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Influence of pinoxaden in combination with other herbicides on nutrient depletion by weeds in wheat

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ABSTRACT

Pinoxaden 50 g/ha alone and as tank mixture with and before metsulfuron-methyl 4 g/ha, carfentrazone ethyl 20 g/ha and 2, 4-D 500 g/ha was compared to isoproturon + 2, 4-D, clodinafop *fb* 2, 4-D, weed free and weedy check for nutrient depletion by weeds and wheat. *Phalaris minor* and *Anagallis arvensis* were the major weeds constituting 60.8 and 21.4% of total weed population, respectively. Pinoxaden *fb* metsulfuron-methyl (50 *fb* 4 g/ha) remaining at par with pinoxaden + metsulfuron-methyl (50 + 4 g/ha) and pinoxaden + 2,4-D (50 + 500 g/ha) resulted in significantly lower total weed dry weight over rest of the herbicidal treatments. Pinoxaden + metsulfuron-methyl (50 + 4 g/ha) and pinoxaden *fb* metsulfuron-methyl (50 *fb* 4 g/ha) were as effective as weed free in reducing N, P and K uptake by weeds. Weeds in weedy check removed 37.4 kg/ha N, 6.9 kg/ha P and 46.8 kg/ha K. Weed free remaining at par with pinoxaden + metsulfuron-methyl (50 + 4 g/ha), pinoxaden *fb* metsulfuron-methyl (50 *fb* 4 g/ha) and pinoxaden *fb* 2, 4-D (50 *fb* 500 g/ha) resulted in significantly higher wheat dry matter accumulation over rest of the treatments. Weed free gave highest grain yield. However, pinoxaden + metsulfuron-methyl (50 + 4 g/ha), pinoxaden (50 g/ha), pinoxaden + carfentrazone-ethyl (50 + 20 g/ha), pinoxaden *fb* metsulfuron-methyl (50 *fb* 4 g/ha), isoproturon + 2, 4-D (1250 + 500 g/ha), clodinafop *fb* 2, 4-D (60 *fb* 1000 g/ha), pinoxaden + 2, 4-D (50 + 500 g/ha), pinoxaden *fb* carfentrazone-ethyl (50 *fb* 20 g/ha) and pinoxaden *fb* 2, 4-D (50 *fb* 500 g/ha) were as good as weed free.

Key words: 2,4-D, Carfentrazone, Metsulfuron-methyl, Nutrient uptake, Pinoxaden, Weeds, Wheat

Among different production factors, weeds pose serious threat to the productivity of wheat. They compete with crop plants for light, water and nutrients. Isoproturon is nationwide recommended herbicide in wheat. However, continuous reliance on isoproturon resulted in a heavy build-up of *Phalaris minor* (Malik and Singh 1995). Clodinafop was recommended as alternate herbicide against isoproturon resistant *Phalaris minor* in 1998-99. But cross resistance of these herbicides (Dhawan *et al*. 2009) necessitating the search for new herbicide molecules. Pinoxaden is new herbicide belonging to phenyl pyrazolin group with acetyl-COA-carboxylase (ACCase) inhibiting action (Hoffer *et al*. 2006). It is a selective grass killer with foliar action. Since grass killers don’t control the broad-leaved weeds, the present study was conducted to evaluate pinoxaden in combination with broad-leaf herbicides such as metsulfuron-methyl, carfentrazone and 2,4-D to reduce nutrient depletion by weeds and increase by wheat under mid hill conditions of Himachal Pradesh.

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MATERIALS AND METHODS

Wheat variety ‘*HPW 155*’ was sown during the first fortnight of November for two consecutive years (2010-11 and 2011-12) with recommended package of practices except weed control. Fifteen weed control treatments, *viz*. pinoxaden (50 g/ha), metsulfuron methyl (4 g/ha), carfentrazone-ethyl (20 g/ha) and 2, 4-D (500 g/ha) alone, pinoxaden (50 g/ha) with and before carfentrazone-ethyl (20 g/ha), metsulfuron-methyl (4 g/ha) and 2, 4-D (500 g/ha), isoproturon + 2, 4-D (1250 + 500 g/ha), clodinafop *fb* 2, 4-D (60 *fb* 1000 g/ha), mesosulfuron + iodosulfuron (13 + 5 g/ha), weed free and weedy check were tested in randomized block design with 3 replications. All herbicides alone and as combination were applied as post-emergence at 28-35 DAS as per treatment with knapsack power sprayer using 750 L water per hectare. Application of the second herbicide was made two days after the first. The soil of experimental field was silty clay loam in texture, acidic in reaction, medium in available nitrogen (323 kg/ha) and high in phosphorus (26 kg/ha) and available potassium (276.4 kg/ha). Observations on weed density and biomass were recorded at 60, 90, 120 and 150 DAS and at harvest using quadrat of 0.5 x 0.5 m, placed at two random spots in each plot. Weed density and biomass data showed variation and were subjected to square root transformation ($\sqrt{(x+1)}$). Wheat grain yield and yield attributes were recorded at maturity. The crop was harvested in the first fortnight of May 2010 and 2011. Weed control efficiency or weed control index was worked out based on weed population or weed dry weight as per the formula outlined by Mani *et al*. (1973) and Mishra and Tosh (1979), respectively.

RESULTS AND DISCUSSION

Effect on weeds

Phalaris minor and *Anagallis arvensis* were the major weeds constituting 60.8 and 21.4% of total weed population, respectively. *Avena ludoviciana*, *Lolium temulentum* and *Poa annua* constituted 4.7, 3.6 and 3.0% of total weed population, respectively. The other weeds showed their little infestation but as a whole constituted 6.5% of the total weed flora.

Dry matter accumulation increased consistently up to 150 DAS, thereafter it declined gradually. The decline in weed dry weight was owed to withering of weeds (Fig. 1). Weed control treatments significantly decreased total weed dry weight as compared to weedy check (Table 1). Removing the weeds whenever they appear under the weed free treatment resulted in complete elimination of weed competition as it resulted in lowest total weed dry weight. Pinoxaden *fb* metsulfuron-methyl (50 *fb* 4 g/ha) remaining at par with pinoxaden + metsulfuron-methyl (50 + 4 g/ha) and pinoxaden + 2,4-D (50 + 500 g/ha) resulted in significantly lower total weed dry weight over rest of the herbicidal treatments. The superiority of pinoxaden + metsulfuron methyl in controlling weeds has been reported by (Kumar *et al.* 2010). Pinoxaden + carfentrazone-ethyl (50 + 20 g/ha), pinoxaden *fb* carfentrazone-ethyl (50 *fb* 20 g/ha), pinoxaden *fb* 2,4-D (50 *fb* 500 g/ha), mesosulfuron + iodosulfuron (13 + 5 g/ha), isoproturon + 2, 4-D (1250 + 500 g/ha), clodinafop *fb* 2, 4-D (60 *fb* 1000 g/ha) behaving statistically alike were the next better treatments. Owing to synergetic enhancement or additive effects, herbicidal combinations in general were better than sole application of herbicides in effectively reducing the total weed dry weight.

Weed control treatments significantly influenced the GR_w and RGR_w (Table 1). All treatments except 2, 4-D (500 g/ha) had significantly lower GR_w over weedy check. All the herbicide combinations and pinoxaden (50 g/ha) were comparable to weed free in reducing the GR_w between 90-120 DAS. Sole application of metsulfuron-methyl (4 g/ha) and carfentrazone-ethyl (20 g/ha) were less effective in influencing GR_w, though the former was superior to the later. Relative growth rate of weeds was not significantly curtailed by any of the treatments

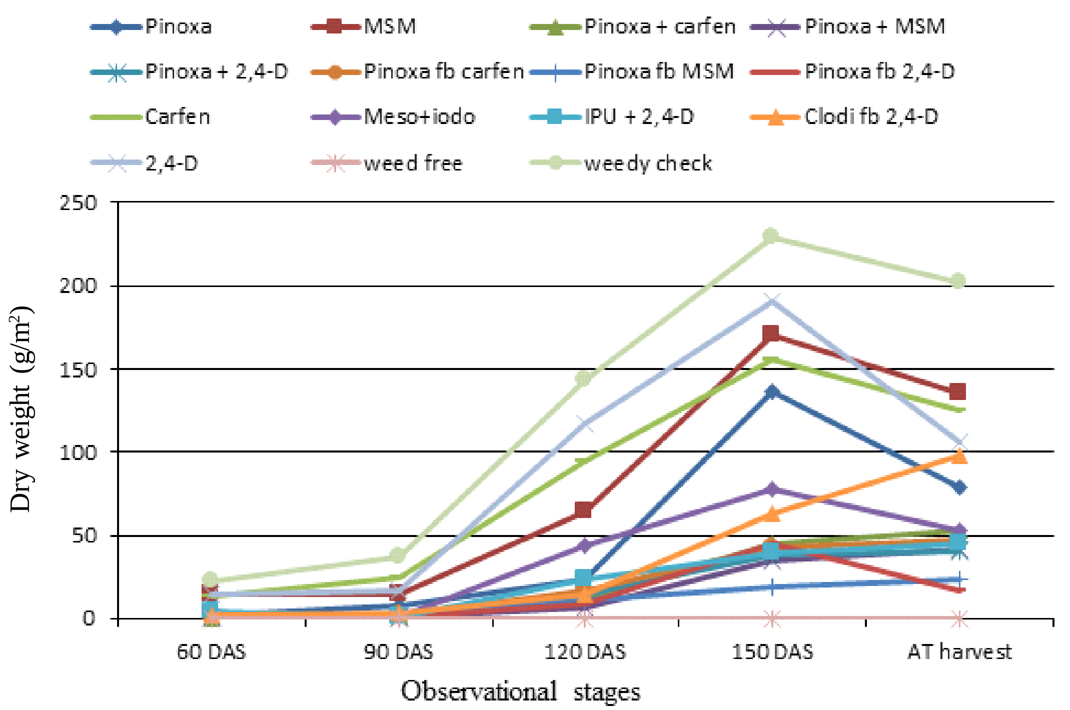

Fig. 1 Effect of weed control treatments on total weed dry matter accumulation

Table 1. Effect of weed control treatments on total weed count, total weed dry matter accumulation and weed growth analysis

Treatment	Dose (g/ha)	Weed count (90 DAS)	Weed weight (g/m^2) (150 DAS)	WCE (%)	WCI (%)	GR_w (g/m^2/day) (90-120 DAS)	RGR_w (g/g/day) (90-120 DAS)
Pinoxaden	50	10.8 (116.0)	11.6 (136.3)	69.4	49.2	0.528	0.043
Metsulfuron-methyl	4	13.8 (193.3)	13.0 (169.6)	54.4	28.0	1.635	0.048
Pinoxaden + carfentrazone-ethyl	50 + 20	6.3 (38.7)	6.7 (44.4)	91.2	77.0	0.320	0.077
Pinoxaden + metsulfuron methyl	50 + 4	3.2 (9.3)	4.3 (18.4)	95.5	82.1	0.210	0.072
Pinoxaden + 2,4-D	50 + 500	6.5 (41.3)	5.8 (37.6)	90.1	81.6	0.456	0.118
Pinoxaden *fb* carfentrazone-ethyl	50 *fb* 20	5.5 (30.7)	6.5 (42.5)	92.6	78.7	0.458	0.054
Pinoxaden *fb* metsulfuron-methyl	50 *fb* 4	4.9 (24.0)	4.8 (23.4)	93.5	89.7	0.366	0.096
Pinoxaden *fb* 2, 4-D	50 *fb* 500	6.5 (44.0)	6.5 (44.7)	90.0	85.6	0.248	0.073
Carfentrazone-ethyl	20	14.8 (222.7)	12.4 (155.0)	48.2	33.8	2.364	0.045
Mesosulfuron + iodosulfuron	13 + 5	7.6 (57.3)	8.7 (77.2)	87.2	69.2	1.402	0.143
Isoproturon + 2,4-D	1250 + 500	5.8 (34.7)	6.3 (39.6)	90.6	77.0	0.751	0.140
Clodinafop *fb* 2,4-D	60 *fb* 1000	7.2 (50.7)	8.0 (63.2)	89.3	44.8	0.374	0.077
2,4-D	500	12.4 (156.0)	13.8 (190.0)	64.4	26.9	3.338	0.067
Weed free		1.0 (0.0)	1.0 (0.0)	100.0	100.0	0.000	0.000
Weedy check		21.0 (445.3)	15.1 (228.8)	0.0	0.0	3.526	0.046
LSD		2.2	2.5	-	-	0.967	0.068

Data transformed to square root transformation ($\sqrt{x+1}$), Values given in parentheses are the means of original values

compared to weedy check. Pinoxaden + 2,4-D (50 + 500 g/ha), mesosulfuron + iodosulfuron (13 + 5 g/ha) and isoproturon + 2,4-D (1250 + 500 g/ha) resulted in significantly higher RGR_w between 90-120 DAS over other treatments.

Because of species-wise better control of weeds under the herbicide mixtures or sequence application, weed control efficiency or index under them was comparable to weed free. Application of herbicide alone gave poor control of weeds, therefore had lower weed control efficiency and weed control index. These results are in close conformity with findings of Yadav *et al*. (2009) and Chopra and Chopra (2005).

Effect on crop

Dry matter accumulation increased consistently with the advancement of crop growth. The rate of increase was lowest from 30-60 DAS. Then it increased consistently up to harvest. Wheat crop accumulated 1.3, 5.3, 26.0, 64.9 and 87.0% of total dry matter accumulation up to 30, 60, 90, 120 and 150 DAS, respectively.

Weed free remaining at par with pinoxaden + metsulfuron methyl (50 + 4 g/ha), pinoxaden *fb* metsulfuron methyl (50 *fb* 4 g/ha) and pinoxaden *fb* 2, 4-D (50 *fb* 500 g/ha) resulted in significantly higher dry matter accumulation over rest of the treatment (Table 2). The reduction in population and dry weight of weeds under these treatments and higher weed control efficiency/index created favourable micro-environment for growth and development of wheat crop and thus increased the dry matter accumulation of wheat. Data pertaining to crop growth rate (CGR) and relative growth rate (RGR) of wheat crop have been embodied in Table 2. Weed control treatments did not significantly influence the CGR and RGR of wheat. This showed that rate of growth of wheat remained unaffected irrespective to variation in population and dry weight of weeds.

All treatments were significantly superior to weedy check in increasing grain yield of wheat (Table 2). Weed free gave highest grain yield. However, pinoxaden + metsulfuron-methyl (50 + 4 g/ha), pinoxaden (50 g/ha), pinoxaden + carfentrazone-ethyl (50 + 20 g/ha), pinoxaden *fb* metsulfuron methyl (50 *fb* 4 g/ha), isoproturon + 2,4-D (1250 + 500 g/ha), clodinafop *fb* 2,4-D (60 *fb* 1000 g/ha), pinoxaden + 2, 4-D (50 + 500 g/ha), pinoxaden *fb* carfentrazone-ethyl (50 *fb* 20 g/ha) and pinoxaden *fb* 2,4-D (50 *fb* 500 g/ha) were as good as weed free. 2,4-D (500 g/ha), metsulfuron-methyl (4 g/ha), carfentrazone-ethyl (20 g/ha) and mesosulfuron + iodosulfuron (13 + 5 g/ha) being statistically at par were less effective in influencing grain yield of wheat. As indicated by weed index, un-interrupted growth of weeds in the weedy check reduced wheat yield by 39.5% over weed free.

All the weed control treatments significantly increased the N, P and K uptake by wheat over weedy check. Because of the higher grain and straw yield, weed free remaining at par with pinoxaden + metsulfuron-methyl (50 + 4 g/ha), pinoxaden +

Table 2. Effect of weed control treatments on total crop dry matter accumulation (g/m²) and crop growth analysis

Treatment	Dose (g/ha)	Crop dry matter (At harvest)	CGR (g/m^2/day) (90-120 DAS)	RGRc (g/g/day) (60-90 DAS)	Grain yield (t/ha)		WI (%)
					2010-11	2011-12	
Pinoxaden	50	1073.8	12.62	0.059	3.68	3.55	6.8
Metsulfuron methyl	4	929.4	12.10	0.053	3.16	3.07	19.9
Pinoxaden + carfentrazone-ethyl	50 + 20	1051.0	14.71	0.044	3.70	3.66	5.2
Pinoxaden + metsulfuron-methyl	50 + 4	1078.0	14.09	0.058	3.84	3.81	1.6
Pinoxaden + 2, 4-D	50 + 500	1056.4	13.26	0.054	3.67	3.60	6.5
Pinoxaden *fb* carfentrazone-ethyl	50 *fb* 20	1062.0	13.34	0.052	3.59	3.50	8.8
Pinoxaden *fb* metsulfuron-methyl	50 *fb* 4	1088.4	13.30	0.056	3.74	3.76	3.5
Pinoxaden *fb* 2, 4-D	50 *fb* 500	1052.3	12.24	0.056	3.52	3.45	10.3
Carfentrazone-ethyl	20	942.9	12.69	0.052	3.07	3.16	19.9
Mesosulfuron + iodosulfuron	13 + 5	963.5	14.09	0.053	3.39	3.40	12.6
Isoproturon + 2, 4-D	1250 + 500	994.4	12.89	0.055	3.60	3.61	7.2
Clodinafop *fb* 2, 4-D	60 *fb* 1000	1036.4	14.62	0.051	3.57	3.54	8.4
2, 4-D	500	938.9	11.73	0.048	3.05	2.99	22.2
Weed free		1095.8	13.06	0.053	3.86	3.90	0.0
Weedy check		715.5	10.93	0.046	2.43	2.26	39.5
LSD		34.2	NS	NS	0.43	0.46	-

Table 3. Effect of weed control treatments on N, P and K uptake (kg/ha) by total weeds at harvest

Treatment	Dose (g/ha)	Weeds			Crop		
		N	P	K	N	P	K
Pinoxaden	50	14.9	2.7	18.3	115.9	21.3	86.1
Metsulfuron-methyl	4	25.1	4.6	31.1	98.4	17.1	74.6
Pinoxaden + carfentrazone-ethyl	50 + 20	7.9	1.4	9.8	115.1	21.1	84.5
Pinoxaden + metsulfuron-methyl	50 + 4	4.4	0.8	5.7	118.9	21.8	86.6
Pinoxaden + 2,4-D	50 + 500	5.6	1.0	7.0	114.5	20.8	84.8
Pinoxaden *fb* carfentrazone-ethyl	50 *fb* 20	8.1	1.5	10.1	113.5	20.1	85.5
Pinoxaden *fb* metsulfuron-methyl	50 *fb* 4	4.6	0.9	5.8	117.6	20.6	87.9
Pinoxaden *fb* 2,4-D	50 *fb* 500	5.7	1.1	7.0	111.9	20.1	83.9
Carfentrazone-ethyl	20	22.8	4.1	29.1	98.3	16.7	76.1
Mesosulfuron + iodosulfuron	13 + 5	9.4	1.7	11.9	105.0	19.3	76.9
Isoproturon + 2,4-D	1250 + 500	7.4	1.4	9.2	107.4	19.5	77.8
Clodinafop *fb* 2,4-D	60 *fb* 1000	15.2	2.9	18.9	110.7	20.7	82.6
2,4-D	500	19.5	3.6	24.6	97.2	16.7	75.8
Weed free		0.0	0.0	0.0	120.5	22.1	87.8
Weedy check		37.4	6.9	46.8	76.4	13.1	59.1
LSD		5.4	1.1	6.7	11.9	2.4	8.7

carfentrazone-ethyl (50 + 20 g/ha), pinoxaden + 2, 4-D (50 + 500 g/ha), pinoxaden *fb* metsulfuron methyl (50 *fb* 4 g/ha) pinoxaden *fb* carfentrazone-ethyl (50 *fb* 20 g/ha) pinoxaden *fb* 2,4-D (50 *fb* 500 g/ha) and pinoxaden (50 g/ha) alone resulted in significantly higher N, P and K uptake by crop. 2,4-D (500 g/ha), metsulfuron-methyl (4 g/ha), isoproturon + 2,4-D (1250 + 500 g/ha), carfentrazone-ethyl (20 g/ha) and mesosulfuron + iodosulfuron (13 + 5 g/ha) were less effective in influencing N, P and K uptake over other treatments (Table 3). In general, all herbicide combinations were superior to alone application of herbicides in improving the N, P and K uptake by crop. The superiority of herbicide combinations in influencing N, P and K uptake by crop has been documented (Khokhar and Nepalia 2010). Weed free resulted in 57.72, 68.70 and 48.56% higher N, P and K uptake over weedy check, respectively.

Nutrient uptake is the function of dry matter and nutrient content. Higher dry matter accumulation by wheat with application of pinoxaden + metsulfuron-methyl (50 + 4 g/ha) may be attributed to higher root spread and penetration in soil due to weed free environment. Also, lower N, P and K removal by weeds allowed wheat to grow vigorously and accumulate more biomass, which consequently led to higher uptake of these nutrients (Kumar and Das 2008). Higher dry matter accumulation by wheat under herbicidal treatments increased the nutrient uptake (Brar and Walia 2008).

The present investigation conclusively inferred that combined application of pinoxaden and metsulfuron-methyl/carfentrazone/2,4-D either as tank mixed or sequential is the better alternative to isoproturon + 2,4-D or clodinafop *fb* 2,4-D in reducing nutrient uptake by weeds and increasing it by wheat.

REFERENCES

Brar AS and Walia US. 2008. Effect of rice residue management techniques and herbicides on nutrient uptake by *Phalaris minor* Retz. and wheat (*Triticum aestivum* L.). *Indian Journal of Weed Science* **40**(3&4): 121-127.

Chopra N and Chopra NK. 2005. Bioefficacy of fenoxaprop, clodinafop, metribuzin alone and in combinations against weeds in wheat and their residual effect on succeeding crops. *Indian Journal of Weed Science* **37**(3&4): 163-166.

Dhawan RS, Punia SS, Singh S, Yadav D and Malik RK. 2009. Productivity of wheat (*Triticum aestivum*) as affected by continuous use of new herbicides for management of littleseed canarygrass (*Phalaris minor*). *Indian Journal of Agronomy* **54**(1): 58-62.

Gill HS and Vijayakumar. 1966. 'Weed Index'. A new method for reporting weed control trials. *Indian Journal of Agronomy* **14**: 96-98.

Hoffer U, Muehlebach M, Hole S and Zoschke A. 2006. Pinoxaden–for broad spectrum grass weed management in cereal crops. *Journal of Plant Disease and Protection* **20**(5): 989-995.

Khokhar AK and Nepalia V. 2010. Effect of herbicides and nutrient management on weed flora, nutrient uptake and yield of wheat (*Triticum aestivum*) under irrigated conditions. *Indian Journal of Weed Science* **42**(1&2): 14-18.

Kumar M and DAS TK. 2008. Integrated weed management for system productivity and economics in soyabean (*Glycine max* L.)-wheat (*Triticum aestivum* L.) systems. *Indian Journal of Agronomy* **53**(3): 56-61.

Kumar S, Sangwan N and Punia SS. 2010. Evaluation of pinoxaden in combination with metsulfuron methyl against complex weed flora in barley. p 94. In: *Proceedings of National Biennial Conference*, Indian Society of Weed Science, Raipur, February 25-26.

Malik RK and Singh S. 1995. Little seed canary grass (*Phalaris minor)* resistance to isoproturon in India. *Weed Technology* **9**(3): 419-425.

Mani VS, Mala ML, Gautam KC and Bhagvandas. 1973. Weed killing chemicals in potato cultivation. *Indian Farming* **23**: 7-13.

Mishra A and Tosh GC. 1979. Chemical weed control studies on dwarf wheat. *Journal of Research* (Orissa University of Agricultural Science and Technology) **10**: 1-6.

Watson DJ. 1962. The physiological basis of variations in yield. *Advances in Agronomy* **4**: 101-145.

Yadav DB, Punia SS, Yadav A and Lal R. 2009. Compatibility of sulfosulfuron with carfentrazone-ethyl for the control of complex weeds flora in wheat. *Indian Journal of Weed Science* **41**(3&4): 146-149.