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EFFICACY OF VARIOUS PRE AND POST-EMERGENCE HERBICIDES TO CONTROL WEEDS IN WHEAT

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The efficacy of various pre and post-emergence herbicides viz. pyroxasulfone @ 0.15 kg a.i. ha^{-1}, terbutryn + triasulfuron @ 0.18 kg a.i. ha^{-1} and flufenacet + pyroxasulfone @ 0.24 + 0.15 kg a.i. ha^{-1} as pre-emergence while flufenacet @ 0.24 kg a.i. ha^{-1}, carfentrazone ethyl + isoproturon @ 0.018 kg a.i. ha^{-1}, bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} as post-emergence and hand weeding at (20 & 40 DAS) with a weedy check were tested against narrow and broad leaved weeds in wheat during Rabi season 2008-09. The results revealed that *Fumaria indica*, *Melilotus indica* and *Rumex dentatus* density significantly decreased by all the herbicides compared with control. Bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} as post-emergence application was most effective in controlling *F. indica*, *M. indica* and *R. dentatus* with maximum mortality at both (30 & 60 DAS) without being phytotoxic to wheat. Bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} as post-emergence spray proved significantly better than other herbicide treatments as it severely reduced the weeds biomass as compared to weedy check. Spikebearing tillers (355.75), spike length (15.07 cm), number of grains spike^{-1} (52.00) and 1000-grain weight (54.00 g) were maximum in bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} as post-emergence treated plots, which ultimately enhanced the yield up to 39.13% over control. Bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} as post-emergence gave the maximum net income of Rs. 97345 ha^{-1}. However, maximum MRR (%) of 191730 was obtained with the use of bromoxynil + MCPA followed by flufenacet with the MRR (%) of 67590.

Keywords: herbicides efficacy, *Fumaria indica*, *Melilotus indica*, *Rumex dentatus*, bromoxynil + MCPA, wheat yield

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major grain crop in Pakistan and staple food for billions of people of the world (Satorre and Slafer, 1999). It is essentially better from nutritional point of view than most cereals and other food. It is a principal source of carbohydrates in human diet as it constitutes 73% of average diet of a common man. Pakistan is among the top ten producers of wheat in the world (Khan, 2003). Average per capita consumption of wheat in the country is 125 kg per annum, which works out 18064 million tons national requirements. In Pakistan, wheat is grown on an area of 9.06 million hectares with total production of 23.42 million tons and an average yield of 2585 kg ha^{-1}. It contributes 13.1 percent to the value added in agriculture and 2.8 percent to GDP (GOP, 2009).

The main constraints limiting wheat production are uneconomical holdings, illiteracy, poor economic conditions of the farmers, the unavailability of quality fertilizers at the time of sowing which are too costly, waterlogging, salinity and low organic matter in most Pakistani soils. Among many factors adversely influencing wheat productivity, weed infestation is one of them. Weeds compete with crop plants for nutrients, light, space, moisture and many other growth factors through competition and allelopathy, resulting in direct loss to quantity and quality of the produce (Gupta, 2004). Crop losses due to weed competition are greater than those resulting from the combined effect of insects and diseases. Weeds may encourage the development of diseases; provide shelter and acts as an alternate host for pests (Marwat *et al*., 2005). Weed infestation is one of the main causes of low wheat yield not only in Pakistan but all over the world, as it reduces wheat yield by 37-50% (Baluch, 1993; Nayyar *et al*., 1995; Waheed *et al*., 2009). However, with the rising costs of labor and power, the judicial use of herbicides is the only acceptable way for effective weed management.

According to Cheema *et al.* (2006) 2, 4-D and hand weeding significantly decrease the weed density and weed dry weight. Dicuran (60WP), Buctril M (40EC) applied to wheat crop and hand weeding resulted in more grain yield compared to non-infested control. Chemical weed control was much better and economical than conventional method (Cheema *et al*., 1988). Ahmad *et al*. (1991) evaluated post-emergence herbicides alone at recommended doses and in combination with DMA-6 for weed control in wheat and concluded that herbicide application suppressed weed population effectively. Weed control has resulted in higher wheat grain yield (Khan *et al*., 2003). Thus, chemical weed control has been proved to be relatively more efficient and

economical method in controlling weeds (Majid and Hussain, 1983; Marwat *et al*., 2008). Therefore, the present study was designed to determine the efficacy of different pre and post-emergence herbicides compared to hand weeding in controlling weeds in wheat crop.

MATERIALS AND METHODS

Present study was carried out to evaluate the efficacy of different pre and post-emergence herbicides on weeds growth and yield of wheat (*Triticum aestivum* L.) at the Agronomic Research Area, University of Agriculture, Faisalabad during Rabi season 2008-09. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replicates having a net plot size of $6.0 \times 3.0 m^2$ on sandy clay loam soil. The experiment comprised of 8 treatments (Table 1). The seedbed at all locations was prepared by using a moldboard plow followed by disking, and smoothing with land leveler. Wheat variety Sehar-2006 was sown in lines 25 cm apart with single row hand drill during 3rd week of November, 2008 with seed rate of 125 kg ha^{-1}. Fertilizer was applied at 125 kg N and 100 kg P_2O_5 ha^{-1} in the form of urea and diammonium phosphate. Whole of the phosphorous and half of the nitrogen was side dressed at sowing time while remaining half of the nitrogen was top dressed with first irrigation. Five irrigations were applied to raise the crop. All other agronomic practices were kept normal and uniform for all the treatments combinations.

Weed flora present at the time of application were *Rumex dentatus*, *Medicago polymorpha*, *Anagallis arvensis*, *Asphodelus tenuifolius*, *Convolvulus arvensis*, *Achyranthes aspara*, *Melilotus indica*, *Fumaria indica* and *Polygonum plebejum* However, *Fumaria indica*, *Rumex dentatus* and *Melilotus indica* L. were dominant. Pre and post-emergence herbicides were used in this experiment. Pre-emergence herbicides just after sowing and post-emergence herbicides after 1st irrigation were applied by "knapsack sprayer" using T-jet nozzle. Volume of spray was determined by calibration. The crop was harvested manually at physiological maturity. This was done when the green color from the glumes and kernels disappeared completely.

During the course of study, data for weed density (m^{-2}) was recorded 30 & 60 DAS. From each plot a unit area of one square meter was taken at random for recording plant height, number of spikebearing tillers, 1000 grain weight, number of grains per spike, biological yield, grain yield and weed count per unit area. Weeds were counted per unit area and then harvested from ground surface. Weeds were dried in an oven for 24 hr at 70°C and dry weight was recorded.

Data collected was analyzed statistically using Fisher's analysis of variance and Least Significantly Difference (LSD) test at 5% probability level was applied to compare the treatments' means (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

***Weed density (m^{-2})*:** The analysis of the data on weed density showed that there were significant effects of different pre and post-emergence herbicides after application. The data regarding the weed control at 30 DAS is presented in Table 2. Analysis of the data revealed that the minimum density of *Fumaria indica* (4.75 m^{-2}) was found where bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} were applied as compared to weedy check (45.25 m^{-2}). The minimum *Melilotus indica* density (14.50 m^{-2}) was with post-emergence bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1}, whereas the maximum weed density (66.75 m^{-2}) was recorded in weedy check plots. Pre-emergence pyroxasulfone @ 0.15 kg a.i. ha^{-1}, post application of carfentrazone ethyl + Isoproturon @ 0.018 kg a.i. ha^{-1} and hand weeding statistically gave the similar weed control. Maximum *Rumex dentatus* count (54.66 m^{-2}) was recorded in weedy check followed by hand weeding (38.66 m^{-2}). The best *Rumex dentatus* control was achieved where bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} was sprayed as a post emergence (Table 2). These results are in conformity with Hashim *et al*. (2002) and Khan *et al.* (2003) who reported that application of the herbicides reduced broad and narrow leaf weeds to a varying degree sometimes approaching to 100% control. Soltani *et al*. (2006) found that post-emergence bromoxynil + MCPA is very effective in controlling weeds. Data regarding weed density (m^{-2}) at 60

Table 1. Various pre and post-emergence herbicides used in wheat during 2008-09

Herbicides	Time of application	Dose (kg a.i. ha^{-1})
T_1=Weedy Check		
T_2=Pyroxasulfone 85WG	Pre	0.15
T_3=Terbutryn + Triasulfuron 64WG	Pre	0.18
T_4=Flufenacet + Pyroxasulfone 500SC + 85WG	Pre	0.24 + 0.15
T_5=Flufenacet 500SC	Post	0.24
T_6=Carfentrazone ethyl + Isoproturon 50WP	Post	0.018
T_7=Bromoxynil + MCPA 40EC	Post	0.49
T_8=Hand weeding	(20 & 40 DAS*)	

*DAS= Days after sowing

DAS (Table 3) showed a significant reduction in weed density in plots where bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} were sprayed as a post emergence. For controlling *Fumaria indica* all the herbicides either applied at pre or post-emergence gave the same control except bromoxynil + MCPA (0.49 kg a.i. ha^{-1}). Minimum *Fumaria indica* density (3.75 m^{-2}) was obtained from bromoxynil + MCPA (0.49 kg a.i. ha^{-1}) treated plots compared to non-treated control. As compared to other weed control treatments, the excellent *Melilotus indica* and *Rumex dentatus* control was obtained where post-emergence bromoxynil + MCPA (0.49 kg a.i. ha^{-1}) was sprayed. The findings of Madafiglio *et al.* (2006) and Sikkema *et al.* (2007) depicted that post-emergence application of bromoxynil + MCPA significantly reduced the weed densities and increased the wheat grain yield, thus supporting the results of the present study.

However, all the herbicides significantly reduced the weed density as compared with control. Hand weeding at 20 & 40 DAS did not prove as good weed control as achieved with the herbicides. Maximum reduction in weed dry weight was achieved by post-emergence application of bromoxynil + MCPA (0.49 kg a.i. ha^{-1}). However, use of post application bromoxynil + MCPA (0.49 kg a.i. ha^{-1}) resulted in higher 77.73% reduction in weed dry weight (Table 3). These results are in line with the findings of Spandl *et al.* (1997) and Zand *et al.* (2007) who reported that post-emergence application of bromoxynil + MCPA significantly reduced the weeds dry weight and increased the wheat yield.

***Wheat yield (t ha^{-1})*:** The results presented in Table 4 revealed that a significant increase in number of spikebearing tillers (m^{-2}) through pre and post herbicidal application was observed as compared to weedy check which was primarily due to the better crop growth as a result of less competition with weeds (Table 2 & 3). On an average maximum spikebearing tillers (m^{-2}) (355.75) were recorded where bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} were applied. Flufenacet @ 0.24 kg a.i. ha^{-1} and Flufenacet + Pyroxasulfone @ 0.24+0.15 kg a.i. ha^{-1} produced statistically similar number of spikebearing tillers (325.75 and 325.00, respectively). Similarly, Pyroxasulfone, carfentrazone ethyl + Isoproturon and hand weeding at (20 & 40 DAS) were statistically at par with one another and gave minimum number of spikebearing tillers after control plots. These results are in line with the previous finding of Khan *et al*. (2003). Spike length was significantly affected with the application of different pre and post-emergence herbicides. Maximum spike length (15.07cm) was recorded by bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} as compared to control (11.17cm). Terbutryn + triasulfuron, flufenacet + pyroxasulfone and carfentrazone ethyl + Isoproturon gave statistically similar spike length (cm) with the values of 13.50cm, 13.60cm and 13.57cm, respectively. Among the

Table 2. Effect of different herbicide treatments on weeds density at 30 (DAS) during 2008-09

Treatments	Dose (kg a.i. ha^{-1})	Weeds density (m^{-2})		
		Fumaria indica	***Melilotus indica***	***Rumex dentatus***
T_1=Weedy Check		45.25 a	66.75 a	54.66 a
T_2=Pyroxasulfone	0.15	27.50 b	55.75 b	30.66 c
T_3=Terbutryn + Triasulfuron	0.18	26.00 bc	43.25 cd	28.66 cd
T_4=Flufenacet + Pyroxasulfone	0.24 + 0.15	25.00 c	42.25 d	26.58 de
T_5=Flufenacet	0.24	25.00 c	45.00 c	24.16 e
T_6=Carfentrazone ethyl + Isoproturon	0.018	25.75 bc	54.50 b	23.83 e
T_7=Bromoxynil + MCPA	0.49	4.75 e	14.50 e	4.66 f
T_8=Hand weeding	(20 & 40 DAS)	21.33 d	55.00 b	38.66 b
LSD (*P* = 0.05)		2.33	2.52	3.40

Table 3. Effect of different herbicide treatments on weeds density and weeds biomass at 60 (DAS) during 2008-09

Treatments	Dose (kg a.i. ha^{-1})	Weeds density (m^{-2})			
		Fumaria indica	***Melilotus indica***	***Rumex dentatus***	**Weeds dry weight (g m^{-2})**
T_1=Weedy Check		37.33 a	55.75 a	56.65 a	10.42 a
T_2=Pyroxasulfone	0.15	15.66 b	43.75 c	17.16 c	6.27 c
T_3=Terbutryn + Triasulfuron	0.18	14.83 b	22.75 d	18.17 c	6.51 c
T_4=Flufenacet + Pyroxasulfone	0.24 + 0.15	14.00 b	21.50 d	12.65 d	6.39 c
T_5=Flufenacet	0.24	15.33 b	23.50 d	12.00 d	7.01 bc
T_6=Carfentrazone ethyl + Isoproturon	0.018	16.00 b	23.75 d	11.25 d	7.40 b
T_7=Bromoxynil + MCPA	0.49	3.75 c	7.00 e	5.16 e	2.32 d
T_8=Hand weeding	(20 & 40 DAS)	15.16 b	52.75 b	28.00 b	6.45 bc
LSD (*P* = 0.05)		2.06	2.33	3.43	0.86

different pre and post-emergence herbicidal treatments pyroxasulfone @ 0.15 kg a.i. ha^{-1} and flufenacet @ 0.24 kg a.i. ha^{-1} were statistically at par with each other and produced the spikes in smaller length. Similar results were reported by Jarwar *et al.* (1999) and Ali *et al.* (2004). Results showed that the application of different pre and post-emergence herbicides significantly increased the number of grains $spike^{-1}$ over weedy check (Table 4). The data revealed that carfentrazone ethyl + Isoproturon gave maximum number of grains $spike^{-1}$ (53.75) which was statistically similar with bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} (52.00). Pyroxasulfone @ 0.15 kg a.i. ha^{-1}, terbutryn + triasulfuron @ 0.18 kg a.i. ha^{-1}, flufenacet + pyroxasulfone @ 0.24+0.15 kg a.i. ha^{-1} and flufenacet @ 0.24 kg a.i. ha^{-1} producing 46.00, 45.50, 45.00 and 46.25 grains $spike^{-1}$, respectively, which were statistically at par with one another. Grain production per spike was the lowest (37.00) in case of weedy check which ultimately resulted in poor yield. Significantly grains spike per spike increased in all the treated plots compared with control and it may be attributed to availability of more nutrients because weed population was reduced (Ashraf *et al*., 1989; Nayyar *et al*., 1994; Sharrar *et al*., 1994). 1000-grain weight is the most important yield contributing component of wheat crop. The results depicted that maximum 1000-grain weight was recorded in bromoxynil + MCPA treated plots (54.00g) followed by flufenacet + pyroxasulfone (51.50g). Within the pre and post-emergence herbicidal treatments pyroxasulfone, terbutryn + triasulfuron, flufenacet and carfentrazone ethyl + Isoproturon treated plots produced less 1000-grain weight, possibly might be due to more weeds (Table 4). However, the lowest 1000-grain weight in control plots was probably due to the effect that there was strict competition between the crop plants and weeds, which ultimately affected the grain development potential of the plant. These results are in conformity with the findings of Khan *et al.* (2003). Maximum grain yield (4.60 t ha^{-1}) was obtained by controlling weeds in bromoxynil + MCPA @ 0.49 kg a.i ha^{-1} treated plots showing an increase of 39.13% over control. It was statistically higher than other *pre* and post application treatments of herbicides. Within the pre and post-emergence herbicide treatments pyroxasulfone @ 0.15 kg a.i. ha^{-1}, terbutryn + triasulfuron @ 0.18 kg a.i. ha^{-1}, carfentrazone ethyl + Isoproturon @ 0.018 kg a.i ha^{-1} and hand weeding at (20 & 40 DAS) treated plots gave less yield with an increase of 26.08%, 25.65%, 25.43% and 26.79% over weedy check. Increased grain yield from treated crop may be attributed to availability of more nutrients, light, moisture and space resulting in crop growth.

These findings are in a great analogy with the previous work of Satao *et al.* (1993), Khan and Haq (1994), Sharar *et al*. (1994), Ahmad *et al*. (1995), Malik *et al*. (1998) and Madafiglio *et al*. (2006) who reported that wheat grain yield enhances with the use of herbicides due to increase in spike length, grains per spike and spike bearing tillers and grain weight.

Economic and marginal analysis: Economic analysis of different weed control treatments revealed that weed control in wheat by the use of herbicides gave more economic return as compared to hand weeding (Table 5). Application of bromoxynil + MCPA @ 0.49 kg a.i ha^{-1} gave the highest net returns (Rs. 97345 ha^{-1}) followed by Flufenacet @ 0.24 kg a.i. ha^{-1} with a net benefit of (Rs. 85670). The highest benefit cost ratio of 191730% was recorded for bromoxynil + MCPA @ 0.49 kg a.i ha^{-1} and proved the most economical herbicide for weed control of wheat (Table 6). Thus, it was concluded that use of chemical control of weed is more economical than hand weeding. Other treatments were dominated due to higher costs involved.

CONCLUSIONS

From the above discussion, it can be concluded that bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} was quite effective to control *F. indica*, *M. indica* and *R. dentatus* density in wheat fields. This herbicide was most effectual than other herbicides tested in this study as judged by reduction in weed density and increase in wheat grain yield.

Table 4. Effect of different herbicide treatments on wheat yield during 2008-09

Treatments	Dose (kg a.i. ha^{-1})	Parameters				
		Spikebearing tillers	Spike length (cm)	No. of grains $spike^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})
T_1=Weedy Check		229.50 e	11.17 e	37.00 d	42.50 e	2.80 d
T_2=Pyroxasulfone	0.15	312.00 d	12.22 d	46.00 c	44.47 d	3.40 c
T_3=Terbutryn + Triasulfuron	0.18	323.00 c	13.50 bc	45.50 c	45.55 d	3.42 c
T_4=Flufenacet + Pyroxasulfone	0.24 + 0.15	325.00 bc	13.60 b	45.00 c	51.50 b	3.96 b
T_5=Flufenacet	0.24	325.75 b	12.37 d	46.25 c	45.95 d	4.05 b
T_6=Carfentrazone ethyl + Isoproturon	0.018	312.25 d	13.57 b	53.75 a	45.85 d	3.43 c
T_7=Bromoxynil + MCPA	0.49	355.75 a	15.07 a	52.00 a	54.00 a	4.60 a
T_8=Hand weeding	(20 & 40 DAS)	310.25 d	13.17 c	49.25 b	48.62 c	3.37 c
LSD (P = 0.05)		2.33	0.37	1.76	1.73	0.10

Table 5. Economic analysis of different weed control treatments

Treatments	Grain yield (t ha^{-1})	Adjusted yield (t ha^{-1})	Gross income (Rs.)	Variable weed control cost				Total cost that varied (a+b+c+d)	Net benefit (Rs. ha^{-1})
				a. Labour charges for 2 hand weeding	b. Cost of herbicides	c. Sprayer rent	d. Labour charges for herbicides application		
T_1	2.80	2.52	59850	---	---	---	---	---	59850
T_2	3.40	3.06	76675	---	450	90	200	740	75935
T_3	3.42	3.07	72912	---	470	90	200	760	72152
T_4	3.96	3.56	84550	---	940	90	200	1230	83320
T_5	4.05	3.64	86450	---	490	90	200	780	85670
T_6	3.44	3.09	73387	---	677	90	200	967	72420
T_7	4.60	4.14	98325	---	690	90	200	980	97345
T_8	3.37	3.03	71962	2600	---	---	---	2600	69362

Any two means sharing same letters did not differ significantly at 5% level of probability; T_1= Weedy Check; T_2= Pyroxasulfone @ 0.15 kg a.i. ha^{-1} as pre-emergence spray; T_3= Terbutryn + triasulfuron @ 0.18 kg a.i. ha^{-1} as pre-emergence spray; T_4= Flufenacet + Pyroxasulfone @ 0.24+0.15 kg a.i. ha^{-1} as pre-emergence spray; T_5= Flufenacet @ 0.24 kg a.i. ha^{-1} as post-emergence spray; T_6= Carfentrazone ethyl + Isoproturon @ 0.018 kg a.i. ha^{-1} as post-emergence spray; T_7= Bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1} as post-emergence spray; T_8= Hand weeding at (20 & 40 DAS); Price of wheat grain @ Rs. 950/ 40 kg.

Prevailing market prices of herbicides:

Pyroxasulfone @ Rs. 450; Terbutryn + triasulfuron @ Rs. 470; Flufenacet + Pyroxasulfone @ Rs. 940; Flufenacet @ Rs. 490; Carfentrazone ethyl + Isoproturon @ Rs. 677; Bromoxynil + MCPA @ Rs. 690; Hand weeding at (20 & 40 DAS) = 13 Man days ha^{-1} @ Rs.100 man^{-1}

Table 6. Marginal analysis of different weed control treatments

Treatments	Cost that varied (Rs. ha^{-1})	Net benefit (Rs. ha^{-1})	***MRR (%)
T_1= Weedy Check	---	59850	---
T_2= Pyroxasulfone @ 0.15 kg a.i. ha^{-1}	740	75935	2174
T_3= Terbutryn + Triasulfuron @ 0.18 kg a.i. ha^{-1}	760	72152	D****
T_5= Flufenacet @ 0.24 kg a.i. ha^{-1}	780	85670	67590
T_6= Carfentrazone ethyl + Isoproturon @ 0.018 kg a.i. ha^{-1}	967	72420	D
T_7= Bromoxynil + MCPA @ 0.49 kg a.i. ha^{-1}	980	97345	191730
T_4= Flufenacet + Pyroxasulfone @ 0.24 + 0.15 kg a.i. ha^{-1}	1230	83320	D
T_8= Hand weeding at (20 & 40 DAS)	2600	69362	D

Cost that vary is the cost that is incurred on variable inputs in the production of a particular commodity; ***Marginal rate of return (MRR%)= change in net benefit/ change in variable cost × 100; ****D= dominated, any treatment that had net

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