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Effectiveness of various post emergence herbicides against broad leaved weeds in wheat crop and their impact on grain yield of wheat (*Triticum aestivum L.*)

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Abstract

Field experiments were performed for two successive crop seasons (2019-20 and 2020-21) to evaluate the effectiveness of various post emergence herbicides for controlling broad-leave weeds in wheat field and their impact on grain yield of wheat at Adaptive Research Farm Sheikhupura Punjab, Pakistan. The effects of herbicides on weed density, yield attributes and grain yield were recorded. Significant impact of herbicides was recorded in decreasing weed density and increasing grain yield with a positive effect on productive tillers, grains per spike and thousand grains weight. Highest weed control efficiency (85.0 & 86.7) (81.5 & 84.3) was calculated from broad-X & wheat star as compared to control during both crop seasons. Maximum grain yield (3783.3 & 4310.0 $kgha^{-1}$) was recorded from plots treated with broad-X with 19.8 and 26.7 % higher than control followed by wheat star that recorded 19.6 and 21.0% higher grain yield as compared to the control during both years. Among the studied herbicides, chlorpyralid+ fluroxypyr methy+ MCPA (broad-X) and chlorpyralid+ fluroxypyr methyl+ tribenuran methyl (wheat star) were the most effective and suitable options in controlling broad leaved weeds as well as increasing the grain yield of wheat crop.

Keywords: Chlorpyralid, Competition, Weed density, Herbicides
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Introduction

Wheat (*Triticum aestivum* L.) being the staple food of Pakistan and king of cereals, plays an important role in the agricultural system of Pakistan, it meets the major dietary requirements and feeds about 220.8 million people of the country. The gap between the local production and consumption is continuously increasing due to continuous population explosion. In Pakistan wheat crop is grown on an area of 9.16 million ha with a total annual production of about 27.46 million tons, with an average yield of approximately 3.0 t ha^{-1}. (Anonymous, 2021). Govt. of Pakistan is putting efforts in achieving the objectives of self-sufficiency in food. There are many interventions involved in crop production. Weeds control is one of them that play a key role in increasing wheat production.

Among the factors limiting crop growth, weeds are important factor that reduced performance of the crop. Siddiqui *et al*. (2010) also reported that weeds are one of the major constraints and reduced productivity due to their competition with wheat crop. Weed competition in wheat crop is the most serious and noticeable reason in grain yield reduction. Weeds compete with crop plants for water, nutrients, space and many other growth factors. Weeds are more efficient to use plant nutrients than crop plants. (Khalil *et al*., 2008) Weeds also encourage the development of pathogens and shelter for pests. Morzouk *et al*. (2009) reported that weed infestation causes higher yield losses than those of other pests. Among different factors responsible for the low actual yield of wheat, weeds hold a key position. In case of wheat, the losses due to weeds are more than any other pest. According to an estimate, weeds can decrease yield of wheat up to 30% (Ashiq and Cheema 2005; Abbas *et al*., 2009). However, an efficient weed control can increase crop yield up to 35%.

Wheat fields are generally infested with *Medicago sativa* (caribeen snoutbean), *Chenopodium album* (common lamsquarters), *Fumaria indica* (fumitory), *Convolvulus arvensis* (field bindweed), *Rumex dentatus* (broad leaf dock). *Cronopus didymus* (lesser swine cress), *Melilotus murale* (trefoil), *Chenopodium murale* (nettle leaved goosefoot) and *Lathyrus aphaca* (wild pea).

A variety of methods are employed to control weeds in arable crops. Among all these methods, chemical control method is considered the most appropriate and efficient for controlling weeds. Moreover, it is the easiest, economical and most successful. Numerous herbicides are available in the market for controlling weeds in wheat and their relative efficiency is a matter of much importance every time. Different researchers worked on efficacy of different herbicides, Akbar *et al*. (2011) reported that herbicides successfully control weeds and improve grain yield. Razzaq *et al*. (2010) also reported that chemical control of weeds by using effective herbicides can improve wheat yield. Cheema and Akhtar (2005) obtained an effective control of broad leave weeds in wheat through chemical herbicides.

For obtaining best results, the chemical control of broad leave weeds associated in wheat crop based on the herbicide selection and effective dose of herbicide as the non-judicious use of herbicides can reduce the crop productivity. For control of broad leave weeds in wheat, there are large number of herbicides available in the market and being used to overcome the problem of weeds in wheat. In view of the importance of wheat crop and weed related problem as well as market situation the present work was designed to investigate the effectiveness of various herbicides for the control of broad-leaved weeds and their effect on yield and yield components of wheat. This study might be considered

an essential component for controlling broad-leaved weeds in wheat and for the guidance to the farming community for the usage of appropriate herbicides.

MATERIALS AND METHODS

The experiment regarding efficacy of different herbicides for controlling broad-leaved weeds in wheat was carried out for two consecutive wheat growing seasons (2019-20 and 2020-21) at Adaptive Research farm Sheikhupura, Punjab, Pakistan. The study comprised of six treatments including check and their details are described in Table-1. Wheat crop was sown at research area of farm during 2nd week of November in both crop seasons and sites for experiments were selected where predominant broad-leaved weeds were present. Experiments were conducted in Randomized Complete Block design with three replications having plot size 48 m^2 during both crop seasons. Post emergence herbicides were applied after complete germination of wheat crop and broad-leaved weeds in proper moisture at upper soil surface.

The prominent broad-leaved weeds found before application of herbicides were *Medicago sativa* (caribeen snoutbean), *Chenopodium album* (common lamsquarters), *Fumaria indica* (fumitory), *Convolvulus arvensis* (field bindweed), *Rumex dentatus* (broad leaf dock). *Cronopus didymus* (lesser swinecress), *Melilotus murale* (trefoil), *Chenopodium murale* (nettle leaved goosefoot) and *Lathyrus aphaca* (wild pea).

The data were recorded for weed parameters like weed density (m^{-2}) before and after herbicides' application, weeds mortality percentage and weeds control efficiency. Similarly, data on wheat yield parameters like number of productive tillers (m^{-2}), spike length (cm), number of grains per spike, thousand grains weight (g) and grain yield (kg ha^{-1}) were also measured.

Weed population/density was recorded from three places randomly selected in each treatment with a quadrate measuring one square meter. Weed mortality and weed control efficiency were recorded after four weeks of herbicidal application.

Weed control efficiency (WCE) was calculated using the following equation:

$$WCE\ (\%) = \frac{NWc - NWt}{NWc} \quad X\ 100\%$$

Where:

NWc = Number of Weeds (m^{-2}) from Control plots (weedy check); NWt = Number Weeds (m^{-2}) in plots treated with herbicide

Where; as, weeds mortality percentage was calculated using the following equation:

$$Mortality\ (\%) = \frac{Wt - Ws}{Wt} \quad X\ 100\%$$

Where; W_t= Total number of weeds; W_s =Number of surviving weeds.

At maturity wheat plants in 1 m^2 from each plot was harvested and threshed to record number of productive tillers (m^{-2}) and grain yield (g/m^2) then it was converted into Kg ha^{-1}. However, 1000 grains weight (g), spike length (cm) and number of grains per spike were also recorded by randomly selected ten spikes from each plot.

Yield increase percentage was also recorded by following equation:

$$T - C$$

$$\text{Yield Increase (\%)} = \frac{T}{} \quad X \quad 100\%$$

Where:

T = grain yield in treated plot

C = grain yield in untreated plot (control)

The statistical analysis of mean data was done by using the software STATISTIX 8.1. The least significant difference (LSD) test at 0.05 probability levels was applied to compare the difference among treatments means.

Table 1. Details of herbicides with trade and chemical name applied against broad- leaved weeds in wheat during crop seasons 2019-20 & 2020-21

Treatments	Trade Name	Chemical Name	Dose (ha^{-1})
T_1	Wheat Star	Chlorpyralid+ Fluroxypyr methy+ Tribenuran methyl	370 g
T_2	Broad-X	Chlorpyralid+ Fluroxypyr methy+ MCPA	875 ml
T_3	Weed away	Bromoxnil +Tribenuran methyl+ MCPA	1250 ml
T_4	Buctril super	Bromoxynil + Octonoate Heptanoate+MCPA	750 ml
T_5	Clean out	Fluroxypyr methy+ Tribenuran methyl+ Carfentrazen	750 g
T_6	Control (Weedy check)		

RESULTS AND DISCUSSION

Data presented in table-2 shows the effect of herbicides on density of broad leaved weeds in wheat crop during two consecutive crop season 2019-20 and 2020-21. Data concerning number of weeds before application of herbicides showed non-significant difference among different treatments. Comparative study of the means showed that maximum number of weeds before spray ranged from 55 to 91 & 71 to 80 m^{-2} during both crop seasons 2019-20 & 2020-21 respectively in all treatments. While data regarding number of weeds after application of herbicides depicted significant differences among the treatments under study. Minimum number of weeds 11 & 11 m^{-2} was counted in T_2 where Broad-X was applied @ 875 ml ha^{-1} during two consecutive crop seasons with 85.0 & 86.7 percent weeds control efficiency followed by 81.5 & 84.3 % weed control efficiency from T_1 where wheat star @ 370 g ha^{-1} was applied as compared with weedy check during 2019-20 & 2020-21 respectively. Highest weed density (76 & 83 m^{-2}) was recorded in weedy check where no herbicide was applied. Reduction in weeds density is attributed to the phytotoxic effect of herbicides on weeds. The comparison of the results presented in table-2 show that all treatments except T_3 significantly reduced weed density. Data regarding weed mortality percentage in response to different post emergence herbicides applied against broad leaved weeds in wheat showed that maximum weeds mortality 87.5 & 84.5 % was recorded in plot treated with broad-X herbicide followed by 82.7 & 83.0 % which was obtained from wheat star treated plot during crop season 2019-20 & 2020-21 respectively. These results are in agreement with the work of Singh *et al*. (2013), who

reported that maximum weed control efficiency was obtained with the use of herbicides in wheat.

Different researchers worked on efficacy of herbicides for controlling broad leaved weeds in wheat like El-Kholy *et al*. (2013) reported that herbicidal treatments gave minimum population of broad-leaved weeds in wheat field. Saad *et al*. (2011) reported that tribenuran methyl was the most effective herbicide for controlling broad-leaved weeds in wheat.

The data presented in Table-3 revealed that all treatments significantly increased productive tillers, thousand grains weight, spike length, grains per spike and grains yield. The number of productive tillers per square meter was significantly affected by all the treatments as compared with weedy check. Comparison of the treatment means revealed that the maximum number of productive tillers 269 & 303 m^{-2} were recorded in plot where broad-X was applied during crop seasons 2019-20 & 2020-21 while minimum 234 & 238 productive tillers m^{-2} were obtained from weedy check during two consecutive crop seasons under study (Table-3). The reduction in tillers was due to high weed infestation and competition of weeds with crop plants for space. Post emergence herbicide, broad-X suppressed weeds efficiently, therefore the crop plants established well and produced the maximum number of tillers m^{-2} followed by wheat star treated plots. Malik *et al*. (2009) reported that number of tillers significantly improved with the control of broad leaved weeds.

Data pertaining to spike length indicated that maximum spike length (9.4 & 9.8 cm) was obtained with broad-X application followed by wheat star (9.2 & 9.3 cm) while minimum 7.36 & 7.8 cm spike length was recorded from weedy check plot where no herbicide was applied (Table-3). It is clear from the data presented in Table-3 that highest (38 & 41) number of grains per spike was counted from plot treated with T_2 followed by T1 (37 & 39) while minimum 28 & 32 from weedy check during both crop seasons. It was probably because of congenial environment provided for weeds to compete with main crop plants for natural sources which reduced the spike length as well as number of grains $spike^{-1}$. Cheema and Akhtar (2005) observed the similar results and concluded that minimum number of grains $spike^{-1}$ recorded in untreated plot due to weed infestation.

Data presented in Table-3 depicted that among all the treatments, broad-X and wheat star gave good results in counting of thousand grains weight during both years of experiment. Maximum 36.40 & 41.16 g of thousand grains weight was recorded where broad-X was applied followed by 36.5 & 39.9 g of thousand grains weight from wheat star treated plots while minimum 32.66 & 34.43 g was calculated in control plot during crop seasons 2019-20 & 2020-21. In weedy check, reduced 1000-grain weight was due to weeds competition with crop plants. The results are in agreement with Safina and Absy (2017) who reported that application of herbicides recorded maximum thousand grains weight due to increased weed control resulting in increased net photosynthesis and dry matter accumulation in the grains. Amre *et al*. (2014) reported that effect of herbicides on thousand grains weight might be due to effective weed control treatments.

Shehzad *et al*. (2012) reported that the lowest grains production per spike and thousand grains weight was observed in untreated plots due to severe competition between the crop plants and weeds. This competition prominently reduced the nutrients mobility towards the grains.

The obtained results that presented in Table-4 indicated that all tested treatments significant effected grain yield during both crop seasons. Maximum (3783.3 & 4310.0 kg ha^{-1}) grain yield was recorded from the plot treated with broad-X having 19.8 & 26.7 percent higher yield as compared with weedy check in crop seasons 2019-20 & 2020-21 while wheat star remained at 2nd rank with 19.6 & 21.8% higher grain yield over control during both crop seasons. Minimum 3156.7 & 3400 kg ha^{-1} grain yield was recorded in weedy check during crop 2019-20 & 2020-21 respectively. Reduction in grain yield in the un-treated plot may be due to competition of weeds with crop plants for resources like nutrients, light, water & space etc. Our findings are in harmony with the results obtained by Zand *et al*. (2007) that chemical weed control significantly reduced weed population and promoted tillering which ultimately resulted in increased grain yield of wheat. Similar findings were reported by Shehzad *et al.* (2012) and Singh *et al.* (2013) who reported that application of effective herbicides gave maximum grains yield of wheat. Soliman *et al.* (2011) found that increased in wheat grains yield might be due to high weed control efficiency of herbicides with significant effects on increasing thousand grains weight, spike length and grains per spike which lead to high grain yield while the poor grain yield in the untreated plot might be attributed to the reduction in wheat growth which occurred as a result of the weeds competition with wheat plants for water, light and nutrients. Similarly, Naseer-ud-din *et al.* (2011) also reported that increased grain yield in the treated plots may be attributed to availability of more nutrients, light, space and moisture for crop growth.

Conclusion

Herbicides are useful tools for minimizing weed competition with wheat crop for nutrients, space, light and water. Amongst tested herbicides, it is concluded that application of Chlorpyralid+ Fluroxypyr methy+ MCPA (Broad-X) and Chlorpyralid+ Fluroxypyr methy+ Tribenuran methyl (Wheat Star) containing herbicides for controlling broad leaved weeds associated to the wheat crop showed maximum weed control efficiency that resulted in an increase in the grain yield and yield parameters and favourable effects on crop growth and development.

Table 2. Effect of various herbicides on weed parameters in wheat during two seasons

Treatments	**Weed density Before treatment (m^{-2})**		**Weed density After treatment (m^{-2})**		**Weed mortality (%)**		**Weed Control Efficiency (%)**	
	2019-20	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
Wheat Star	81.00b	76.66 a	14.00d	13.00de	82.7	83.0	81.5	84.3
Broad-X	91.00 a	71.00 a	11.33d	11.00 e	87.5	84.5	85.0	86.7
Weed away	63.66 c	78.00 a	28.00b	27.33 b	56.0	64.9	64.0	67.0
Buctril super	63.33 c	71.66 a	23.33bc	16.66 d	63.1	76.8	69.3	79.9

Clean out	55.66d	75.33 a	22.00c	22.00 c	60.4	70.7	71.0	73.4
Weedy check	69.66 c	80.33 a	76.00 a	83.00 a	-	-	-	-
LSD P≤ 0.05	7.09	9.97	5.51	4.02	-	-	-	-

Means having different letters vary significantly *at 5 % probability level.*

Table 3. Effects of various herbicides on yield parameters during two wheat growing seasons

Treatments	**No. of fertile tillers (m^{-2})**		**Spike length (cm)**		**Grains $spike^{-1}$**		**1000 grain weight (g)**	
	2019-20	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
Wheat Star	269.67a	286.67 b	9.20 ab	9.33 b	37.33 ab	39.66 ab	36.56 a	39.90 a
Broad-X	268.67 a	302.67 a	9.40 a	9.76 a	38.66 a	40.66 a	36.40 ab	41.16 a
Weed away	250.33 bc	275.33 c	8.833	8.76 c	32.66 c	38.00 bc	34.11 c	38.46 b
Buctril super	258.33 b	261.33 d	8.46 c	8.40 c	35.33 b	35.66 d	35.47 b	36.33 c
Clean out	248.00 c	271.00 c	9.40 a	8.66 c	31.66 c	37.00 cd	34.26 c	36.93 c
Weedy check	234.33 d	238.33 e	7.36 d	7.83 d	28.66 d	32.00 e	32.66 d	34.43 d
LSD P≤ 0.05	8.54	7.94	0.499	0.40	2.43	1.69	0.94	1.29

Means having different letters vary significantly *at 5 % probability level.*

Table 3. Effect of various herbicides on yield parameters during two wheat growing seasons

Treatments	**Grain Yield (kg ha^{-1})**			
	2019-20		**2020-21**	
	Yield	**% increase/ Decrease**	**Yield**	**% increase/ decrease**
Wheat Star	3776.7 a	19.6	4116.7 b	21.0
Broad-X	3783.3 a	19.8	4310.0 a	26.7
Weed away	3460.0 c	9.6	3700.0 d	8.8
Buctril super	3616.7 b	14.5	3950.0 c	15.9
Clean out	3433.3 c	8.7	3733.3 d	9.6

Weedy check	3156.7 d	-	3400.0 e	
LSD P≤ 0.05	96.70		155.97	

Means having different letters vary significantly *at 5 % probability level.*

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