.17b	7592a	67.593bc	2818.1a
Twice Hand weeding	16.44ab	7.667cb	1.97b	72.03a	3547ab	284.08b	7491a	67.593bc	2594.7a
Weedy check	14.278b	48.5a	5b	82.03a	5721a	1944.09a	2170b	72.8	1200.2b
LSD	2.9351	4.8599	0.4852	16.356	3152.2	163.4	4667.7	67.593	532.19
CV	18.5	36.02	20.89	23.03874	151.1609	28.54	65.79	7.29	22.33
Mean	16.55	14.08	2.42	74.1	2176.7	597.47	7405.48	68.37	2487.103

Means within columns not sharing the same letter show significance difference at $p < 0.05$.
Where:-wbs=weed before spray wh=weed height cb=crop biomass
was=weed after spray wg=weed green biomass ch=crop height
wi=weed infestation wd=weed dry biomass gy=grain yield

Table 4. *% Increase in grain yield of five different treatments over control.*

Treatments	Rate L/ha	Yield (kg/ha)	Additional yield (kg/ha)	% increase
Flurasulam (75g, Flumelsulam (100g/l)+Pyroxsulam	1+0.45	2849.7a	1649.5	57.88
2, 4-D+Pyroxsulam	1+0.45	2663.6a	1463.4	54.94
Mesosulfuron methyl+Iodosulfuron methyl sodium	1	2796.3a	1596.1	57.088
Flurasulam (75g, Flumelsulam (100g/l)	1	2818.1a	1617.9	49.48
Twice Hand weeding		2594.7a	1394.5	53.74
Weedy check		1200.2b	-	-

4. Conclusion

The data were collected on weed dynamics and growth and yield parameters of wheat like weed before spray (number/m^2), weed after spray (number/m^2), weed height (cm), crop height (cm), crop biomass (kg ha-1), weed green biomass (kg ha-1), weed infestation (scale 0-5), weed dry biomass (kg ha-1), grain yield (kg ha-1).

The study demonstrates that the overall weed count means of herbicidal treatments were significantly lower than the controls (weedy check), the highest weed suppression were from Pyroxsulam+2, 4-D and twice hand weeding followed by Flurasulam (75g/L, Flumelsulam (100g/L)+Pyroxsulam herbicide; and the highest was from weedy check and single herbicide application either for grass or broad leaf purposes. From the results of the present investigations we conclude that: annual weed species like (*Amaranthus hybridus, Argemon mexicana, Bindens pilosa, commelina benghalensis, Datura stramonium, Galinsoga parviflora, Guizotia scabra Plantago lanceolata* and *Xanthium strumarium* were highly managed by these sequential herbicides.

Recommendation

Generally, the finding demonstrated that combined herbicide weed management practices are essential for future if further research is done. Based on such performance and

observation of data's from field during two the cropping seasons the activities important to continue in on the most three perennial weed species to develop final management system.

The emphasis has been given on the management of both broad and grass weeds with sequential herbicidal management options because of the labour and time limitation in hand weeding. An integrated strategy consisting of crop rotation and reduction of weed seed bank benefited for small holder farmers not only as control of weed but also increase soil fertility should be involved for the sustainable management of the crop system. In addition more studies should be undertaken on perennial weed species. These suggest that there is a need to encourage the research on perennial weed species like, *Convolvulus* and *Cichorium*, evaluate the efficacy of research findings at farmer's field with individual weed based, emphasize on the advanced research on these unique species and establish infrastructure to develop advanced but farmer's friendly simple and effective management methods.

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