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Effect of weed management practices on nutrient uptake and productivity of wheat (*Triticum aestivum*)

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India is self-sufficient in catering to the needs of major food staples like rice and wheat. On an average, wheat contributes to around 35% of total food grain production and 21% of cultivated area in the country (Tripathi *et al.* 2016). The wheat productivity of the country is low as compared to world average. Such mismatch in the yield may be attributed to various biotic and abiotic stress constraints augmented by environmental factors which adversely affect growth, metabolism and yield (Afzal *et al.* 2015). Among various biotic factors, weeds are the foremost pests that possess highest loss potential to wheat which can go up to 23%, that is even greater than that of pathogens (16%) (Oerke 2006). Severe weed infestation could result in decrease wheat yield up to 18–73% (Walia 2006). The use of herbicides not only reduces weed density, but also increases nutrient uptake by wheat thus reducing nutrient losses and increasing production (Verma *et al.* 2015). With this background, the present investigation was undertaken to study the effect of different herbicides treatments on nutrient uptake and yield of wheat crop.

An experiment was conducted at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh (29°40' N latitude, 77°42' E longitude; 237 m amsl) during *rabi* 2016–17 with wheat (PBW 590) as a test crop. The experiment was laid out in a randomized block design (RBD) with 3 replications. Wheat was hand sown at a seed rate of 125 kg/ha. The herbicide treatments included pre-emergence (PE), post-emergence (PoE) and pre followed by post-emergence (PE *fb* PoE) along with a weed free and weedy check treatment as control. In the plots of hand weeding treatments, weeding was done by manual labour with the help of *khurpi* as per the treatment. The pre-emergence herbicide, pendimethalin @750 g/ha was applied one day after sowing of wheat. All the post-emergence herbicides viz. sulfosulfuron @25 g/ha, 2,4-D @0.5 kg/ha, pinoxaden @40 g/ha, clodinafop-propargyl @60 g/ha, metsufuron-methyl @4 g/ha, carfentarazone-ethyl @20 g/ha, iodosulfuron @24 g/ha and isoproturon @0.75 kg/ha were applied at 35 DAS. The details of the treatment combinations are mentioned in Table 1. The field was fertilized with $N:P_2O_5:K_2O$ @150:75:60 kg/ha in the form of urea, di-ammonium phosphate and muriate of potash, respectively. Weight of biomass and grain yield per plot was recorded after harvest.

Harvest index, the ratio between the economic yield and biological yield, was calculated as (Donald 1963);

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

It measures the partitioning of photosynthates towards grains, and is expressed in percentage.

The analysis for N, P and K were done in crop plants at harvest stage by adopting micro-kjeldhal, vanado-molybdate yellow colour method (Koenig and Johnson 1942) and flame emission photometry method (Jackson 1973), respectively. The uptake of these nutrients was calculated as kg/ha by multiplying the contents with grain and straw yields in different treatments.

$$\text{Nutrient uptake (kg/ha)} = \text{Nutrient content (\%)} \times \text{crop yield dry matter (q/ha)}$$

The data recorded during the course of investigation were subjected to statistical analysis using analysis of variance (ANOVA) technique for RBD as prescribed by Gomez and Gomez (1984). Standard error of mean in each case and critical difference only for significant cases were calculated at 5% levels of probability.

Biological yield and harvest index: The effect of chemical control measures of weeding on biological yield was studied. The final yield of the crop is the cumulative

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Table 1 Grain, straw, biological yield (q/ha) and harvest index of wheat as influenced by various weed management treatments

Treatment	Yield (q/ha)			Harvest index
	Grain	Straw	Biological	
T_1 : Pendimethalin fb 1HW*	41.66	62.49	104.16	40.06
T_2 : Pendimethalin fb Sulfosulfuron	42.90	63.63	106.50	40.35
T_3 : Sulfosulfuron	43.09	63.92	107.00	40.03
T_4 : Sulfosulfuron + Metsulfuron-methyl	43.39	65.82	109.04	39.16
T_5 : Clodinafop-propargyl	43.64	63.28	106.92	40.83
T_6 : Clodinafop + Metsulfuron-methyl	43.88	64.35	108.24	40.60
T_7 : Pinoxaden + Metsulfuron-methyl	38.95	58.42	91.09	40.36
T_8 : Pinoxaden + Carfentarazone-ethyl	36.09	55.20	92.09	40.23
T_9 : Metsulfuron-methyl + Iodosulfuron	37.29	54.32	92.27	40.76
T_{10} : Isoproturon+2, 4-D	35.35	54.11	83.34	40.23
T_{11} : Weed free	45.53	68.73	110.06	41.43
T_{12} : Weedy check	31.22	43.24	76.06	38.50
SEm±	1.38	2.04	3.38	1.45
CD (P=0.05)	4.07	6.04	10.004	4.35

HW, Hand weeding.

effect of yield attributes and the factors which directly or indirectly influence them during growth stages. In present study, the crop yield per unit area was significantly influenced by different weed management treatments. All treatments showed a greater yield (grain+straw) and harvest index than unweeded control (Table 1). The highest biological yield was recorded in weed free treatment 110.04 q/ha which was statistically at par with T_1, T_2, T_3, T_4, T_5, T_6 and significantly higher than remaining treatments. Among the herbicidal treatment the highest biological yield was recorded in sulfosulfuron+metsulfuron-methyl @20+2 g a.i/ha (109.04 q/ha) treatment (T_4) which was statistically at par with T_1, T_2, T_3, T_5, T_6 and significantly higher than rest of the treatments. The highest HI (41.43%) was found in weed free plot which was significantly higher than weedy check (Table 1). Among the herbicide treatments the highest harvest index was recorded with the application of clodinafop-propargyl @60 g a.i /ha (40.83%) which was statistically at par with all other treatments and significantly higher than weedy check. This significant increase in harvest index of wheat over weedy check was due to reduced crop-weed competition, better sink development and more ability of the plant to convert the dry matter into grains yield brought about by controlling the weeds (Ahmad *et al.* 2005). The

Table 2 Nutrient content and uptake in wheat as influenced by various weed management treatments

Treatment		Nitrogen (%)		Phosphorus (%)		Potassium (%)		Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1	Pendimethalin fb 1HW*	1.34	0.73	0.41	0.19	0.40	1.57	55.82	45.61	101.43	17.08	11.87	28.95	16.66	98.10	114.76
T_2	Pendimethalin fb Sulfosulfuron	1.33	0.74	0.40	0.19	0.36	1.53	57.05	47.08	104.13	16.67	10.29	26.96	16.73	98.35	115.08
T_3	Sulfosulfuron	1.32	0.73	0.40	0.19	0.38	1.55	56.87	46.66	104.42	16.80	10.86	27.66	16.37	99.07	115.44
T_4	Sulfosulfuron +Metsulfuron-methyl	1.34	0.72	0.41	0.19	0.37	1.54	58.57	47.39	105.95	17.78	11.84	29.62	15.79	98.45	114.24
T_5	Clodinafop-propargyl	1.35	0.71	0.42	0.20	0.35	1.52	58.91	44.92	103.83	17.45	11.39	28.84	15.27	86.18	111.45
T_6	Clodinafop+ Metsulfuron-methyl	1.31	0.70	0.42	0.20	0.39	1.56	57.48	45.05	103.53	18.08	11.29	29.46	16.04	101.36	117.4
T_7	Pinoxaden+ Metsulfuron-methyl	1.27	0.64	0.39	0.19	0.34	1.51	49.46	37.38	86.84	14.41	8.76	23.17	13.24	88.21	101.45
T_8	Pinoxaden+Carfentarazone-ethyl	1.29	0.66	0.38	0.18	0.33	1.50	46.55	36.43	82.98	12.99	8.28	21.27	11.90	82.08	94.07
T_9	Metsulfuron-methyl+Iodosulfuron	1.28	0.63	0.38	0.19	0.32	1.49	47.73	34.77	85.50	13.05	7.60	20.65	11.93	80.93	92.86
T_{10}	Isoproturon+2, 4-D	1.26	0.62	0.39	0.19	0.30	1.48	44.54	33.54	79.84	12.01	7.03	19.04	10.60	80.08	90.68
T_{11}	Weed free	1.41	0.78	0.43	0.20	0.43	1.61	64.19	53.26	112.05	21.30	15.02	36.32	19.57	109.9	128.87
T_{12}	Weedy check	1.18	0.45	0.41	0.19	0.28	1.31	36.83	19.45	56.28	9.05	9.08	18.13	8.74	56.64	65.38
	SEm ±	0.04	0.02	0.014	0.011	0.01	0.05	1.81	1.38	3.20	0.52	0.36	0.88	0.48	3.08	3.60
	CD (P= 0.05)	0.12	0.06	NS	NS	0.03	0.15	5.35	4.15	9.45	1.54	1.07	2.60	1.41	9.10	10.63

HW, Hand weeding; NS, Non-significant.

recommended practices of isoproturon+2, 4-D @750+500 g a.i/ha produced only 4.4% higher harvest index over weedy check.

Nutrient content in wheat grain and straw: The maximum N, P and K content in grain and straw was observed in weed free which was significantly higher than weedy check (Table 2). The weedy check plot showed significantly lower value of N, P and K content in grain and straw compared to overall treatments. The maximum N, P and K content in grain and straw was observed in weed free treatment. This might be due to: (i) increased supply of most essential nutrients directly to the crop; (ii) indirectly through checking the loss of nutrients by weeds and (iii) increased nutrient use efficiency.

Nutrient uptake by wheat crop: Nutrient uptake is the function of nitrogen, phosphorus and potassium content in grain and straw yield of the crop. The maximum N, P and K uptake by grain and straw, and total uptake was observed in weed-free treatment (Table 2). The weed free treatment showed maximum N, P and K (grain, straw and total, respectively) in wheat crop, which was statistically at par with T_2, T_3, T_4, T_5 and T_6 and significantly higher than remaining treatments. The weedy check plot recorded minimum nitrogen uptake by wheat crop (grain, straw and total) which was significantly lower than all other treatments. The higher uptake of N, P and K in weed free and different treatments might be due to increased supply of most essential nutrients directly to the crop and indirectly through checking the loss of nutrients resulting in increased nutrient use efficiency (Tomar and Tomar 2014). The lower density of weeds under the treatments might be another valid reason for higher nutrient uptake by crop plants (Verma *et al.* 2015).

SUMMARY

The study was undertaken to devise an efficient herbicide treatment combination for efficient weed control and higher yield and nutrient uptake. A field experiment was conducted to evaluate the performance of different herbicides for weed control and increasing yield as well as nutrient uptake in wheat (*Triticum aestivum* L.) at Meerut, Uttar Pradesh, during *rabi* season in 2016–17. The commonly used herbicides for restricting weed growth in wheat crop were taken in various combinations and appropriate doses. The study comprised 12 treatments (3 replications), of which 10 treatments were of various herbicidal combinations while the rest 2 were weed free and weedy checks. The weed control measure that involved Sulfosulfuron +Metsulfuron-methyl @20+2 g a.i/ha was found to be an efficient weed control measure that satisfactorily enhanced nutrient uptake and gave highest yield among various treatment combinations. The total biological yield of wheat in this treatment was around 1.4 times higher than that of weedy check. Therefore, the post emergence application of sulfosulfuron and metsulfuron-methyl @20+2 g a.i/ha can be an effective measure for weed control giving a higher productivity and nutrient uptake in wheat crop. The results were even comparable to that of weed free plots. The treatment showed an increase of 88.25%, 63.37%, 74.73%, and 43.36% increase in total N, P, K uptake and biological yield, respectively, and therefore may be recommended.

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