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Weed management in wheat (*Triticum aestivum* L.) under peninsular India

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ABSTRACT

A field experiment was conducted during *Rabi* season of 2014-15 at farmer's field at Vijayapur, Karnataka to study the performance of pre-emergence (pendimethalin 1.0 kg a.i./ha, metribuzin 175 g a.i./ha) and post-emergence (2,4-D 2 kg a.i./ha, metsulfuron methyl 4.0 g a.i./ha) herbicides on weed dynamics, crop growth and yield of irrigated wheat. Unchecked weed growth caused 25.04% reduction in grain yield of wheat. Better monocot weed control was obtained with pendimethalin *fb* one intercultivation at 30 DAS and metribuzin *fb* by one intercultivation at 30 DAS whereas dicot weed count and total weed dry weight were significantly lower with pendimethalin *fb* metsulfuron methyl and pendimethalin *fb* 2,4-D. At harvest, pendimethalin *fb* metsulfuron methyl recorded ~ 29% increase in total dry matter production (7.18 g/plant) and increased the crop N, P, K uptake by 32.3, 53.3 and 34.5% respectively as compared to weedy check. Grain yield was significantly higher in weed free check (4.3 t/ha) and was at par with pendimethalin *fb* metsulfuron-methyl, pendimethalin *fb* 2,4-D and pendimethalin *fb* one intercultivation at 30 DAS.

Key words: Grain yield, Herbicides, Nutrient uptake, Weed growth, Wheat.

Wheat [*Triticum aestivum* (L.)] is one of the most important staple food crop of India mainly grown in the states of Punjab, Haryana, Rajasthan and Western U.P. India ranks first in area (30.47 million hectares) and second in production (93.50 million tons) of wheat with an average productivity of 3069 kg/ha (Anonymous, 2016). Recently, wheat cultivation is becoming popular in the canal command areas of peninsular India owing to the advent of short duration cultivars tolerant to terminal heat stress, better market opportunities and a change in food habits of people. The low productivity of wheat in this region may be attributed to a number of factors, of which weed interference is a significant one. The grain yield of wheat decreased by 37.9 per cent due to season long weed-crop competition (Gopinath *et al.*, 2007). The short stature of dwarf wheat varieties coupled with high fertilizer and irrigation requirement creates favourable ecological conditions for heavy weed infestation. The extent of yield reduction largely depends on growth behavior of individual weed species in relation to agro-ecological conditions (Singh *et al.*, 1997). The weed community of wheat crop under peninsular India is mainly dominated by the broad-leaved weeds as opposed to the grassy weeds prevailing in northern India. Moreover, these weeds have a higher growth rate and emerge in recurrent flushes through out the crop-growing season, primarily due to the availability of abundant sunshine, higher temperatures and higher stored soil moisture. A majority of the

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herbicides recommended for wheat are grass killers having foliage activity and hence find limited success in south Indian conditions. 2,4-D is recommended for broadleaf control in wheat, but certain broadleaf weeds like *Rumex dentatus, Malva parviflora, Lathyrus aphaca* and *Fumaria parviflora* are not controlled effectively. Metsulfuron methyl, a sulfonylurea herbicide used for effective control of only broadleaf weeds in wheat (Yadav *et al.,* 2006), can be used under such situations. Often a single pre or post emergence herbicide is unable to control multiple weed populations and necessitates the sequential application for achieving higher weed control efficiencies and improved yields. Pre-emergence application of pendimethalin resulted in efficient control of monocot and dicot weeds whereas post-emergence application of metsulfuron-methyl and 2,4-D amine salt controlled dicot weeds efficiently (Pisal and Sagarka, 2013). Therefore, the present investigation was undertaken with an objective to evaluate the efficacy of sole and sequential application of pre-emergence (pendimethalin, metribuzin) and post-emergence (2,4-D and metsulfuron-methyl) herbicides, against a diverse set of weed flora in wheat under peninsular Indian conditions.

Materials and Methods

An experiment was conducted during *Rabi* season of 2014-15 at a farmer's field in Vijayapur district under Northern Dry Zone of Karnataka. The soil of the experimental field was clayey in texture, low in available N (135.4 kg/ha) and medium in available P (16.8 kg/ha) and K (273.3 kg/ha) and slightly alkaline in reaction with pH 8.10 and EC 0.35 dS m^{-1}. Two pre-emergence (pendimethalin @ 1 kg a.i. ha^{-1} and metribuzin @ 175 g a.i. ha^{-1}) and post-emergence (2, 4-D @ 2 kg a.i. ha^{-1} and metsulfuron-methyl @ 4 g a.i. ha^{-1}) herbicides were applied singly and in sequence and were compared with weedy check and weed free check. Total of 10 treatments were tested in randomized block design with three replications. The wheat variety 'UAS-304' was sown at 22.5 cm row spacing using 150 kg seed/ ha on November 6, 2014 and harvested on March 1, 2015. The recommended fertilizer dose of 100:75:50 kg/ha N: P: K was applied, of which, 1/2 of nitrogen and full dose of P & K was applied at basal. The remaining nitrogen at the rate of 50 kg/ha was top dressed at 30 days after sowing. Pendimethalin and metribuzin were sprayed at 1 DAS (days after sowing) and 2, 4-D and metsulfuron-methyl at 25 DAS with a spray volume of 750 l/ha. Spraying was done by manually operated knapsack sprayer. The crop was grown with standard package of practices for the region. The data on weed count and dry weight were subjected to $\sqrt{(x + 0.5)}$ square root transformation to normalize their distribution. The weed index was calculated by following the formula given by Gill and Kumar (1969).The weed control efficiency was calculated by using the formula given by Mani *et al.* (1981).

Nutrient (N, P, K) concentrations in the plant was determined according to the standard procedures, and the nutrient uptake (kg/ha) was calculated based on the formula :

$$\text{Nutrient uptake (kg/ha)} = \frac{\%\ \text{nutrient concentration} \times \text{biomass (kg/ha)}}{100}$$

All the experimental data were statistically analyzed and critical difference was worked out as described by Gomez and Gomez (1984).

Results and Discussions

Weed growth and weed control efficiency

Important weed species observed in the experimental plot were *Cynodon dactylon, Dinebra retroflexa, Eleusine indica* and *Echinochloa colona* among grasses, *Cyperus rotundus (sedges)* and broad leaved weeds *Convolvulus arvensis, Digera arvensis, Chenopodium album, Amaranthus viridis, Parthenium hysterophorus* and *Latuca runcinata.*

At 60 DAS and at harvest respectively, significantly higher monocot weed count (4.06 and 5.07 per m^2) and dicot weed count (5.14 and 6.20 per m^2) as well as total weed dry weight (210.2 and 466.7 kg/ha) was recorded in unweeded check (Table 1). Application of pendimethalin @ 1 kg a.i./ha *fb* one intercultivation at 30 DAS recorded significantly lower population of monocot weeds (2.27 and 2.91 per m^2) as compared to the other weed control treatments except metribuzin @ 175 g a.i./ ha fb by one intercultivation at 30 DAS. However, broadleaved weed population (1.93 and 2.40 per

Table 1. Weed density, total weed dry weight and weed control efficiency in wheat as influenced by different weed control treatments.

Treatments	Weed density (No./m^2)				Total weed dry weight (kg/ha)		Weed Control Efficiency (%)	
	60 DAS		Harvest					
	Monocot	Dicot	Monocot	Dicot	60 DAS	Harvest	60 DAS	Harvest
Pendimethalin 1 kg/ha (PE) *fb* one IC at 30 DAS	2.27* (4.67)	2.85 (7.67)	2.91 (8.00)	3.72 (13.33)	55.5	140.9	73.57	69.81
Pendimethalin 1 kg/ha (PE) *fb* 2,4-D 2 kg/ha (PoE)	2.61 (6.33)	2.11 (4.00)	3.39 (11.00)	2.67 (6.67)	39.1	90.3	81.23	80.65
Pendimethalin 1 kg/ha *fb* Metsulfuron methyl 4 g/ha (PoE)	2.54 (6.00)	1.93 (3.33)	3.29 (10.33)	2.40 (5.33)	34.9	84.0	83.50	81.96
Metribuzin 175 g/ha (PE) *fb* one IC at 30 DAS.	2.34 (5.00)	2.97 (8.33)	3.23 (10.00)	3.72 (13.33)	60.2	145.4	71.17	68.87
Metribuzin 175 g/ha (PE) *fb* 2,4-D 2 kg/ha (PoE)	2.73 (7.00)	2.34 (5.00)	3.67 (13.00)	2.91 (8.00)	46.6	104.3	77.80	77.64
Metribuzin 175 g/ha (PE) *fb* Metsulfuron methyl 4 g/ha (PoE)	2.64 (6.67)	2.26 (4.67)	3.53 (12.00)	2.73 (7.00)	44.0	91.7	79.20	80.35
2,4-D 2 kg/ha (PoE)	3.53 (12.00)	2.67 (6.67)	4.10 (16.33)	3.07 (9.00)	72.3	133.3	65.38	71.44
Metsulfuron methyl 4 g/ha (PoE)	3.44 (11.33)	2.54 (6.67)	3.94 (15.00)	3.03 (8.67)	67.6	124.9	67.74	73.25
Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.0	0.0	100.00	100.00
Weedy check	4.06 (16.00)	5.14 (26.00)	5.07 (25.33)	6.20 (38.00)	210.2	466.7	0.00	0.00
SEm±	0.16	0.14	0.26	0.18	4.4	7.0	1.96	1.43
CD (P = 0.05)	0.48	0.41	0.80	0.54	12.9	20.8	5.84	4.24

Note : IC = Intercultivation, fb = followed by, PE = Pre-emergence application, PoE = Post-emergence application, * : Data subjected to (x+0.5)1/2 transformation, figures in parentheses are original values

m^2) as well as total weed dry weight (34.9 and 84.0 kg/ha) was significantly lower with pendimethalin @ 1 kg a.i./ha *fb* metsulfuron-methyl @ 4 g a.i./ha which was at par with pendimethalin @ 1 kg a.i./ha *fb* 2,4-D @ 2 kg a.i./ha, metribuzin @ 175 g a.i./ha *fb* metsulfuron-methyl @ 4 g a.i./ha and metribuzin @ 175 g a.i./ha *fb* 2,4-D @ 2 kg a.i./ha. At 60 DAS and at harvest respectively, weed control efficiency (WCE) was significantly higher with pendimethalin @ 1 kg a.i./ha *fb* metsulfuron-methyl @ 4 g a.i./ha (83.50 and 81.96 %) and was at par with pendimethalin @ 1 kg a.i./ha *fb* 2,4-D @ 2 kg a.i./ha, metribuzin @ 175 g a.i./ha fb metsulfuron-methyl @ 4 g a.i./ha and metribuzin @ 175 g a.i./ha *fb* 2,4-D @ 2 kg a.i./ha. Weed index, which is a measure of yield reduction due to weed competition, was significantly higher in weedy check (25.04%) as compared to all the weed control treatments.

In general the better performance of sequential herbicide applications in terms of weed control can be attributed to the reduced germination and retarded initial growth of weed seeds as a result of the soil active pre-emergence herbicides. This was followed by an additional control of the emerged weeds through foliage active post-emergent broad leaved killers at the later stages of crop growth. In general, pendimethalin 1 kg a.i./ha and metsulfuron-methyl @ 4 g a.i./ha proved to be the superior counterparts among the pre and post emergent herbicides respectively. These results are in conformity with the findings of Pisal and Sagarka (2013) who reported that pre-emergence pendimethalin resulted efficient control of monocot and dicot weeds, where as post-emergence application of metsulfuron-methyl and 2,4-D amine salt controlled dicot weeds efficiently.

Effect on crop growth and yield

At harvest, leaf area index (LAI) ranged from 1.06 in weedy check to 1.75 in weed free check (Table 2). Among the weed control treatments, maximum LAI was recorded with pendimethalin @ 1 kg a.i./ha *fb* metsulfuron- methyl @ 4 g a.i./ ha (1.65) which also recorded significantly higher total dry matter (7.18 g/plant). However, it was at par with the treatments pendimethalin @ 1 kg a.i./ha *fb* 2,4-D @ 2 kg a.i./ha and pendimethalin @ 1 kg a.i./ha *fb* one intercultivation at 30 DAS. Yield attributes *viz*., effective tillers/m, panicle length, grains/spike and 1000 grain weight were found to be significantly higher in weed free check (76.83, 12.32 cm, 46.01 and 42.53 g respectively) but was at par with the treatments pendimethalin @ 1 kg a.i./ha *fb* metsulfuron-methyl @ 4 g a.i./ha, pendimethalin @ 1 kg a.i./ ha *fb* 2,4-D @ 2 kg a.i./ha and pendimethalin @ 1 kg a.i./ha fb one intercultivation at 30 DAS. The above treatments also registered significantly higher nutrient (N, P, K) uptake at harvest.

Significantly higher grain yield (Figure 1) was recorded under weed free check (4.35 t/ha) which was at par with the treatments pendimethalin @ 1 kg a.i./ha *fb* metsulfuron- methyl @ 4 g a.i./ha (4.17 t/ha), pendimethalin @ 1 kg a.i./ha *fb* 2,4-D @ 2 kg a.i./ha (4.15 t/ha) and pendimethalin @ 1 kg a.i./ha *fb* one intercultivation at 30 DAS (4.03 t/ha). The increase in yield in these treatments was to the tune of 28.15, 27.26 and 23.70 per cent over weedy check, respectively. This could be attributed to a better accumulation of plant biomass (source) which was later mobilized to the reproductive parts (sink) owing to lower crop-weed competition at the critical stages of crop growth, brought about by a combined effect of pre and post emergence herbicides. These results are in conformity with the findings of Sharma (2009) who found that the maximum grain and straw yield of 2530 and 2900

Table 2. Crop growth parameters, yield attributes and nutrient uptake in wheat at harvest as influenced by different weed control treatments.

Treatments	Leaf Area Index	Total dry matter production (g/plant)	Effective tillers /m	Panicle length (cm)	Grains /spike	1000 Grain weight	Nutrient uptake (kg/ha) by crop		
							N	P	K
Pendimethalin 1 kg/ha (PE) *fb* one IC at 30 DAS	1.55	6.99	70.17	12.00	42.87	40.73	71.53	12.66	80.58
Pendimethalin 1 kg/ha (PE) *fb* 2,4-D 2 kg/ha (PoE)	1.64	7.11	72.83	12.19	44.00	41.53	73.69	12.93	81.65
Pendimethalin 1 kg/ha *fb* Metsulfuron methyl 4 g/ha (PoE)	1.65	7.18	74.17	12.27	44.87	41.73	74.06	13.11	82.40
Metribuzin 175 g/ha (PE) *fb* one IC at 30 DAS.	1.14	5.69	57.33	9.82	33.60	37.00	60.33	9.92	68.92
Metribuzin 175 g/ha (PE) *fb* 2,4-D 2 kg/ha (PoE)	1.15	5.83	58.83	9.94	34.04	37.15	61.33	10.02	70.36
Metribuzin 175 g/ha (PE) *fb* Metsulfuron methyl 4 g/ha (PoE)	1.19	5.94	60.17	10.12	34.10	37.42	62.57	10.12	71.01
2,4-D 2 kg/ha (PoE)	1.44	6.69	67.33	11.43	38.87	40.13	69.71	12.31	77.36
Metsulfuron methyl 4 g/ha (PoE)	1.50	6.76	68.83	11.68	39.17	40.67	70.39	12.43	78.35
Weed free check	1.75	7.33	76.83	12.32	46.01	42.53	77.57	13.75	85.00
Weedy check	1.06	5.04	54.50	9.45	32.93	35.93	55.97	8.55	61.27
SEm±	0.08	0.12	2.31	0.43	1.15	0.73	2.25	0.41	1.96
CD (P = 0.05)	0.24	0.35	6.87	1.28	3.41	2.16	6.69	1.22	5.81

Note : IC = Intercultivation, fb : followed by, PE = Pre-emergence application, PoE = Post-emergence application

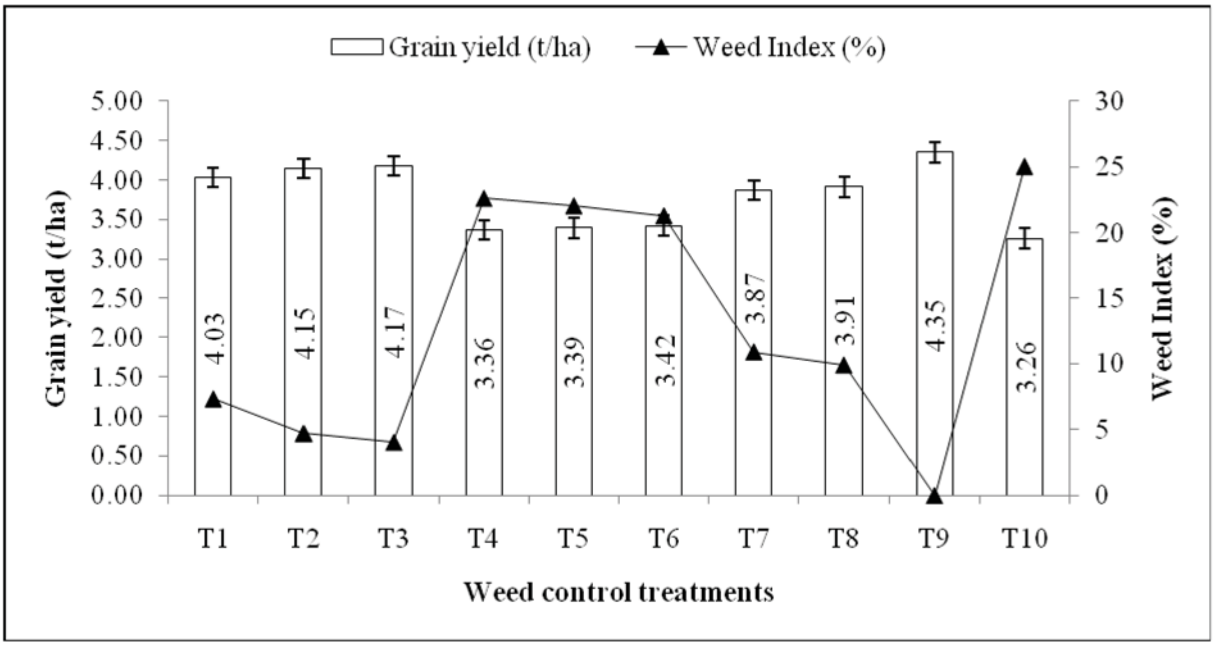

Fig. 1. Grain yield (t/ha) and Weed Index (%) in wheat as influenced by different weed control treatments

kg/ha, respectively, were recorded with post emergence application of metsulfuron methyl at 0.004 kg/ha.

Despite decent weed control, crop growth parameters, nutrient uptake as well as grain yield was significantly lower in the treatments metribuzin @ 175 g a.i./ha *fb* by one intercultivation at 30 DAS, metribuzin @ 175 g a.i./ha *fb* 2,4-D @ 2 kg a.i./ha and metribuzin @ 175 g a.i./ha *fb* metsulfuron methyl @ 4 g a.i./ha. This was due to the phtotoxicity caused by pre-emergence application of metribuzin to wheat crop which ranged upto scale 3 (moderate crop injury, bleached leaves, few dead tillers, recovery at later stages) at 14 days after spraying. Metribuzin toxicity to wheat was also reported by Singh *et al.* (2002).

It was concluded that pendimethalin @ 1 kg a.i./ha *fb* metsulfuron-methyl @ 4 g a.i./ha and pendimethalin @ 1 kg a.i./ha *fb* 2,4-D @ 2 kg a.i./ha were the best treatments for weed control in wheat under peninsular Indian conditions, which can control a diverse range of monocot and dicot weed populations giving very high weed control efficiencies throughout the crop growing period and thereby providing high grain yields.

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