Short communication

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Bioefficacy of some herbicides and their mixtures against complex weed flora in wheat

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Wheat (*Triticum aestivum* L. emend, Fiori and Paol) is widely grown winter cereal and is the backbone of food security in India. During last four decades, wheat production and productivity have increased almost six times and it alone contributed about one-third of the total food grain production of India. It is grown in about 29.25 million ha area in the country with the production of 93.90 million Mt in India. In Madhya Pradesh, it is grown in 4.89 million ha area with the production of 10.58 million (Agril. Stastistics 2013). Though the production and productivity of wheat have increased in the country during the last five years, but productivity levels are still low in Madhya Pradesh as compared to wheat growing states. There are many factors which affect the yield of the wheat but weed infestation is one of the most serious causes of low yields of irrigated wheat. The reduction in yields is mainly due to severe competition between weeds and crop plants for moisture, nutrient, light and space. The studies of Brar and Walia (2008) revealed that sever competition of grassy weeds like *Phalaris minor* caused 30-80% reduction in grain yield of wheat. Therefore, bioefficacy of some herbicdes was tested to control the weeds of wheat to overcome the yield loss due to wheat..

To study the effect of post-emergence herbicides for controlling weeds in wheat, a field experiment was carried out at Directorate of Weed Science Research, Jabalpur, M.P., India. The experimental field was vertisol (medium to deep depth and black in colour) clayey in texture. It was medium in organic carbon (0.61%), available nitrogen (178 kg N/ha) and phosphorus (40 kg P_2O_5/ha) but high in available potassium (344 kg K_2O/ha). The soil was nearly natural in reaction (7.2 pH) and concentration of soluble salts (0.32/dsm) was below to the harmful limit. The wheat variety '*GW-273*' was sown on November, 23,2012, using a seed rate of 100 kg/ha under furrow irrigated raised-bed system (FIRBS) by keeping two rows/ bed on the top of beds. The crop was raised with all recommended package of practices except the herbicidal treatments. Fourteen treatments consisted with eleven herbicidal treatments, post-emergence application of clodinafop-p-propargyl 60 g/ha (T_1), clodinafop-p-propargyl + 2,4-D (60+500) g/ha (T_2), pinoxaden 60 g/ha (T_3), sulfosulfuron 25 g/ha (T_4), metsulfuron-methyl + carfentrazone 25 g/ha (T_5), metsulfuron-methyl + 0.2% non ionic surfactant 4 g/ha (T_6), carfentrazone + sulfosulfuron 45 g/ha (T_7), sulfosulfuron + metsulfuron-methyl 40 g/ha (T_8), mesosulfuron-methyl + iodosulfuron-methyl sodium 12 g/ha (T_9), penoxsulam + cyhalofop 105 g/ha (T_{10}), penoxsulam + cyhalofop 150 g/ha (T_{11}) and carfentrazone 25 g/ha (T_{12}) along with two hand weedings (T_{13}) and weedy check (T_{14}), were tested in randomized block design with three replications.

Sowing of the experiment was done on November 23, 2012 in 5.0 x 4.5 m plots with seed rate 100 kg/ha by drilling in rows 22.5 cm apart. A uniform dose of 120 kg N, 60 kg P_2O_5, and 40 kg K_2O/ha was given through urea, single super phosphate and muriate of potash, respectively, in all plots. The herbicides were sprayed as post-emergence at 30 days after sowing (DAS) using a spray volume of 500 L/ha with a knapsack sprayer fitted with flat fan nozzle. The data on weed count and weed biomass was recorded at 60 DAS with the quadrate of 0.25/m^2 at two places under each plot. Data on weed population were subjected to square root transformation.

The dominant weed species identified in the experiment of wheat field were *Avena ludoviciana*, *Phalaris minor*, *Cichorium intybus*, *Medicago denticulata*, *Euphorbia geniculata.* The relative density of monocot and dicot weeds in unweeded plot at 30 days after sowing (DAS) was 86.82 and 13.18 per cent, respectively, indicating the predominance of monocot weeds (Table. 1) in wheat. Among the monocots, *Phalaris minor* (66.38%) was the most dominant weed followed by *Avena ludoviciana*(20.44%),

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while *Cichorium intybus* (11.76%), *Euphorbia geniculata* (0.74%), *Medicago denticulate* (0.32%), *Vicia sativa* (0.20%) and *Physalis minima* (0.13%), *Chenopodium album* (0.03%) were important among the dicot weeds. The density or biomass of predominant weeds was maximum under weedy check plots, where weeds were allowed to grow with wheat crop. But density of weeds and weed biomass reduced identically in pots receiving herbicidal and mechanical weed control.

The post-emergence application of clodinafop-p-propargyl 60 g/ha curbed the density and biomass of *A. ludoviciana.* and *P. minor* at 30 days after application. On the contrary, the efficacy of clodinafop-p-propargyl 60 g/ha, sulfosulfuron 25 g/ha, pinoxaden 60 g/ha, penoxsulam + cyhalofop 105 g/ha, penoxsulam + cyhalofop 150 g/ha and carfentrazone 25 g/ha was poor against *Cichorium intybus, Medicago denticulata* and *E. geniculata*. However, the post-emergence application of sulfosulfuron + metsulfuron-methyl 40 g/ha and clodinafop-p-propargyl +2,4-D (60+500) g/ha curtailed the density and dry weight of both the broad-leaved weeds satisfactory being the higher under ready mix combination of mesosulfuron-methyl + iodosulfuron-methyl sodium 12 g/ha. The hand weeding treatments performed better than all the herbicidal treatments in reducing the density, biomass of weeds and recorded maximum weed control efficiency (71.34%).

Table 1. Effect of weed control treatments on density (no./m²) of different weed

Treatment	Dose g/ha	*Avena ludoviciana*		*Phalaris minor*		*Cichorium intybus*		*Medicago denticulata*		*Euphorbia geniculata*	
		60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest
T_1 - Clodinafop	60	1.25 (1.67)	4.47 (23.0)	0.99 (0.67)	1.70 (3.00)	9.93 (105)	2.05 (4.67)	0.88 (0.33)	1.09 (1.00)	1.50 (3.00)	1.09 (1.00)
T_2 – Clodinafop + 2,4-D	60+500	2.63 (6.67)	4.23 (17.7)	0.99 (0.67)	0.70 (0.00)	2.64 (6.67)	2.54 (6.00)	0.70 (0.00)	0.70 (0.00)	1.38 (2.33)	0.99 (0.67)
T_3 - Pinoxaden	60	0.70 (0.00)	4.00 (16.7)	1.25 (1.67)	0.70 (0.00)	5.97 (38.3)	2.38 (5.33)	1.79 (3.67)	2.17 (5.00)	2.07 (5.67)	1.94 (3.33)
T_4 - Sulfosulfuron	25	13.68 (187)	3.8 (14.3)	0.70 (0.00)	1.18 (1.33)	7.79 (67.3)	2.66 (6.67)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.88 (0.33)
T_5 – Metsulfuron-methyl 0 + carfentrazone	25	3.70 (19.0)	5.83 (28.0)	18.10 (336)	1.25 (1.67)	3.89 (35.0)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.88 (0.33)	1.05 (0.67)
T_6- Metsulfuron-methyl + 0.2% NIS	4	5.10 (25.7)	4.20 (17.7)	15.32 (322)	1.79 (3.67)	0.70 (0.00)	0.70 (0.00)	1.09 (1.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
T_7 – Carfentrazone + sulfosulfuron	45	4.57 (36.3)	4.90 (23.7)	8.96 (92.3)	1.29 (1.33)	0.88 (0.33)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	1.68 (2.33)
T_8 - Sulfosulfuron + metsulfuron-methyl	32	6.84 (51.3)	3.18 (10.0)	3.58 (17.3)	1.32 (2.00)	3.25 (13.7)	2.54 (6.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
T_9 – metsulfuron-methyl + iodosulfuron-methyl sodium	16	1.93 (3.33)	2.57 (8.0)	0.70 (0.00)	1.93 (4.00)	4.05 (18.0)	2.18 (4.33)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	1.38 (1.67)
T_{10} - Penoxsulam + cyhalofop	105	2.45 (11.7)	4.33 (18.3)	7.05 (69.)	1.09 (1.00)	7.30 (54.0)	2.26 (4.67)	0.70 (0.00)	1.18 (1.33)	0.88 (0.33)	1.09 (1.00)
T_{11} - Penoxsulam + cyhalofop	150	1.29 (1.33)	3.39 (15.3)	2.12 (5.00)	0.70 (0.00)	9.40 (89.7)	2.45 (5.67)	1.79 (3.67)	1.09 (1.00)	0.70 (0.00)	0.99 (0.67)
T_{12} - Carfentrazone	20	3.82 (16.3)	3.28 (15.0)	10.35 (362)	1.09 (1.00)	3.05 (12.3)	1.93 (4.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	1.29 (1.33)
T_{13} - Hand weeding (2HW)	30, 60 DAS	1.83 (3.67)	3.59 (12.7)	2.82 (16.3)	0.70 (0.00)	3.84 (16.3)	1.32 (2.00)	0.70 (0.00)	0.88 (0.33)	1.09 (1.00)	0.70 (0.00)
T_{14} - Weedy check	-	20.42 (724)	4.45 (20.0)	21.73 (477)	1.44 (2.67)	11.64 (137)	2.32 (5.00)	2.70 (8.00)	1.93 (3.33)	2.19 (6.67)	0.99 (0.67)
LSD (P=0.05)		4.18	NS	7.85	NS	4.11	0.99	1.02	0.74	NS	NS

Figures in parentheses are original values and were transformed to ($\sqrt{x+0.5}$) before statistical analyses, DAS – Days after sowing

Table 2. Effect of weed control treatments on weed dry matter, weed control efficiency at 60 DAS, yield attributes and yield of wheat

Treatment	Biomass of weeds (g/m^2)		WCE 60 DAS (%)	Effective tillers/m^2	Effective spike/m	1000 grain weight (g)	Grain yield (t/ha)
	GW	BLW					
T_1	0.0	48.5	67.8	179.0	44.7	44.5	2.41
T_2	12.2	42.3	63.7	197.5	45.3	44.8	2.73
T_3	0.0	56.8	62.3	103.5	42.0	41.0	1.55
T_4	44.4	14.5	60.8	112.2	42.8	41.3	1.61
T_5	108.3	0.0	28.0	121.2	43.6	42.6	1.60
T_6	105.2	0.0	30.0	108.2	41.6	42.0	1.13
T_7	92.4	0.0	38.5	141.0	42.2	42.1	1.71
T_8	22.4	16.8	73.9	200.5	46.0	45.0	3.42
T_9	0.3	33.5	77.5	203.5	46.9	45.3	3.61
T_{10}	34.5	16.6	66.1	124.5	42.1	41.4	1.63
T_{11}	33.3	35.8	54.1	121.8	42.4	42.1	1.80
T_{12}	64.2	2.1	55.9	133.2	41.2	43.5	2.10
T_{13}	10.5	1.2	92.2	210.3	48.0	46.1	3.81
T_{14}	110.4	40.0	0.0	103.5	38.2	40.0	0.73
LSD (P=0.05)	49.33	20.96	-	15.1	NS	NS	1.47

GW – Grassy weed, BLW – Broad leaf weed

The value of growth parameters *viz.* plant height, number of tillers/m^2, leaf area index and crop biomass were minimum under weedy check plots, which improved in plots receiving post-emergence application of clodinafop-p-propargyl 60 g/ha, sulfosulfuron 25 g/ha, penoxsulam + cyhalofop 105 g/ha penoxsulam + cyhalofop 150 g/ha and carfentrazone 25 g/ha. However, these parameters were further improved with the application of sulfosulfuron + metsulfuron-methyl 40 g/ha and clodinafop-p-propargyl + 2,4-D (60+500 g/ha).These parameters attained the superior values under ready mix combination of mesosulfuron-methyl + iodosulfuron-methyl sodium 12 g/ha. The hand weeding treatments performed better than all the herbicidal treatments as it had the maximum values of all the growth parameters.

The yield attributing traits, *viz.* effective tillers/m^2, ear head length, grains per ear head and test weight including grain and straw yields, harvest index were affected significantly due to weed control treatments. These attributes attained the poorest values under weedy check plots and were improved due to application of metsulfuron-methyl + iodosulfuron-methyl sodium 12 g/ha and sulfosulfuron + metsulfuron-methyl 40 g/ha being the higher under combined application of clodinafop-p-propargyl + 2,4-D (60+500) g/ha. However, hand weeding in wheat excelled to all the herbicidal treatments as it registered the maximum values of above parameters.

The plant growth yield parameter and yield of wheat grain improved, remarkably, under the post-emergence application of mesosulfuron-methyl + iodosulfuron-methyl sodium 12 g/ha (ready mix) followed by sulfosulfuron + metsulfuron-methyl 40 g/ha and clodinafop + 2,4-D (60+500) g/ha. Use of pinoxaden 60 g/ha or clodinafop 60 g/ha brought about reduction in infestation of grassy weeds. Use of ready mix combination of mesosulfuron-methyl + iodosulfuron-methyl sodium 12 g/ha, sulfosulfuron + metsulfuron-methyl (Total) 40 g/ha and clodinafop + 2,4-D (60+500) g/ha appear to be more profitable and efficient over other treatments.

SUMMARY

The bio-efficacy of clodinafop-p-propargyl 60 g/ha was better against *Avena ludoviciana* Dur. and *Pharalis minor* Retz. to that of sulfosulfuron 25 g/ha, penoxsulam + cyhalofop 105 g/ha· penoxsulam + cyhalofop 150 g/ha and carfentrazone 25 g/ha but it was poor against broad leaved weeds. However, the mesosulfuron-methyl + iodosulfuron-methyl sodium 12

g/ha, sulfosulfuron + metsulfuron-methyl 40 g/ha and combined application of clodinafop-p-propargyl + 2,4-D (60+500) g/ha gave effective control of grassy and broad leaved weeds. Use of pinoxaden 60 g/ha or clodinafop 60 g/ha a brought about a reduction in infestation of grassy weeds. Presently, some new herbicide ready mix combination of mesosulfuron-methyl + iodosulfuron-methyl sodium 12 g/ha, sulfosulfuron + metsulfuron-methyl 40 g/ha and tank mixture herbicides clodinafop + 2,4-D (60+500) g/ha appeared to be more profitable and efficient over other treatments.

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