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Herbicidal control of problematic weeds in wheat

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ABSTRACT

On-farm trials were conducted at farmers' fields in Ropar and Ferozpur districts of Punjab to validate, refine and popularize the technology developed by Punjab Agricultural University, Ludhiana for managing grassy and broad-leaf weeds in wheat. The objective of the study was to test the effectiveness of clodinafop 60 g/ha and carfentrazone-ethtyl 20 g/ha over farmer practice of using un-recommended herbicides and brands on the infestation of weeds and profitability of wheat in central Punjab. Recommended practice of clodinafop followed by carfentrazone-ethyl resulted in significantly higher grain yield (4.56 and 4.69 t/ha) than other treatments including farmer practice. There was 14.4 and 17.9, 3.4 and 5.7 and 3.0 and 4.3 per cent increase in grain yield with recommended practice over control, metribuzin and farmers' practice, respectively. The population of grassy weeds was minimum with metribuzin 175 g/ha treatment, which was statistically at par with recommended practice but was significantly lower than other two treatments, whereas the number of broad-leaf weeds was significantly lower with recommended treatment. The herbicide efficiency index (HEI) was highest (16.8 and 21.8) with recommended practice indicating higher efficiency of this treatment in controlling weeds. A slight phytotoxicity was observed with metribuzin which resulted in significant reduction in effective tillers than other herbicidal treatments. Highest B: C ratio (2.45 and 2.77) and net returns (` 45.99 and 52.86 x 10^3 /ha) were recorded with recommended practice.

Key words: Clodinafop, Carfentrazone-ethyl, Herbicide efficiency index (HEI), Metribuzin, Weed density

Wheat (*Triticum aestivum*) with an area of 35 million ha is the most widely cultivated winter cereal in Punjab and occupies a significant position in the economy of the state. Several grassy and broad-leaf weeds compete with the crop during its growing period. Weed infestation is one of the main causes of low wheat yield all over the world, as it reduces wheat yield by 37 to 50% (Waheed *et al.* 2009). The reduction in productivity depends upon the type of weed flora and weed density (Balyan and Malik 1989, Afentouli and Eleftherohorinos 1996). Weeds are the most omnipresent class of pests that interfere with crop plants through competition and allelopathy, resulting in direct loss to quantity and quality of the product (Gupta 2004) and indirectly increasing production costs. Herbicidal weed control seems indispensable and has proved efficient in controlling weeds (Kahramanoglu and Uygur 2010) and hence presently about two-third, by volume, of the pesticides used worldwide in agricultural production are herbicides.

Introduction of semi dwarf genotypes of wheat coupled with better irrigation and fertilizer application has provided congenial growing conditions for weeds, particularly *Phalaris minor* predominantly in rice-wheat cropping system where it has emerged as major weed of wheat causing yield reduction to the level of 30-80% (Brar and Walia 1993, Singh *et al.* 1999). Dependence on only one herbicide isoproturon for very long period to control of *Phalaris minor* in wheat has resulted in problem of resistance to this herbicide (Malik and Singh 1995, Walia *et al.* 1997). Herbicides are the most important weed control tool for alleviating the infestation of weeds and getting higher yield in wheat as reported by Ashiq *et al.* 2007. Walia and Brar (2006) reported that in Punjab non-recommended herbicides were used by 13.6% farmers. More than 27 per cent farmers used non-recommended herbicides or unapproved brands of recommended herbicides, whereas more than 19% of the farmers used under or over doses of herbicide. The efficacy of these herbicides was found below satisfactory levels by more than 30% of the farmers. In the sub-mountainous zone of Punjab especially in district Ropar, the problem of weeds in wheat is even more serious leading to lower grain yields. *Malwa parviflora*, a broad-leaf weed with long tap root and capacity to withstand moisture stress, has increased its occurrence in wheat crop which is posing a serious challenge as it is not controlled by metsulfuron-methyl. This weed is con-

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trolled by carfentrazon-ethyl but farmers were unaware of this. They continued to use metsulfuron-methyl for its control. This often lead to poor control of weeds and also sometimes toxicity on the crop. The use of recommended and conventional herbicides provides more effective control of grassy and broad-leaf weeds in wheat and are also cost effective.

There was a need to evaluate the location specific efficacy of various post-emergence herbicides recommended by Punjab Agricultural University in order to alleviate the weed infestation in wheat. The present investigation (On-farm trial) was therefore conducted at selected farmers' fields with the objective to validate, assess and refine the improved and recommended technology of herbicidal weed management over traditional farmer's practice.

MATERIALS AND METHODS

Field Experiments were conducted at farmers' fields at ten different locations in district Ropar during *Rabi* 2010-11 and 2011-12 and in district Ferozpur on 8 locations during *Rabi* 2010-11. The climate of the experimental sites was sub-tropical characterized by hot summers with mean maximum temperature of 42±5 ^{0}C during June and cool winters with mean minimum temperature of 4±2 ^{0}C during December. The average annual rainfall (AAR) in the study area varied from 650 - 1300 mm of which 75 - 80 per cent was received during summer season extending from July to September and rest during the winter season. The soil of experiment locations was sandy loam to loam in texture, normal in soil reaction (pH 7.56 - 8.02) and electrical conductivity (0.136-0.320 dS/m), low to medium in OC (0.361-0.425 %), available P (11-24.5 kg/ha) and available K (116-166.7 kg/ha).

The experiment was laid out in randomized complete block design. Each location was considered as one block and replication. The weed control treatments thus replicated at different locations consisted recommended practice (clodinafop 60 g/ha *fb* carfentrazone-ethyl 20 g/ha); farmers practice (non-recommended herbicides/brands) metribuzin 175 g/ha and un-weeded control. Wheat variety '*DBW 17*' was sown in first fortnight of November using a seed rate of 100 kg/ha with conventional seed cum fertilizer drill. Light planking was done after sowing to cover the seeds properly with soil. Nitrogen (125 kg/ha), phosphorus (60 kg/ha) and potash (30 kg/ha) were applied through urea, diammonium phosphate (DAP) and muriate of potash (MOP), respectively. Half the dose of nitrogen and whole of phosphorus was applied at the time of sowing, while the remaining half dose of N was applied as broadcast after first irrigation. First irrigation was applied at Crown root initiation (CRI) stage. Clodinafop and metribuzin were sprayed at 35 (2010-11) and 39 (2011-12) days after sowing with knapsack sprayer fitted with flat fan nozzle. Spray of carfentrazone-ethyl was done a week after clodinafop to control broad-leaf weeds. The gross plot size was 500 m^2 (50 x 10 m). Soil reaction (pH) and E.C. were determined by using 1: 2 soil: water (w/v basis) ratio (Jackson 1967). Soil organic carbon content was determined by method of Walkley and Black (1934). The available P (Olsen-P) content in the soil samples was determined as described by Olsen *et al.* (1954). Available K was determined using 1 N, CH_3COONH_4 (pH=7.0) followed by flame photometric estimation. The density of weeds was recorded at 75 days after sowing with the help of a quadrate measuring 1 x 1 m. Data on yield attributes and yield was recorded at maturity of the crop to draw valid conclusions. Data on density of weeds was subjected to square root transformation before statistical analysis. Data was subjected to analysis as detailed by Cheema and Singh (1991) in statistical package CPCS-1. Herbicide efficiency index (HEI) was calculated by using standard formula.

RESULTS AND DISCUSSION

Effect on weeds

The main weed flora of experimental fields consisted of *Phalaris minor, Coronopus didymus, Anagallis arvensis, Melilotus indica, Medicago denticulata, Rumex dentatus, Rumex spinosus, Trigonella polycerata, Malwa parviflora* and *Chenopodium album*.

The density of weeds was significantly influenced by weed control treatments in both the years. The highest weed density both for grassy and broad-leaf was found in the control plots. All herbicides reduced the growth of weeds compared to those observed in control (Table 2). Data revealed that during 2010-11, the density of grassy weeds was minimum with metribuzin (175 g/ha) treatment which was statistically at par with recommended treatment of clodinafop (60 g/ha) followed by carfentrazone-ethyl (20 g/ha) but was however significantly lower than other two treatments. During 2011-12, significantly lowest number of grassy weeds were found with recommended treatment, which was statistically at par with metribuzin, but significantly lower than the other two. All the herbicidal treatments were significantly better in controlling grassy weeds than control treatment. Singh *et al.* 2002 also reported that clodinafop provides effective control of isoproturon resistant *Phalaris minor* biotypes.

Table 1. Effect of herbicidal weed management on growth, yield and yield attributes of wheat

Treatment	Dose (g /ha)	Plant height (cm)		Grains/ear		Effective tiller /m^2 row length		Test weight (g)		Grain yield (t/ha)		Herbicide efficiency index (HEI)	
		2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Recommended practice													
Clodinafop followed by carfentrazone-ethyl	60, 20	84.2	85.2	46.8	47.6	77.0	79.5	40.8	40.7	4.56	4.69	16.8	21.8
Farmers practice													
non-recommended herbicides and brands	-	83.7	84.5	44.2	44.8	74.7	75.3	39.4	39.8	4.43	4.49	13.3	16.5
Metribuzin	175	82.2	84.7	43.6	44.0	72.6	73.0	38.9	39.2	4.41	4.42	12.9	14.9
Unweeded control	-	81.6	83.6	40.5	41.1	63.5	64.5	36.8	37.4	3.91	3.85	-	-
LSD (P= 0.05)		NS	NS	2.6	2.4	1.2	2.1	NS	NS	0.11	0.16	-	-

Table 2. Effect of herbicidal weed management on weed density (no./m^2) and dry weight (g/m^2) of wheat

Treatment	Dose (g/ha)	Weed density (no./m^2)				Weed dry weight (g/m^2)			
		Grassy weeds		Broad-leaf weeds		Grassy weeds		Broad-leaf weeds	
		2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Recommended practice									
Clodinafop followed by carfentrazone-ethyl	60, 20	4.08 (15.9)	3.85 (14.7)	1.67 (2.0)	3.5 (1.83)	25.2	24.0	2.24	2.32
Farmers practice									
Non-recommended herbicides and brands	-	4.91 (23.3)	4.45 (22.6)	2.62 (6.12)	7.22 (2.68)	38.4	37.8	4.10	4.22
Metribuzin	175	4.06 (15.7)	4.02 (15.0)	2.05 (3.21)	2.98 (1.79)	26.7	27.2	2.40	2.33
Unweeded control	-	9.94 (98.1)	9.98 (100.5)	47.1 (6.89)	52.1 (6.84)	105.7	108.2	9.57	10.85
LSD (P=0.05)	-	0.28	0.33	0.35	0.47	6.8	10.4	1.63	1.71

*Original figures in parentheses were subjected to square root transformation

In 2010-11, significant reduction in number of broad-leaf weeds was observed with recommended treatment of clodinafop (60 g/ha) which was at par with metribuzin but was significantly lower than the other two treatments. During 2011-12, minimum number of weeds were recorded with metribuzin, which was at par with recommended treatment, but lower than other two. Farmers sprayed metsulfuraon-methyl for control of broad-leaf weeds, which effectively controlled all broad-leaf weeds except *Malwa parviflora* locally called 'Button buti'. This weed is controlled with carfentrazone-ethyl. Punia *et al.* (2006) also reported excellent control of broad-leaf weeds with application of carfentrazone-ethyl.

Effect on crop

The data revealed that the differences with respect to plant height were found to be non-significant during both years. Highest plant height (84.20 and 85.20 cm) was observed with recommended treatment of clodinafop (60 g/ha) *fb* carfentrazone-ethyl (20 g/ha). In 2010-11, ear length (8.97 cm) was maximum with recommended treatment, which was significantly higher than all other treatments. However in 2011-12, there was no effect on ear length. Number of grains and effective tillers, which are main determinants of grain yield, were significantly higher with recommended treatment during both years than all other treatments. The significant reduction in number of effective tillers in metribuzin treatment could be attributed to phytotoxicity of metribuzin on crop. The differences with respect to test weight were found to be non-significant in both the years (Table 2).

Application of clodinafop 60 g/ha *fb* carfentrazone-ethyl 20 g/ha recorded highest grain yield of wheat (4.56 and 4.69 t/ha) during both the years and was significantly higher than all other treatments. Lowest grain yield of wheat (3.91and 3.85 t/ha) was recorded with unweeded control due to highest infestation of grassy and broad-leaf weeds and relatively inferior yield attributes as compared to all other herbicidal treatments. There was 14.4 and 17.9, 3.4 and 5.7 and 3.0 and 4.3 per cent increase in grain yield with recommended practice over control, metribuzin and farmers practice, respectively. Chhokar and Malik (2002) also reported significantly higher grain yields of wheat with application of clodinafop.

Table 3. Economics of different weed management practices in wheat

Treatment	Dose (g/ha)	Production unit (t/ha)		Gross returns (x10³ `/ha)		Cost of cultivation (x10³ `/ha)		Net returns (x10³ `/ha)		B:C Ratio	
		2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Recommended practice											
Clodinafop followed by carfentrazone-ethyl	60, 20	4.56	4.69	64.78	71.96	18.79	19.10	45.99	52.86	2.45	2.77
Farmers practice											
Non-recommended herbicides and brands	-	4.43	4.49	62.84	68.84	18.50	18.68	44.34	50.16	2.40	2.69
Metribuzin	175	4.41	4.42	62.59	67.66	18.38	18.60	44.22	49.06	2.41	2.64
Control	-	3.91	3.85	55.45	59.07	17.35	17.74	38.10	41.33	2.20	2.33

Economics

Among different treatments, recommended treatment of clodinafop 60 g/ha *fb* application of carfentrazone-ethyl 20 g/ha recorded maximum net returns (` 45.99 and 52.86 x 10^3/ha) and benefit cost ratio (2.45 and 2.77) followed by metribuzin 175 g/ha and farmers practice which makes these herbicides economically feasible and cost effective for controlling weeds. The lowest net returns were however observed with unweeded control.

It was concluded that for obtaining sustainably higher wheat grain yields and effective control of weeds, use of recommended herbicides clodinafop 60 g/ha *fb* carfentrazone 20 g/ha was a viable solution. The use of non-recommended herbicides and brands could be avoided as they do not control the weeds effectively, which lowers the grain yield of wheat and ultimately net returns.

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