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Efficacy and Economics of Different Herbicides Against Narrow Leaved Weeds in Wheat

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ABSTRACT

The efficacy and economics of six herbicides namely Chlodenafop (Topic), Isoproturon+Carfentrazone (Affinity), Isoproturon (Arelon), Fenoxaprop (Puma super), Metribuzin (Sencor) and Isoproturon+Diflufenicon (Panther) were tested on clay loam soil at Adaptive Research Farm, Vehari against narrow leaved weeds in wheat during 2000-03. Average of three years results revealed that all the herbicides significantly decreased *Phalaris minor* and *Avena fatua* population compared with control. Isoproturon and Isoproturon+Diflufenicon were most effective in controlling *P. minor* with maximum mortality of 87.08 and 81.81% without being phytotoxic to wheat while *A. fatua* was controlled with Fenoxaprop and Chlodenafop resulting in 86.76 and 85.52% mortality, respectively. Wheat plant height, fertile tillers m^{-2}, grains $spike^{-1}$ and 1000-grains weight were maximum in Chlodenafop and Fenoxaprop treated plots which ultimately enhanced the yield upto 31.08 and 28.45%, respectively over control. Isoproturon was almost as effective as Isoproturon+ Diflufenicon which increased the yield over the control by 25.02 and 22.61%, respectively. Isoproturon+Carfentrazone and Metribuzin proved significantly to be inferior than other herbicides. Chlodenafop, Fenoxaprop and Isoproturon gave the maximum net income of Rs. 29221.00, 28597.35 and 28309.23 ha^{-1}, respectively. Similarly, Chlodenafop gave higher benefit cost ratio (4.08) closely followed by Isoproturon (4.02) as against the minimum (1.00) with Isoproturon+Carfentrazone. However, maximum M.R.R. of 460.23 was obtained with the use of Isoproturon followed by Metribuzin and Chlodenafop with the M.R.R. of 360.39 and 180.29%, respectively.

Key Words: *Triticum aestivum; P. minor; A. fatua;* Herbicides; Economics

INTRODUCTION

The weeds infesting in wheat fields throughout Pakistan has undergone changes during the past few years. As a result of intensive weed control with different selective herbicides in wheat, the population of broad leaf weeds has been replaced almost entirely by narrow leaf weeds in the cotton zone of southern Punjab. Among the narrow leaved weeds, *Phalaris minor* Retz. and *Avena fatua* L. are predominant and wide spread, which are usually more aggressive and strong competitors for water, nutrients, light etc. with the result that benefits of applied inputs are not fully realized. However successful control of both these weeds has been reported with Arelon applied post emergence at 0.7 to 0.9 L $Acre^{-1}$ with an increase in wheat yield from 6.29 to 20.25% (Khan *et al*., 1984). In another study, Isoproturon 75WP gave 78.57% control of *P. minor* in wheat and increased yield by 20.59% compared with unweeded control by providing a cost benefit ratio of 3.30 (Khan & Makhdum, 1987). Shah (1988) also found an increase of 102.23% in grain yield with Isoproturon over control without phytotoxic effect to wheat by controlling *P. minor* and *A. fatua*. An increase in plant height, number of fertile tillers $plant^{-1}$, number of grains ear^{-1}, 1000-grain weight and grain yield of wheat was also observed with the application of Isoproturon 50WP (Ashraf *et al*., 1989). Nayyar *et al*. (1994) reported that post emergence application of Panther 520FW, Arelon 500FW and Puma super 69FW gave 97.24, 96.33 and 88.65% mortality against monocot weeds and increased grain yield of wheat by 43.83, 44.24 and 40.46%, respectively due to significant increase in number of tillers m^2, number of grains $spike^{-1}$ and 1000-grain weight. Isoproturon was the most effective herbicide in controlling *A. fatua* and *P. minor* and increasing wheat yield by 68% (Khan & Haq 1994). While testing the efficacy of Puma super, Tolkan and Sencor Sharar *et al*. (1994) observed that all the herbicides significantly decreased weed population over check. An increase in grain yield was also recorded due to increase in number of fertile tillers, grains $spike^{-1}$ and grain weight. Ahmad *et al*. (1995) applied Topic 240EC and Puma super 69FW which gave 96.37 and 97.95% control of *P. minor*, respectively as compared with weedy check. Topic 240EC treated plots resulted in 92% more grain yield than control plots. Fenoxaprop and Chlodenafop are the successful chemicals against Isoproturon-resistant *P. minor* (Malik *et al*., 1998). Chemical weed control significantly decreased weed population and biomass and promoted tillering per unit area which ultimately resulted in increased wheat grain yield over weedy check (Jabbar *et al*., 1999). Arelon 75EW and Sencor 70WP increased the grain yield of wheat by 30.22 and 40.19% and other attributes like plant height, number of fertile tillers $plant^{-1}$, number of grains $spike^{-1}$ and 1000-grain

weight by controlling 89.09 and 95.30% weeds over the unweeded treatment, respectively (Jarwar *et al*., 1999).

Keeping in view the importance of weed problem variation in response to various herbicides, the present studies were undertaken to evaluate the efficacy and economics of different herbicides against narrow leaved weeds in wheat under irrigated environment.

MATERIALS AND METHODS

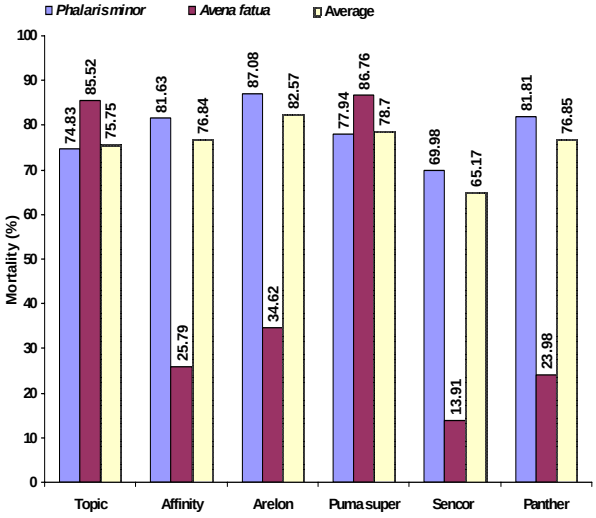
Field investigations were conducted at Adaptive Research Farm, Vehari for three consecutive years i.e. 2000-01 to 2002-03 on a clay loam soil with low organic matter. The herbicides namely Chlodenafop propargyle 150 g/kg + Chloquintoset mexyle 37.5 g/kg (Topic 15WP), Isoproturon 50% + Carfentrazone-ethyl A.I. 0.75% (Affinity 50WG), Isoproturon 45.1% (Arelon 50DP), Fenoxaprop-P-ethyle 7.15% (Puma super 75EW), Metribuzin 70% (Sencor 70WP) and Isoproturon 50% + Diflufenicon 5% (Panther 550SC) were sprayed with knap sack hand sprayer using water at 300 L ha^{-1} at post emergence stage after first irrigation in a moist soil. A check plot was left unweeded. The experiment was laid out in randomized complete block design with three replicates having 6m x 9m plots. Wheat cultivar Punjab-96 was seeded on summer fallowed land on November, 24, 21 and 27 in 2000, 2001 and 2002, respectively, in 22.5 cm apart rows with a single row hand drill using a seed rate of 125 kg ha^{-1}. The weeds under study were naturally occurring and were not seeded. Nitrogen and Phosphorus were applied at 150-100 kg ha^{-1}, respectively. Full dose of P2O5 and ½ of N was applied at the time of sowing while the remaining N was added with first irrigation. The irrigation was applied at crown root initiation, tillering, booting, milking and dough stages of wheat. All other cultural practices were kept normal and uniform for all the experimental units.

The weeds were counted from three different places randomly selected (one meter square) in each experimental plot, 25 days after herbicidal spray, weed mortality percentage was estimated. The crop was harvested in the first week of May during all the years of study and observations on plant height, number of fertile tiller m^{-2}, number of grains $spike^{-1}$, 1000-grains weight and grain yield were recorded by following the standard procedures. Analysis of variance and mean separation tests were applied (Gomez & Gomez, 1984) and Economic analysis was done using Marginal Rate of Return (Perrin *et al*., 1979).

RESULTS AND DISCUSSION

The common narrow leaved weeds found in the experimental area during the study years were *P. minor* Retz. and *A. fatua* L.. Weed species at the site were assumed to be similar in control and treated plots, however, *P. minor* infestation was higher than *A. fatua* during all the years of study.

Fig. 1. Mortality percentage of *Phalaris minor, Avena fatua* and average of both the weeds in Wheat during 2000-03



Weed density and mortality. Mortality percentage of both the weeds with different herbicides is shown in Fig.1 which indicated that herbicides employed in this study controlled weeds reasonably well and average percentage mortality of both the narrow leaved weeds ranged from 65.17 to 82.57. Isoproturon treated plots showed maximum mortality of 87.08% followed by Isoproturon+Diflufenicon and Isoproturon+Carfentrazone showing mortality of 81.81 and 81.63%, respectively, against *P. minor*, which was moderately controlled with Fenoxaprop and Chlodenafop. Metribuzin offered the minimum results. Maximum mortality percentage of 86.76 was observed from Fenoxaprop treated plots closely followed by Chlodenafop which gave 85.52% control against *A. fatua*. All the other herbicides partially suppressed the *Avena sp*. except Metribuzin which appeared as the least effective giving only 13.91% mortality. Similar results in respect of Isoproturon+Diflufenicon, Isoproturon, Fenoxaprop and Chlodenafop against monocot weeds have already been reported by Nayyar *et al.* (1994) and Ahmad *et al.* (1995). Wheat showed tolerance to all the herbicides, except Isoproturon+Carfentrazone and Metribuzin, which caused phytotoxicity to the crop. Plants recovered with time but were shorter and poorly tillered.

The data shown in Table I indicate that all the herbicides decreased both the narrow leaved weeds significantly over the control plots during all the years of study except Metribuzin which was statistically at par with control during 2000-01 and 2002-03 against *A. fatua*. Maximum number of weeds was recorded in control plots in all the experimental years. The average results indicated that the number of *P. minor* and *A. fatua* plants m^{-2} in herbicidal treatments varied from 12.17 to 28.27 and 1.17 to 7.61 against the maximum of 94.17 and 8.84, respectively in

Table I. Effect of different herbicides against *Phalaris minor* and *Avena fatua* population m^{-2} during 2000-03

Treatments	Number of *Phalaris minor* plants m^{-2}				Number of *Avena fatua* plants m^{-2}			
	2000-01	2001-02	2002-03	Average	2000-01	2001-02	2002-03	Average
Chlodenafop	36.17bc	20.83c	14.17bc	23.70bc	2.17e	0.83d	0.83d	1.28e
Isoproturon+Carfentrazone	31.83c	12.17de	8.00c	17.30de	9.17cd	6.00bc	4.50d	6.56cd
Isoproturon	19.83d	10.50e	6.17c	12.17e	8.50d	5.33c	3.50c	5.78d
Fenoxaprop	34.83bc	17.17cd	10.33bc	20.77cd	1.67e	1.17d	0.67d	1.17e
Metribuzin	40.50b	26.83b	17.50b	28.27b	11.17ab	6.50b	5.17ab	7.61b
Isoproturon+Diflufenicon	26.50cd	15.67cde	9.17c	17.13de	10.00bc	5.83bc	4.33bc	6.72c
Control	142.50a	82.50a	56.67a	94.17a	12.17a	8.83a	5.50a	8.84ab
LSD > 0.05	9.77	5.79	5.89	5.42	1.23	1.15	0.97	0.82

Table II. Effect of different herbicides on plant height and fertile tillers of wheat during 2000-03

Treatments	Plant height (cm)				Number of fertile tillers (m^{-2})			
	2000-01	2001-02	2002-03	Average	2000-01	2001-02	2002-03	Average
Chlodenafop	91.20a	97.47a	91.60a	93.42a	356.67a	380.00a	340.00a	358.89a
Isoproturon+Carfentrazone	86.77cd	92.40d	82.23c	87.13d	320.00d	338.67de	296.00de	318.22c
Isoproturon	88.23bc	96.47ab	88.07b	90.92c	339.00bc	361.67b	312.33cd	337.67b
Fenoxaprop	90.40ab	96.80ab	89.47ab	92.22b	348.00ab	372.00ab	332.67ab	350.89a
Metribuzin	85.97d	93.50cd	83.67c	87.71d	326.67cd	343.00cd	287.33e	319.00c
Isoproturon+Diflufenicon	88.83bc	95.43bc	88.87ab	91.05c	335.00bcd	356.33bc	321.00bc	337.44b
Control	80.27e	90.40e	79.33d	83.33e	288.00e	322.00e	265.33f	291.78d
LSD > 0.05	2.25	1.99	2.73	1.09	15.72	16.32	17.37	8.20

Table III. Effect of different herbicides on number of grains $spike^{-1}$ and 1000-grains weight of wheat during 2000-03

Treatments	Number of grains $spike^{-1}$				1000-Grains weight			
	2000-01	2001-02	2002-03	Average	2000-01	2001-02	2002-03	Average
Chlodenafop	36.11a	38.92a	34.96a	36.66a	36.61a	41.27a	36.27a	38.05a
Isoproturon+Carfentrazone	33.28cd	35.14d	32.67cd	33.70d	34.96cd	39.63bc	34.52bc	36.37cd
Isoproturon	34.87ab	37.27bc	33.06bc	35.07c	35.87abc	40.23abc	35.03abc	37.04bc
Fenoxaprop	35.67a	38.04ab	34.22ab	35.86b	36.16ab	40.97ab	35.88ab	37.67ab
Metribuzin	32.46d	34.43d	31.23d	32.87e	34.66d	39.13c	34.26c	36.01d
Isoproturon+Diflufenicon	34.05bc	36.69c	33.72abc	34.82c	35.29bcd	40.56abc	35.47abc	37.11bc
Control	28.47e	30.28e	27.26c	28.67f	29.27e	34.43d	29.87d	31.19e
LSD > 0.05	1.50	1.27	1.47	0.74	0.92	1.53	1.40	0.82

control plots. Isoproturon, Panther and Affinity were found to be very effective and equally good in controlling the *P. minor* plants but had little control over the *A. fatua.* This might probably be due to the presence of Isoproturon in these herbicides, which had proved to be the most effective killer of *P. minor* as reported earlier (Khan & Makhdum 1987). Fenoxaprop and Chlodenafop proved to be very effective in killing *A. fatua* but were less effective in reducing the *P. minor* population. The least effective herbicide was Metribuzin, but it significantly reduced the population of *P. minor* below that of the control treatment and failed to control the *A. fatua* plants. Similar results in respect of weed control were reported by Nayyar *et al*. 1994. In 2000-01, both the narrow leaved weeds were far higher than in the years 2001-02 and 2002-03, however the herbicidal effects on weed control were comparable during all the experimental years.

Wheat yield and components. The results presented in Table II revealed that plant height was significantly affected with the application of different herbicides. The maximum plant height of 93.42 cm was recorded by Chlodenafop followed by Fenoxaprop (92.22). Higher plant height was obtained as compared to control (83.33) with the values of 91.05 and 90.92 in Isoproturon+Diflufenicon and Isoproturon treatments which was statistically at par with each other. Among the herbicidal treatments Metribuzin and Isoproturon+ Diflufenicon were at par and produced the smaller plants which can be attributed to phytotoxic effect on wheat crop. From the perusal of individual years results, it was concluded that Chlodenafop and Fenoxaprop produced the taller plants, whereas, the lowest plant height was observed in Metribuzin and Isoproturon+Carfentrazone treated plots as compared to other herbicides. Isoproturon and Isoproturon+Diflufenicon produced the intermediate plants during all the years of study. Similar results were reported by Ashraf *et al.* (1989) and Jarwar *et al.* (1999).

A significant increase in number of fertile tillers m^{-2} through the herbicidal application was observed as compared to control which was primarily due to the better crop development as a result of less competition with weeds (Table II). On an average maximum tillers m^{-2} (358.89) was recorded where Chlodenafop was applied, which however

Table IV. Effect of different herbicides on grain yield of wheat during 2000-03

Treatments	Grain yield (kg ha^{-1})				%inc.
	2000-01	2001-02	2002-03	Average	
Chlodenafop	3961a	4456a	3845a	4087a	31.08
Isoproturon+Carfentrazone	3529d	3860c	3290c	3560c	14.18
Isoproturon	3790bc	4355ab	3549b	3898b	25.02
Fenoxaprop	3877ab	4383a	3755ab	4005a	28.45
Metribuzin	3479d	3933c	3250c	3554c	13.98
Isoproturon+Diflufenicon	3706c	4168b	3596b	3823b	22.61
Control	3065e	3431d	2857d	3118d	-
LSD > 0.05	143.21	187.20	241.40	102.39	

Table V. Economic analysis of different herbicides

Particulars	Chlodenafop	Isoproturon+ Carfentrazone	Isoproturon	Fenoxaprop	Metribuzin	Isoproturon+ Diflufenicon	Control
Average grain yield (kg. ha^{-1})	4087	3560	3898	4005	3554	3823	3118
Gross yield value/income (Rs. ha^{-1})	30652.50	26700.00	29235.00	30037.50	26655.00	28672.50	23385.00
Cost of herbicides (Rs. ha^{-1})	1111.50	1337.75	904.02	1120.15	390.26	1124.47	-
Cost of labor for herbicide application (Rs. ha^{-1})	200	200	200	200	200	200	-
Rent of sprayer (Rs. ha^{-1})	120	120	120	120	120	120	-
Total cost that vary (Rs. ha^{-1})	1431.50	1657.75	1224.02	1440.15	710.26	1444.47	-
Net benefit (Rs. ha^{-1})	29221.00	25042.25	28309.23	28597.35	25944.74	27228.03	23385.00
Benefit Cost Ratio	4.08	1.00	4.02	3.62	3.60	2.66	-

a) Average prevailing market prices of herbicides during 2000-01 to 2002-03
i. Chlodenafop @ Rs. 450 / 100g, ii. Isoproturon+Carfentrazone @ Rs. 677 / kg
iii. Isoproturon @ Rs. 488 / lit., iv. Fenoxaprop @ Rs. 907 / lit.
v. Metribuzin @ Rs. 158 / 100g, vi. Isoproturon+Diflufenicon @ Rs. 607 / lit.
b) Labor for herbicide application = 2 man / day / ha @ Rs. 100 / man
c) Rent of sprayer = Rs. 60 / day, d) Price of wheat grain = Rs. 7.5 / kg

was statistically at par with Fenoxaprop where 350.89 tillers m^{-2} were obtained. Isoproturon and Isoproturon+ Diflufenicon produced statistically similar number of fertile tillers m^{-2}, similarly Isoproturon+Carfentrazone and Metribuzin were statistically at par with one another and control plots gave minimum number of tillers. In general, tiller number was higher during 2001-02 compared with 2000-01 and the minimum tillers m^{-2} were recorded in 2002-03, however, herbicides effect was almost similar in all the years. These results are similar or even better than those reported by Nayyar *et al*. (1994), Sharrar *et al*. (1994), Jabbar *et al.* (1999) and Jarwar *et al*. (1999).

The average and the individual years results showed that the application of different herbicides significantly improved the number of grains spike^{-1} over control (Table III). The average data revealed that Chlodenafop gave maximum number of grains spike^{-1} (36.66) followed by Fenoxaprop, Isoproturon and Isoproturon+Diflufenicon producing 35.86, 35.07 and 34.82 grains spike^{-1}, respectively, however, the later two herbicides were statistically at par with one another. Grain production per spike was the lowest (32.87) in case of Metribuzin which ultimately resulted in poor yield. Significantly more number of grains spike^{-1} in all the treated plots compared with control 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; Jarwar *et al*., 1999).

Grain weight is the most important yield component of wheat. The average data (Table III) showed that maximum 1000-grain weight was recorded in Chlodenafop treated plots followed by Fenoxaprop, Isoproturon+Diflufenicon and Isoproturon, however, the first two and the later three chemicals were at par with each other. Within the herbicidal treatments, Metribuzin and Isoproturon+Carfentrazone treated plots produced less grain weight possibly might be due to more weeds. However, the lowest grain weight in control plots, was probably due to the effect that there was hard competition between the crop plants and weeds for mineral nutrients, moisture etc. which ultimately affected the grain development potential of the plant. The increase in grain weight due to use of different herbicides has also been reported elsewhere (Ashraf *et al*., 1989; Nayyar *et al*., 1994; Sharrar *et al.*, 1994).

The data showed that all the herbicidal treatments out yielded control during all the experimental years (Table IV). Maximum grain yield of 4087 kg ha^{-1} was obtained by controlling both the narrow leaved weeds in Chlodenafop treated plots registering an increase of 31.08% over control. It was statistically higher than other herbicidal treatments but remained at par with Fenoxaprop which produced 28.45% higher yield than control. Isoproturon and Isoproturon+Diflufenicon occupied the 3rd and 4th position

Table VI. Marginal analysis of different herbicides

Treatments	Cost that vary (Rs. ha^{-1})	Marginal costs (Rs. ha^{-1})	Net benefit (Rs. ha^{-1})	Marginal net benefit (Rs. ha^{-1})	Marginal rate of return (%)
Control	-	-	23385.00	-	-
Metribuzin	710.26	710.26	25944.74	2559.74	360.39
Isoproturon	1224.02	513.76	28309.23	2364.49	460.23
Chlodenafop	1431.50	505.73	29221.00	911.77	180.29
Fenoxaprop	1440.15	8.65	28597.35D	-	-ve
Isoproturon+Diflufenicon	1444.47	4.32	27228.03D	-	-ve
Isoproturon+Carfentrazone	1657.75	213.28	25042.25D	-	-ve

M.R.R. = $\frac{\text{Marginal net benefit}}{\text{Marginal cost}}$ X 100

D = Dominated due to less benefits than preceding treatment

giving 25.02 and 22.61% more yield, respectively than control. Within the herbicidal treatments Isoproturon+ Carfentrazone and Metribuzin treated plots gave the less yield of 3560 and 3554 kg ha^{-1} with an increase of 14.18 and 13.98% over control, which seems to be dueless fertile tillers, grains spike^{-1} and grain weight etc. Increased grain yield from treated crop may be attributed to availability of more nutrients, light, moisture and space resulting in crop growth. The year 2001-02 was a better harvest year for wheat. The increase in yield as a result of *P. minor* and *A. fatua* control has also been amply demonstrated by various workers (Khan *et al*., 1984; Shah, 1988; Khan & Haq, 1994; Nayyar *et al*., 1994; Sharrar *et al.*, 1994; Ahmad *et al.*, 1995; Malik *et al*., 1998).

Economic and marginal analysis. Economic analysis calculated on the basis of average grain yield of three years revealed that all the herbicides gave considerably higher net benefit than control (Table V). The plots treated with Chlodenafop gave the highest net benefit amounting to Rs. 29221.00 ha^{-1} followed by Fenoxaprop and Isoproturon with a net benefit of Rs.28597.35 and Rs. 28309.23, respectively against the minimum of Rs. 25042.25 in Isoproturon+Carfentrazone treated plots. Chlodenafop gave higher benefit cost ratio (4.08) closely followed by Isoproturon (4.02) as against the minimum (1.00) with Isoproturon+ Carfentrazone. These findings are more or less in line with the results of Khan and Makhdum, (1987). The data further revealed that maximum MRR of 460.23 was obtained with the use of Isoproturon, followed by Metribuzin and Chlodenafop with the MRR of 360.39 and 180.29%, respectively (Table VI). All the other herbicides were dominated or uneconomical than Chlodenafop.

CONCLUSIONS

In the light of above discussion, it may be concluded that Chlodenafop, Isoproturon or Fenoxaprop @ 247 gm, 1.850 L and 1.235 L ha^{-1}, respectively, are quite effective to control *P. minor* and *A. fatua* in wheat. These herbicides were more effective than other herbicides tested in these studies as judged by reductions in narrow leaved weed population and increases in wheat yield. Chlodenafop, Fenoxaprop and Isoproturon recommended being more economical herbicide for controlling *A. fatua*; whereas, these herbicides are comparatively more effective and economical and can be safely adopted on a commercial scale without any phytotoxicity to wheat crop.

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