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Bioefficacy of Pinoxaden 5 EC in Combination with Broadleaf Herbicide against Complex Weed flora in Wheat

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A field experiment was conducted during 2010-11 and 2011-12 to evaluate the efficacy of pinoxaden alone and in combination with other herbicides against complex weed flora in wheat. Pinoxaden 50 g/ha alone and as tank mix combination individually with carfentrazone 20 g/ha , metsulfuron 4 g/ha or 2,4-D 500g/ha at 28 DAS and pinoxaden 50 g/ha alone at 28 DAS followed by carfentrazone 20 g/ha or metsulfuron 4 g/ha or 2,4-D 500g/ha at 35 DAS, was compared to idosulfuron + mesosulfuron (2.4 + 12 g/ha), weed free and weedy check for weed control and grain yield. *Medicago denticulata, Chenopodium album and Alternanthera triandera* were the major weeds constituting 86.46% during 2010-11 and 87.27% during 2011-12. It was concluded that other than hand weeding twice, combined application of pinoxaden + carfentrazone @ 50 + 20 g/ ha and pinoxaden + metsulfuron @ 50 + 4 g/ ha produced significantly higher grain yield of wheat than weedy check due to the lowest weed dry matter production, high weed control efficiency and higher yield attributes. Weed index was the highest under weedy check and reduced the grain yield of wheat by 36.9%.

Key words: Carfentrazone, Metsulfuron, Pinoxaden, Weeds, Wheat

In order to sustain global agricultural food production, the importance of protecting arable crops against negative yield effects from weeds is well recognized. Wheat (*Triticum* spp) is one of the most important grain crops which is grown in approximately 225 million ha worldwide. It constitutes one of the most abundant sources of energy and protein for the world population and its increased production is essential for food security (Chhokar *et al.* 2008). Severe competition from weeds is one of the most important factors determining productivity and sustainability of any crop. Weeds compete with crop plants for space, solar radiation, nutrients, water and carbon-di-oxide. Several broad-leaved weeds are becoming a serious problem along with grassy weeds in wheat. Continuous use of same herbicide for many years resulted in development of resistance by weeds against herbicides necessitating the search for new herbicide molecules. Pinoxaden, belonging to phenylpyrazolin group with acetyl-COA-carboxylase (ACCase) has inhibiting action (Hoffer *et al*. 2006). It is a selective grass killer with foliar action. Since grass killers do not control the broad-leaved weeds, the present study was conducted to evaluate the bioefficacy of pinoxaden in combination with herbicides that were reported to be effective against broad-leaved weeds such as metsulfuron-methyl, carfentrazone and 2, 4-D for managing complex weed flora in wheat. There is a need for tank mix or sequential application of herbicides like 2,4-D, carfentrazone and metsulfuron for the control of complex weed flora. Keeping this in view, efforts were made to explore the possibility of using pinoxaden in tank mixture with 2,4-D, metsulfuron and carfentrazone for satisfactory control of complex weed flora in wheat.

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Materials and Methods

An experiment to evaluate the bioefficacy of pinoxaden 5 EC alone and in combination with broad-leaved herbicides against mixed weeds in wheat was conducted during *the Rabi* seasons of 2010-11 and 2011-12, at Instructional cum Research farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur. The experimental soil was inceptisols, low in organic carbon, low in available nitrogen, medium in phosphorus and high in potassium with neutral soil reaction. The experiment was laid down in randomized block design replicated thrice with thirteen weed control treatments *viz.,* pinoxaden (50g/ha), metsulfuron-methyl (4g/ha), pinoxaden + carfentrazone (50 + 20 g/ha), pinoxaden + metsulfuron (50 + 4g/ha), pinoxaden + 2,4-D (50 + 500g/ha), pinoxaden (g/ha) *fb* carfentrazone (50 *fb* 20 g/ha), pinoxaden *fb* metsulfuron-methyl (50 *fb* 4 g/ha), pinoxaden *fb* 2,4-D (50 *fb* 500 g/ha), carfentrazone (20 g/ha), Idosulfuron + mesosulfuron (2.4 + 12 g/ha), 2,4-D (500g/ha), weed free (hand weeding twice) and a weedy check. All herbicides alone and in combination were applied as post emergence between 28-35 DAS as per treatment

with knapsack power sprayer using flat fan nozzle and 500 L of water per ha. Application of the second herbicide was made two days after the first. Wheat variety 'Kanchan' was sown during first fortnight of December for both the years. The recommended fertilizer dose of 100:50:30 kg/ha N:P:K was applied, of which, 1/3 of nitrogen and full dose of P and K was applied as basal dose. A seed rate of 100 kg/ ha was sown at a distance of 20 cm row to row spacing. Rest of the recommended package of practices was followed (Package of Practices, Rabi 2012). Observations on weed density and biomass were recorded at 28, 60 DAS and at harvest. Wheat grain yield and yield attributes were recorded at maturity and analyzed using ANOVA.

Results and Discussion

Weed flora

Wheat field was infested with both grassy and broad leaved weeds. However, the flora was dominated by broad leaved weeds (*Medicago denticulata, Chenopodium album and Alternanthera triandera*) constituting 86.46% and 87.27% of the total weed flora during 2010-11 and 2011-2012, respectively. Other weeds include the meager occurrence of *Echinocloa colona*, *Melilotus indica*, *Rumex dentatus* and *Anagallis arvensis*. *Medicago denticulata* had the highest proportion (45.12% and 45.09%) of the total weed flora in 2010-11 and 2011-12, respectively.

Table 1. Effect of pinoxaden 5 EC in combination with broad leaf herbicides on weed density (m^{-2}) at 28 DAS during 2010-11 and 2011-12

Treatment	*Medicago denticulata*		*Chenopodium album*		*Alternenthera traindera*		Others		Total	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Pinoxaden	3.72	3.44	2.11	1.95	2.20	2.11	1.68	1.58	4.95	4.60
	(13.33)	(11.3)	(4.00)	(3.3)	(4.33)	(4.0)	(2.33)	(2.0)	(23.99)	(20.6)
Metsulfuron-	3.85	3.72	1.86	1.87	2.04	1.95	1.58	1.56	4.85	4.71
methyl	(14.33)	(13.3)	(3.00)	(3.0)	(3.66)	(3.3)	(2.00)	(2.0)	(22.99)	(21.6)
Pinoxaden +	3.85	3.89	1.95	1.77	2.48	2.27	1.68	1.58	5.02	5.05
carfentrazone	(14.33)	(14.6)	(3.33)	(2.6)	(5.66)	(4.6)	(2.33)	(2.0)	(24.65)	(24.9)
Pinoxaden +	3.67	3.67	2.11	2.04	2.27	2.20	1.77	1.77	4.95	4.92
Metsulfuron	(12.66)	(13.0)	(4.00)	(3.6)	(4.66)	(4.3)	(2.66)	(2.6)	(23.98)	(23.6)
Pinoxaden +	3.81	3.76	1.87	1.95	2.34	2.20	1.86	1.77	5.05	4.95
2,4-D	(14.00)	(13.6)	(3.00)	(3.3)	(5.00)	(4.3)	(3.00)	(2.6)	(25.00)	(23.9)
Pinoxaden fb	3.85	3.76	1.86	1.86	2.54	2.61	1.87	1.77	5.18	5.12
carfentrazone	(14.33)	(13.6)	(3.00)	(3.0)	(6.00)	(6.3)	(3.00)	(2.6)	(26.33)	(25.6)
Pinoxaden fb	4.02	3.85	1.87	1.95	2.48	2.34	1.68	1.68	5.21	5.05
metsulfuron	(15.66)	(14.3)	(3.00)	(3.3)	(5.66)	(5.0)	(2.33)	(2.3)	(26.65)	(24.9)
Pinoxaden fb	4.14	3.94	1.95	1.95	2.41	2.27	2.27	2.04	5.52	5.21
2,4-D	(16.66)	(15.0)	(3.33)	(3.3)	(5.33)	(4.6)	(4.66)	(3.6)	(29.98)	(26.6)
Carfentrazone	3.76	3.76	2.34	2.20	2.54	2.41	2.03	2.03	5.37	5.24
	(13.66)	(13.6)	(5.00)	(4.3)	(6.00)	(5.3)	(3.66)	(3.6)	(28.32)	(26.9)
Idosulfuron +	3.81	3.76	2.48	2.20	2.55	2.41	1.77	1.68	5.37	5.12
mesosulfuron	(14.00)	(13.6)	(5.66)	(4.3)	(6.00)	(5.3)	(2.66)	(2.3)	(28.32)	(25.6)
2,4-D	3.76	3.76	1.86	1.86	2.34	2.27	2.04	1.68	5.08	5.02
	(13.66)	(13.6)	(3.00)	(3.0)	(5.00)	(4.6)	(3.66)	(2.3)	(25.32)	(24.6)
Weedy check	4.38	3.81	2.04	1.95	2.27	2.27	1.95	1.95	5.55	5.08
	(18.66)	(14.0)	(3.66)	(3.3)	(4.66)	(4.6)	(3.33)	(3.3)	(30.31)	(25.3)
Weed free	2.41	2.20	1.68	1.34	1.95	1.77	1.77	1.46	3.72	3.24
	(5.33)	(4.3)	(2.33)	(1.3)	(3.33)	(2.6)	(2.66)	(1.6)	(13.32)	(9.98)
CD (P=0.05)	2.17	2.06	1.25	1.16	1.43	1.36	1.14	1.09	2.98	2.81

Weed density

The weed density decreased after the application of post emergence herbicides up to harvest. However, weed density at 28 DAS was the lowest under hand weeding than rest of the treatments and remained low in the later part of the crop growth till harvest. Pinoxaden with carfentrazone and metsulfuron were as good as weed free check until harvest during both the years. At 60 DAS and at harvest, the total weed density was significantly lower under pinoxaden and carfentrazone @50 + 20 g/ha and pinoxaden + metsulfuron @ 50 + 4 g / ha than weedy check but, this was comparable with hand weeding twice and other treatments. Similar findings on the effectiveness of metsulfuron in combination with other herbicides have been reported by Kumar *et al*. (2010). However, application of pinoxaden 50 g/ha and 2,4-D 500 g/ha alone or as sequence application was not effective in reducing the density of the weeds. Similarly, metsulfuron–methyl, carfentrazone and idosulfuorn + mesosulfuron (2.4 + 12 g/ha) showed little effect on the weed density during both the years (Table 1, 2 and 3).

Dry weight of weeds

It was found that dry weight of broad leaved weeds at 60 DAS and at harvest was affected significantly. Weedy check had the highest weed dry weight. The dry weight of weeds decreased significantly due to

Table 2. Effect of pinoxaden 5 EC in combination with broad leaf herbicides on weed density (m^{-2}) at 60 DAS during 2010-11 and 2011-12

Treatment	*Medicago denticulata*		*Chenopodium album*		*Alternenthera traindera*		Others		Total	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Pinoxaden	3.08	2.97	2.34	2.27	2.41	2.34	1.34	1.46	4.60	4.49
	(9.00)	(8.3)	(5.00)	(4.6)	(5.33)	(5.0)	(1.33)	(1.6)	(20.66)	(19.6)
Metsulfuron-methyl	2.54	2.20	1.46	1.34	2.04	2.04	1.95	2.04	3.89	3.67
	(6.00)	(4.3)	(1.66)	(1.3)	(3.66)	(3.6)	(3.33)	(3.6)	(14.65)	(12.9)
Pinoxaden +	2.48	2.41	1.34	1.34	1.58	1.46	1.22	1.34	3.24	3.19
carfentrazone	(5.66)	(5.3)	(1.33)	(1.3)	(2.00)	(1.6)	(1.00)	(1.3)	(9.99)	(9.6)
Pinoxaden +	2.34	2.27	1.34	1.34	1.34	1.34	1.68	1.77	3.24	3.23
Metsulfuron	(5.00)	(4.6)	(1.33)	(1.3)	(1.33)	(1.3)	(2.33)	(2.6)	(9.99)	(9.9)
Pinoxaden + 2,4-D	2.54	2.48	1.58	1.46	1.68	1.46	2.34	2.48	3.98	3.89
	(6.00)	(5.6)	(2.00)	(1.6)	(2.33)	(1.6)	(5.00)	(5.6)	(15.33)	(14.6)
Pinoxaden fb	2.61	2.48	1.34	1.34	1.77	1.58	1.87	1.95	3.72	3.58
carfentrazone	(6.33)	(5.6)	(1.33)	(1.3)	(2.66)	(2.0)	(3.00)	(3.3)	(13.32)	(12.3)
Pinoxaden fb metsulfuron	2.68	2.48	1.46	1.46	1.86	1.95	1.95	2.04	3.89	3.85
	(6.66)	(5.6)	(1.66)	(1.6)	(3.00)	(3.3)	(3.33)	(3.6)	(14.65)	(14.3)
Pinoxaden fb 2,4-D	2.55	2.41	1.56	1.77	1.95	1.95	2.11	2.04	3.98	3.94
	(6.00)	(5.3)	(2.00)	(2.6)	(3.33)	(3.3)	(4.00)	(3.6)	(15.33)	(14.9)
Carfentrazone	2.80	2.68	1.58	1.58	1.58	1.46	1.87	1.87	3.85	3.72
	(7.33)	(6.6)	(2.00)	(2.0)	(2.00)	(1.6)	(3.00)	(3.0)	(14.33)	(13.3)
Idosulfuron +	2.91	2.80	2.11	2.04	1.87	1.86	1.95	2.04	4.34	4.26
mesosulfuron	(8.00)	(7.3)	(4.00)	(3.6)	(3.00)	(3.0)	(3.33)	(3.6)	(18.33)	(17.6)
2,4-D	2.91	2.86	1.22	1.22	1.58	1.46	2.11	2.20	3.94	3.89
	(8.00)	(7.6)	(1.00)	(1.0)	(2.00)	(1.6)	(4.00)	(4.3)	(15.00)	(14.6)
Weedy check	5.46	5.73	2.61	2.73	2.67	2.73	2.97	3.03	7.15	7.45
	(29.33)	(32.3)	(6.33)	(7.0)	(6.66)	(7.0)	(8.33)	(8.6)	(50.65)	(55.0)
Weed free	2.27	2.04	1.34	1.22	1.34	1.34	1.58	1.34	3.13	2.80
	(4.66)	(3.6)	(1.33)	(1.0)	(1.33)	(1.3)	(2.00)	(1.3)	(9.32)	(7.3)
CD (P=0.05)	1.72	1.63	1.04	1.01	1.11	1.09	1.19	1.17	2.43	2.34

Figures given in parenthesis are original values

different herbicide treatments as compared to untreated check at 60 DAS and at harvest (Table 4). The data on dry weight of weeds at 60 DAS revealed that significantly the lowest weed dry weight was recorded under pinoxaden + carfentrazone, followed by weed free treatment and pinoxaden+ metsulfuron.

Table 3. Effect of pinoxaden 5 EC in combination with broad leaf herbicides on weed density (m^{-2}) at harvest during 2010-11 and 2011-12

Treatment	*Medicago denticulata*		*Chenopodium album*		*Alternenthera traindera*		Others		Total	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Pinoxaden	3.44	3.63	2.73	2.68	2.20	2.11	1.22	1.34	4.92	5.02
	(11.33)	(12.6)	(7.00)	(6.6)	(4.33)	(4.0)	(1.00)	(1.3)	(23.66)	(24.6)
Metsulfuron-methyl	2.86	2.68	1.58	1.68	1.68	1.56	1.34	1.34	3.72	3.58
	(7.66)	(6.6)	(2.00)	(2.3)	(2.33)	(2.0)	(1.33)	(1.3)	(13.32)	(12.3)
Pinoxaden +	2.73	2.61	1.56	1.46	1.58	1.46	1.46	1.34	3.63	3.39
carfentrazone	(7.00)	(6.3)	(2.00)	(1.6)	(2.00)	(1.6)	(1.66)	(1.3)	(12.66)	(10.9)
Pinoxaden +	2.80	2.54	1.58	1.46	1.46	1.34	1.56	1.46	3.67	3.34
metsulfuron	(7.33)	(6.0)	(2.00)	(1.6)	(1.66)	(1.3)	(2.00)	(1.6)	(12.99)	(10.6)
Pinoxaden + 2,4-D	2.91	2.97	1.68	1.58	1.46	1.46	1.86	1.77	3.93	3.89
	(8.00)	(8.3)	(2.33)	(2.0)	(1.66)	(1.6)	(3.00)	(2.6)	(14.99)	(14.6)
Pinoxaden fb	2.97	3.03	1.56	1.58	1.46	1.58	1.58	1.46	3.81	3.85
carfentrazone	(8.33)	(8.6)	(2.00)	(2.0)	(1.66)	(2.0)	(2.00)	(1.6)	(13.99)	(14.3)
Pinoxaden fb	2.86	2.80	1.77	1.86	1.68	1.56	1.58	1.46	3.89	3.81
metsulfuron	(7.66)	(7.3)	(2.66)	(3.0)	(2.33)	(2.0)	(2.00)	(1.6)	(14.65)	(14.0)
Pinoxaden fb 2,4-D	3.03	3.13	1.56	1.46	1.34	1.22	2.34	2.20	4.18	4.10
	(8.66)	(9.3)	(2.00)	(1.6)	(1.33)	(1.0)	(5.00)	(4.3)	(16.99)	(16.3)
Carfentrazone	3.19	3.29	1.68	1.56	1.34	1.17	1.58	1.46	3.98	3.94
	(9.66)	(10.3)	(2.33)	(2.0)	(1.33)	(1.0)	(2.00)	(1.6)	(15.32)	(15.0)
Idosulfuron +	3.39	3.49	2.27	2.20	1.46	1.34	1.87	1.77	4.56	4.51
mesosulfuron	(11.00)	(11.6)	(4.66)	(4.3)	(1.66)	(1.3)	(3.00)	(2.6)	(20.32)	(19.8)
2,4-D	3.29	3.29	1.58	1.46	1.58	1.46	1.86	1.77	4.22	4.10
	(10.33)	(10.3)	(2.00)	(1.6)	(2.00)	(1.6)	(3.00)	(2.6)	(17.33)	(16.3)
Weedy check	6.04	6.44	3.08	3.39	2.73	2.91	2.80	2.68	7.74	8.20
	(36.00)	(41.0)	(9.00)	(11.0)	(7.00)	(8.0)	(7.33)	(6.6)	(59.33)	(66.6)
Weed free	2.68	2.54	1.58	1.46	1.58	1.46	1.56	1.46	3.63	3.39
	(6.66)	(6.0)	(2.00)	(1.6)	(2.00)	(1.6)	(2.00)	(1.6)	(12.66)	(10.9)
CD (P=0.05)	1.96	1.94	1.17	1.14	1.05	1.03	1.09	1.05	2.58	2.53

Table 4. Effect of pinoxaden 5 EC in combination with broad leaf herbicides on the weed dry weight and weed control efficiency during 2010-11 and 2011-12

Treatments	Dose	Weed dry weight (g/m²)				WCE	
		60 DAS		At harvest		At harvest	
		2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Pinoxaden	50	2.64	2.64	4.87	4.84	38.40	38.29
		(6.48)	(6.49)	(23.24)	(22.88)		
Metsulfuron-methyl	4	1.60	1.56	4.61	4.56	44.98	45.38
		(2.05)	(1.94)	(20.76)	(20.25)		
Pinoxaden + carfentrazone	50 + 20	1.36	1.36	4.00	3.96	58.83	58.95
		(1.36)	(1.34)	(15.53)	(15.22)		
Pinoxaden + Metsulfuron	50 + 4	1.46	1.45	4.13	4.11	56.10	55.69
		(1.64)	(1.60)	(16.56)	(16.43)		
Pinoxaden + 2,4-D	50 + 500	2.00	1.99	4.52	4.52	47.28	46.27
		(3.51)	(3.45)	(19.89)	(19.92)		
Pinoxaden fb carfentrazone	50 & 20	1.89	1.88	4.63	4.62	44.39	43.66
		(3.09)	(3.05)	(20.98)	(20.89)		
Pinoxaden fb metsulfuron	50 & 4	1.77	1.75	4.70	4.71	42.67	41.45
		(2.62)	(2.57)	(21.63)	(21.71)		
Pinoxaden fb 2,4-D	50 & 500	1.97	1.96	4.84	4.84	39.12	38.21
		(3.39)	(3.35)	(22.97)	(22.91)		
Carfentrazone	20	2.00	1.98	4.45	4.44	48.90	48.27
		(3.49)	(3. 42)	(19.28)	(19.18)		
Idosulfuron + mesosulfuron	2.4 + 2.0	2.32	2.31	4.85	4.65	39.09	43.04
		(4.87)	(4.83)	(22.98)	(21.12)		
2,4-D	500	1.89	1.88	4.50	4.50	47.60	47.95
		(3.08)	(3.02)	(19.77)	(19.73)		
Weedy check		4.00	4.01	6.18	6.13	—	—-
		(15.47)	(15.62)	(37.73)	(37.08)		
Weed free		1.42	1.41	3.92	3.87	60.58	61.05
		(1.53)	(1.50)	(14.87)	(14.44)		
CD (P=0.05)		1.66	1.66	3.16	3.07	—-	—-
		(2.24)	(2.25)	(9.50)	(8.94)		

This is in conformity with the findings of Shoeran *et al*. (2013) and Yadav *et al*. (2009). At harvest, significantly lower weed dry weight was recorded under weed free treatment, but was comparable with pinoxaden + carfentrazone and pinoxaden+ metsulfuron, in descending order. The same trend was depicted during both the years. The weed control efficiency against broad leaved weeds at harvest was found to be maximum in weed free check (60.58% and 61.05%) followed by pinoxaden

Table 5. Effect of pinoxaden 5 EC in combination with broad leaf herbicides on the yield attributes and yield of wheat during 2010-11 and 2011-12

Treatment	Dose	Plant height		No. of tillers/m row length		Test weight(g)		Grain yield(t/ha)		Weed Index	
		At harvest (cm)		At harvest							
		2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Pinoxaden	50	81.30	81.6	63.55	63.5	33.94	33.9	2.18	2.28	19.55	18.57
Metsulfuron-methyl	4	83.34	83.2	70.77	71.1	36.04	36.1	2.35	2.42	13.28	13.57
Pinoxaden + carfentrazone	50 + 20	86.88	86.1	82.00	82.5	38.11	39.1	2.65	2.73	2.21	2.85
Pinoxaden + Metsulfuron	50 + 4	84.94	84.8	76.77	76.4	38.08	38.2	2.62	2.66	3.32	1.78
Pinoxaden + 2,4-D	50 + 500	83.73	83.4	72.55	72.9	36.27	36.4	2.42	2.51	10.70	10.35
Pinoxaden fb carfentrazone	50 & 20	83.43	83.4	69.88	70.3	35.63	35.7	2.34	2.37	13.65	15.37
Pinoxaden fb metsulfuron	50 & 4	83.27	83.3	69.44	70.7	35.33	35.4	2.34	2.42	13.65	13.57
Pinoxaden fb 2,4-D	50 & 500	83.24	83.4	69.22	69.5	34.63	34.5	2.51	2.45	7.38	12.50
Carfentrazone	20	84.66	84.7	76.66	76.8	37.40	37.5	2.53	2.54	6.64	9.28
Idosulfuron + mesosulfuron	2.4 + 12.0	81.43	81.5	66.11	67.1	34.37	34.5	2.21	2.29	18.45	18.21
2,4-D	500	84.03	84.3	76.22	76.4	36.35	36.4	2.50	2.58	7.75	7.85
Weedy check		74.84	74.6	63.22	63.8	33.27	33.4	1.75	1.73	35.42	38.21
Weed free		87.04	87.2	96.89	72.3	38.26	38.3	2.71	**2.80**	—-	—
CD (P=0.05)		2.85	N.S.	3.74	8.26	N.S.	N.S.	0.41	0.47	—-	—

+ carfentrazone with mean values of 58.83% and 58.95% during both the years, respectively.

Effect of weedicides on crop

Tank mixing of carfentrazone with pinoxaden although caused injury in terms of yellowing of tips, the injury disappeared within 15 days after spray and did not result in any detrimental effect on grain yield of wheat. Different weed control treatments had significant effect on the plant height in the 1st year, number of tillers per meter row length at harvest, and grain yield except plant height in the 2nd year and 1000 seed weight during both the years (Table 2). In the first year of experiment, plant height was found to be significantly higher in weed free conditions, but was statistically at par with pinoxaden+carfentrazone and pinoxaden + metsulfuron. Distinctly higher number of tillers per meter row length was recorded in weed free, followed by pinoxaden + carfentrazone during both the years, respectively. Significantly higher grain yield was recorded in weed free treatment during both the years with mean values of 2.71 and 2.80 t/ha, respectively, and was comparable with herbicidal treatments pinoxaden + carfentrazone (2.73 and 2.66 t/ha) followed by pinoxaden +metsulfuron, in both the years. The higher yield and yield attributes were owing to superior weed control both in terms of reduction in density and dry weight of weeds. These findings fall in line with Katara *et al*. 2012. The increase in growth and yield attributes under these treatments might be attributed to the reduction in weed competitiveness with the crop, which ultimately would have favored better growth and development of crop. Uncontrolled weeds reduced wheat grain yield by 36.9%. All the weed control treatments substantially reduced the competition by weeds for various resources resulting in lower weed index. In the 1st year (2010-11), pinoxaden + carfentrazone recorded the least weed index (2.21) followed by pinoxaden + metsulfuron (3.32) and in the 2nd year (2011-12) pinoxaden + metsulfuron recorded the least weed index (1.78) followed by pinoxaden + carfentrazone (2.85). Hence, pinoxaden can safely be used as tank mix with metsulfuron or carfentrazone with no loss of herbicide efficacy (Table 5).

Conclusion

It is concluded that other than hand weeding twice, combined application of pinoxaden + carfentrazone @ 50 + 20 g/ ha and pinoxaden + metsulfuron @ 50 + 4 g/ ha at 28 days after sowing could result in significantly higher grain yield of wheat than weedy check due to the lowest weed dry matter production, high weed control efficiency and higher yield attributes. Weed index was the highest under weedy check, which reduced the grain yield of wheat by 36.9%.

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