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Herbicidal weed management in dual purpose tall wheat (*Triticum aestivum)*

MEENAKSHI SANGWAN[1], V S HOODA[2], JAGDEV SINGH[3] and ANIL DUHAN[4]

CCS Haryana Agricultural University, Hisar 125 004, India

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ABSTRACT

The field efficacy of pre- and post-emergence herbicide combinations for control of complex weed flora in dual purpose tall wheat was evaluated in a field study conducted at Research farm of CCS HAU Hisar (Haryana) during *rabi* of 2015-16 and 2016-17. *Phalaris minor* Retz., *Rumex dentatus* L., *Convolvulus arvensis* L., *Medicago denticulata* Willd., *Cirsium arvense* (L). Scape, *Cyperus rotundus* L. etc. were major weeds in experimental area. Application of herbicides in both growing seasons reduced weed density and increased wheat grain yield as compared with weedy. After cutting of wheat for fodder, total weed density was reduced under application of pendimethalin 1500 g/ha PRE *fb* pinoxaden + metsulfuron (50+4) 2 WAC (week after cutting at 55 DAS), pendimethalin 1500 g/ha PRE *fb* sulfosulfuron+ metsulfuron (30+2) 2 WAC and pendimethalin 1500 g/ha PRE *fb* clodinafop + metsulfuron (60+4) 2 WAC as compared to alone application of post emergence herbicides. During 86-115 DAS period, more crop growth rate was observed under sequential application of herbicides as compared to post-emergence herbicides. Among herbicidal treatments, significantly higher leaf area index, crop dry weight, grain yield and B:C ratio was reported under sequential application of herbicides which were significantly higher than weedy and alone pre- and post-emergence application of herbicides during both the years of study.

Key words: Dual purpose tall wheat, Sequential herbicide application, Weed density, Weed control

Wheat (*Triticum aestivum* L.) is one of the most important crop among cereals.Weeds are a major impediment to crop production due to their ability to compete for resources i.e. nutrients, water, sunlight, and space etc. resulting in yield loss. Wheat fields are generally infested with both grassy as well as broad leaf weeds and cause yield loss upto 7–50% depending upon the type of weed flora and their intensity (Singh *et al.* 2004). Mongia *et al.*(2005) also reported yield reduction up to 25-30% in wheat due to weed infestation in North West Plain Zone of India. Herbicides are becoming more and more important in modern agriculture due to lack of effective weed control measures against crop associated weeds like *Phalaris minor* and *Avena ludoviciana* and development of herbicide resistance in *Rumex dentatus* against metsulfuron-methyl (Chhokar *et al.* 2017), in *Avena ludoviciana* against clodinafop (Singh 2016) and also due to high cost involved in manual weeding (Chhokar *et al.* 2012).Thus, herbicides are the key component of weed management in wheat in India, particularly in North Western states of India. Herbicides efficacy against weeds by applying them after cutting of crop for fodder has been studied in present study. There is possibility of greater competition from the weeds in dual purpose wheat as the crop will require time to regenerate and attain some growth after cutting for fodder. Pre- or post-emergence herbicide application alone cannot control various flushes of weeds, thus under such situations, sequential application of herbicides may play critical role for the broad-spectrum weed management in dual purpose tall wheat crop.

MATERIALS AND METHODS

Field experiments were conducted during 2015-16 and 2016-17 at Research Farm of Haryana Agricultural University, Hisar, India. Soil texture of experimental field was sandy loam with pH (7.9), EC (0.25 dS/m), Organic carbon (0.35%), and was low in available nitrogen (132 kg/ha), medium in available phosphorous (17 kg/ha) and high in available potassium (370 kg/ha). Crop received 33 mm rainfall in 2015-16 and 47.2 mm in 2016-17, respectively. During second year (2016-17) mean weekly temperature for initial 7-8 weeks period of crop growth was relatively 2-3°C higher than first year and had an adverse impact on yield of crop. Wheat variety C-306 with seed rate of 100 kg/ha was sown during last week of October at 22.5 cm spaced rows during both the seasons. Crop was raised with recommended package of practices of CCS, HAU except weed control treatments. Experiment was conducted in a randomized complete block design with three replications during both the growing seasons. There were nine treatments

Present address: [1]District Extension Specialist (meenakshisangwan1991@gmail.com), Krishi Vigyan Kendra, Rohtak; [2]Professor (singhjagdev58@gmail.com), [3]Assistant Scientist (vshooda79@gmail.com), [4]Assistant Residue Chemist (a.duhan@rediffmail.com), Department of Agronomy, CCS HAU, Hisar, Haryana 125004.

including weed-free, weedy check and seven treatments consisting of five herbicides, viz. pendimethalin 1500 g/ha PRE alone (T1) and followed by (*fb*) post-emergence (POE) application of pinoxaden 50 g/ha + metsulfuron 4 g/ha (T2), sulfosulfuron + metsulfuron (30+2) g/ha (T3) and clodinafop + metsulfuron (60+4) g/ha (T4) at 2 week after cutting (WAC), alone application of pinoxaden 50 g/ha + metsulfuron 4 g/ha (T5), sulfosulfuron + metsulfuron (30+2) g/ha (T6) and clodinafop + metsulfuron (60+4) g/ha (T7) at 2 WAC. All the herbicides were applied using knapsack sprayer with a flat fan nozzle which was calibrated to deliver 250 L/ha of spray solution. Grassy and broad leaf weed (including sedges) density was recorded by randomly placing a quadrant (0.25 m^2) in each plot at 25, 55, 85, 115 DAS and at harvest. Visual weed control was observed at 90 DAS. After 55 days of sowing, dual purpose tall wheat crop was harvested for fodder at 5 cm stubble height and yield was recorded. Crop dry weight was measured in each plot at harvest. Crop growth rate and leaf area index at different intervals were calculated by:

$$\text{CGR (g/m}^2\text{/day)} = \frac{W_2 - W_1}{t_2 - t_1}, \quad \text{LAI} = \frac{\text{Total leaf area}}{\text{Land area ha}}$$

The crop was harvested manually at maturity, thereafter treatment wise biological and grain yield was recorded after threshing. Benefit-cost ratio (B:C) was calculated with:

$$\text{B:C ratio} = \frac{\text{Gross return}}{\text{cost of cultivation}} \times 100$$

The data with zero value were subjected to square root transformation and percent data were subjected to arcsine transformation to normalize their distribution.

Table 1 Effect of different herbicides on grassy and broad leaf weeds density (pooled data) in dual purpose wheat

Treatment	Dose (g/ha)	Time of application	25 DAS	55 DAS	85 DAS	115 DAS	At harvest
			Grassy weed density (No./m$_2$)				
Pendimethalin	1500	PRE	1.8 (2.3)	2.2 (3.7)	4.1 (14.9)	4.2 (16.5)	3.9 (14.2)
Pendimethalinfb pinoxaden + metsulfuron	1500 fb (50+4)	PRE fb 2 WAC	1.9 (2.7)	2.3 (4.4)	2.7 (6.0)	1.7 (2.0)	1.9 (2.7)
Pendimethalinfb sulfosulfuron+ metsulfuron	1500 fb (30+2)	PRE fb 2 WAC	1.5 (1.3)	2.2 (3.9)	2.8 (6.5)	1.8 (2.2)	1.7 (2.0)
Pendimethalinfb clodinafop + metsulfuron	1500 fb (60+4)	PRE fb 2 WAC	1.8 (2.3)	2.4 (4.7)	2.9 (7.0)	1.7 (2.0)	1.8 (2.2)
Pinoxaden + metsulfuron	50 + 4	2 WAC	3.9 (14.5)	5.8 (32.2)	6.3 (39.0)	4.3 (17.7)	4.1 (15.5)
Sulfosulfuron+ metsulfuron	30 + 2	2 WAC	4.2 (16.9)	5.4 (28.5)	6.2 (36.5)	4.2 (16.2)	3.8 (13.5)
Clodinafop + metsulfuron	60 + 4	2 WAC	4.1 (15.4)	5.7 (30.7)	6.2 (37.5)	4.4 (17.7)	4.0 (15.2)
Weed free	-		1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
Weedy check	-		4.4 (17.8)	5.6 (30.5)	6.3 (39.0)	7.1 (17.7)	6.9 (15.2)
CD (P=0.05)			1.1	1.5	1.4	1.8	1.7
			Broad leaf weed density including sedges (No./m$_2$)				
Pendimethalin	1500	PRE	4.5 (18.9)	5.7 (31.0)	6.7 (43.4)	6.1 (36.5)	4.5 (18.9)
Pendimethalinfb pinoxaden + metsulfuron	1500 fb (50+4)	PRE fb 2 WAC	4.6 (19.7)	5.8 (32.0)	2.3 (4.5)	2.4 (4.5)	4.6 (19.7)
Pendimethalinfb sulfosulfuron+ metsulfuron	1500 fb (30+2)	PRE fb 2 WAC	4.4 (18.0)	5.3 (27.0)	2.1 (3.5)	2.2 (3.7)	4.4 (18.0)
Pendimethalinfb clodinafop + metsulfuron	1500 fb (60+4)	PRE fb 2 WAC	4.4 (18.5)	5.5 (29.0)	2.3 (4.4)	2.1 (3.2)	4.4 (18.5)
Pinoxaden + metsulfuron	50 + 4	2 WAC	9.2 (83.3)	10.3 (104.4)	5.6 (30.5)	5.3 (27.5)	9.2 (83.3)
Sulfosulfuron+ metsulfuron	30 + 2	2 WAC	9.2 (82.4)	10.2 (102.7)	5.9 (33.9)	5.5 (28.5)	9.2 (82.4)
Clodinafop + metsulfuron	60 + 4	2 WAC	9.3 (86.9)	10.4 (107.0)	5.7 (31.7)	5.5 (28.9)	9.3 (86.9)
Weed free	-		1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
Weedy check	-		9.2 (83.5)	10.6 (110.9)	10.9 (117.2)	10.0 (99.2)	9.2 (83.5)
CD (P=0.05)			2.0	2.2	2.4	2.3	2.0

*Original data given in parenthesis was subjected to square root transformation

All experimental data were analyzed using SPSS version 7.5. The data were subjected to analysis of variance and significant differences among treatment means were compared by calculating CD at 5% level of significance using one-way ANOVA.

RESULTS AND DISCUSSION

Weed density and visual weed control: Before cutting among herbicidal treatments, application of pendimethalin 1500 g/ha PRE, pendimethalin 1500 g/ha PRE *fb* pinoxaden + metsulfuron (50+4) 2 WAC (weeks after cutting), pendimethalin 1500 g/ha PRE *fb* sulfosulfuron+ metsulfuron (30+2) 2 WAC and pendimethalin 1500 g/ha PRE *fb* clodinafop + metsulfuron (60+4) 2 WAC significantly reduced grassy (*P. minor*) and broad leaf weeds density and were statistically at par with each other during both the years, which might be due to efficacy of pedimethalin as a PRE herbicide application in controlling weeds (Table 1). After cutting of wheat for fodder, a new flush of weeds had emerged because of application of irrigation and fertilizer in the field. After cutting, total weed density was significantly reduced under sequential application of pendimethalin 1500 g/ha PRE *fb* pinoxaden + metsulfuron (50+4) 2 WAC (week after cutting at 55 DAS), pendimethalin 1500 g/ha PRE *fb* sulfosulfuron+ metsulfuron (30+2) 2 WAC and pendimethalin 1500 g/ha PRE *fb* clodinafop + metsulfuron (60+4) 2 WAC as compared to alone application of post-emergence herbicides. This might be due to lower efficacy of herbicides against aged (older) weeds, as after taking a cut from the wheat crop for fodder in the late fall, new weeds germinate or the existing weed stubbles find an opportunity to flourish in the absence of competitionand becomes hardy with more developed roots and less meristematic tissue, thus delayed application (70 DAS or 2 weeks after cutting) of alone POE herbicidal mixture was less effective against aged (older) and hardy weeds in the absence of PRE herbicide application. The results are in conformity with Das T. K. (2008). Similarly, sequential application of pendimethalin 1.5 kg/ha PRE followed by tank mix pinoxaden + metsulfuron 64 g/ha or mesosulfuron + iodosulfuron 14.4 g/ha or sulfosulfuron + metsulfuron (RM) 32 g/ha POE provided excellent control of *P. minor* as well as broad leaf weeds in wheat field (Anonymous 2015-16).

Among different herbicide treatments sequential application of pendimethalin 1500 g/ha PRE *fb* pinoxaden + metsulfuron(50+4) 2 WAC, pendimethalin 1500 g/ha PRE *fb* sulfosulfuron+ metsulfuron (30+2) 2 WAC and pendimethalin 1500 g/ha PRE *fb* clodinafop + metsulfuron (60+4) 2 WAC proved equally effective against various flush of mixed flora of weeds comprising broad-leaf and grassy, and provided significantly higher visual weed control than their alone applications during both the crop seasons (Table 2). Baghestani *et al.* (2008) also reported that tank-mix or pre-mix use of different herbicide chemistry or sequential application of pre- and post-emergence herbicides at different times showed effective weed control.

Crop growth parameters: During both the years, highest crop dry weight was recorded under weed free (Table 2). Among different herbicidal treatments, significantly less dry weight and leaf area index of crop were recorded under alone application of PRE pendimethalin 1500 g/ha, POE pinoxaden + metsulfuron (50+4) 2 WAC, sulfosulfuron+ metsulfuron (30+2) 2 WAC and clodinafop + metsulfuron (60+4) 2 WAC as compared to sequential application of both PRE and POE herbicides, which might be due to more competition by weeds to crop plants for resources like nutrients, light, space and moisture which ultimately led to reduction of photosynthetic area, activity and growth performance of dual purpose wheat.

Table 2 Effect of different herbicides on visual weed control, crop growth and yields of dual purpose wheat

Treatment	Dose (g/ha)	Time of appli-cation	*Visual weed control (%)	2015-16					2016-17				
				Fodder yield (q/ha)	LAI at 115 DAS	Crop dry weight (g/m.r.l) at harvest	Grain yield (q/ha)	B-C ratio	Fodder yield (q/ha)	LAI at 115 DAS	Crop dry weight (g/m.r.l) at harvest	Grain yield (q/ha)	B-C ratio
Pendimethalin	1500	PRE	65.3	38.01	3.60	209.6	22.64	1.76	36.24	3.48	198.4	20.12	1.58
Pendimethalinfb pinoxaden + metsulfuron	1500 fb (50+4)	PRE fb 2 WAC	96.0	38.45	3.87	226.8	29.30	2.08	36.10	3.63	214.5	26.80	1.89
Pendimethalinfb sulfosulfuron+ metsulfuron	1500 fb (30+2)	PRE fb 2 WAC	98.0	38.22	3.89	227.9	29.90	2.14	36.23	3.62	216.5	27.45	1.95
Pendimethalinfb clodinafop + metsulfuron	1500 fb (60+4)	PRE fb 2 WAC	95.7	37.97	3.88	227.3	28.99	2.08	36.41	3.64	215.9	26.47	1.89
Pinoxaden + metsulfuron	50 + 4	2 WAC	77.0	36.99	3.63	213.2	25.98	1.96	35.14	3.46	203.6	24.10	1.82
Sulfosulfuron+ metsulfuron	30 + 2	2 WAC	79.7	37.46	3.66	212.5	27.02	2.05	34.87	3.48	202.9	24.85	1.87
Clodinafop + metsulfuron	60 + 4	2 WAC	76.3	37.23	3.65	213	26.41	2.01	35.12	3.47	203.4	23.98	1.82
Weed free	-		100.0	38.37	3.91	231.1	30.89	1.82	36.18	3.71	220.6	27.90	1.62
Weedy check	-		0.0	36.87	3.52	199.5	19.87	1.65	34.68	3.41	190.4	17.51	1.46
CD (P=0.05)			-	NS	0.18	12.5	192.2	-	NS	0.13	11.9	145.4	-

* Average data of two years

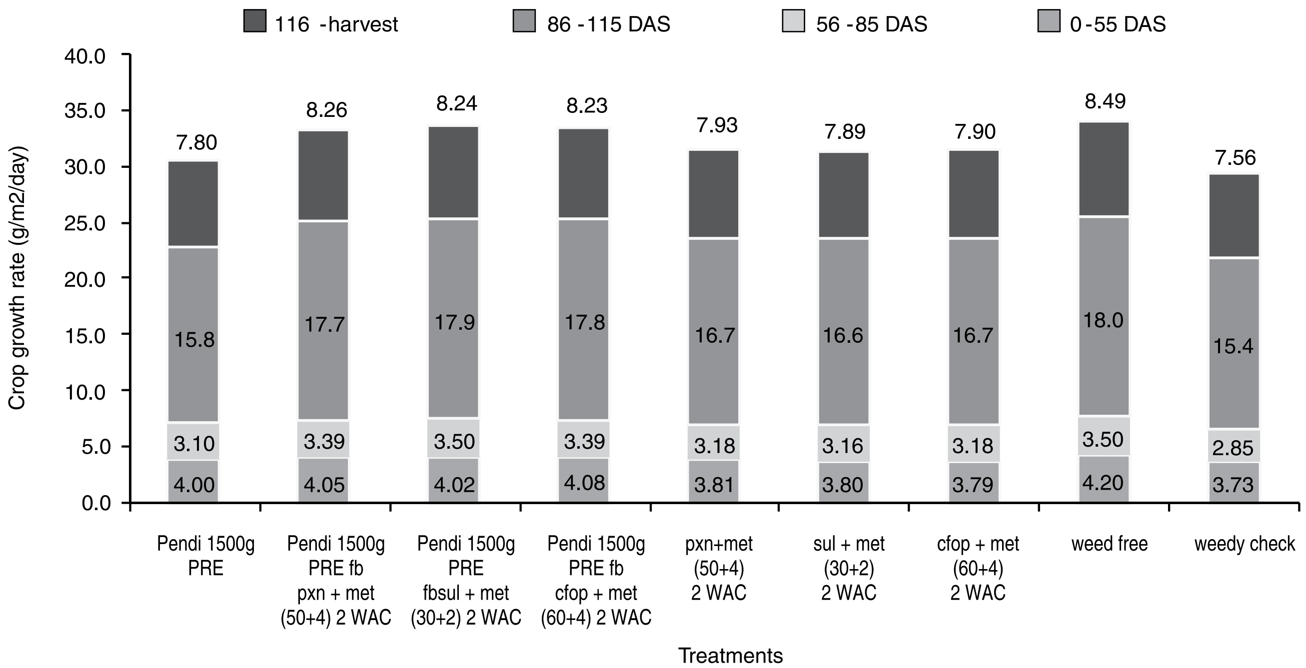

Fig 1 Effect of different herbicides on crop growth rate (pooled data of two years) of dual purpose wheat

Different herbicidal treatments did not cause any change in CGR of wheat recorded for 0-55, 56- 85 and 115 DAS-harvest period during both the years (Fig 1). While for 86-115 DAS period, more crop growth rate was observed under sequential application of herbicides as compared to alone application and weedy check.

Yield and economics: No statistically significant difference in B:C ratio and grain yield of dual purpose wheat were observed among weed free treatment and sequential application of herbicides. These treatments produced significantly higher grain yield than weedy check and alone pre- and post-emergence application of herbicides during both the years of study (Table 2). Sequential application of pendimethalin 1500 g/ha PRE *fb* pinoxaden + metsulfuron (50+4) 2 WAC, pendimethalin 1500 g/ha PRE *fb* sulfosulfuron+ metsulfuron (30+2) 2 WAC and pendimethalin 1500 g/ha PRE *fb* clodinafop + metsulfuron (60+4) 2 WAC recorded higher grain yield and B:C ratio of dual purpose wheat. The increase in grain yield of dual purpose wheat might be due to more dry weight, CGR and LAI higher yield attributes due to less competition from weeds under sequential application of herbicides. Biomass production is an important determinant of grain yields in wheat, therefore more the crop biomass, greater the amount of photosynthates that can be translocated to the grain during grain filling stage. The results corroborates with the findings (Anonymous 2015-16). Less crop yield was reported during 2016-17, which might be due to higher mean weekly temperature (2-3°C) for initial 7-8 weeks period of crop growth than first year and had an adverse impact on yield of crop.

From the present study it may be concluded that sequential application of pendimethalin 1500 g/ha PRE *fb* pinoxaden + metsulfuron (50+4) g/ha or sulfosulfuron + metsulfuron (30+2) g/ha or clodinafop + metsulfuron (60+4) g/ha 2 WAC could be adopted for broad spectrum weed control in dual purpose wheat.

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