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Bioefficacy of post-emergence herbicide Prioxofop-Propanyl (Markclodina) against weeds in wheat

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ABSTRACT

A field study was carried out to evaluate the efficacy of Prioxofop-Propanyl 15% WP (Markclodina) herbicide for wider weeds range in wheat crop during Rabi 2015-16. Six treatments including four herbicides treatments *viz.* Pendimethalin at 1.0 kg/ha, Clodinafop at 0.060 kg/ha, Markclodina at 0.060 kg/ha, Isoproturon + 2, 4-D at 1.0+0.5 kg/ha along with hand weeding twice (30 and 60 DAS) and one weedy check were used. *Avena ludoviciana* (34.30 %) and *Phlaris minor* (25.26 %) were the most dominating grassy weeds. New test herbicide Markclodino had better efficacy in controlling *Phalaris minor*, *Avena fatua* and *Lolium temulentum* as evidenced from significantly less number of weeds at all the stages of observations. The highest weed control efficiency (80.5 %) was recorded with post emergence application of Markclodina 0.060 kg/ha at 90 DAS. The application of markclodina at 0.06 kg/ha remaining at par with clodinofop propargyl (market sample) at 0.06 kg/ha, isoproturon + 2,4-D at 1.0 + 0.5 kg/ha produced significantly higher grain yield. The magnitude of increase in yield due to Markclodina over weedy check was 68.9 %. Field demonstrations on the performance of Markclodina under various locations showd that there was maximum 19.7 % increase in grain yield over control at distt. Hamirpur (Himachal Pradesh).

Introduction

Wheat (*Triticum aestivum* L.) is the second most important food grains next to rice in India in terms of area and production being used as a staple diet. Wheat is considered as one of the most important sources of carbohydrate and protein supply for human and animal communities and mostly, contains starch, protein, fat, inorganic ions, and vitamins (B-complex and E) (Guarda et al. 2004; Rueda-Ayala et al. 2011). In India, wheat is grown on 30.47 m ha area with 98.51 million

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tonnes of production and 3.2 t/ha productivity (Tripathi and Mishra, 2017) In Himachal Pradesh, wheat is cultivated in an area of 0.346 m ha with production of 0.663 million tones and productivity of 1.92 q/ha (Kumar and Prashar, 2012). Weeds cause substantial losses in yield and quality of wheat crop. In wheat, weeds alone account for 10 to 82 % yield losses depending upon weed species, severity and duration of weed infestation and climatic conditions (Jat et al. 2003). Several constraints are accountable for low wheat yield i.e. use of poor quality seeds, improper sowing, low seeding rate, imbalance use of fertilizers and irrigation, water logging and salinity (Shehzad et al. 2012). Chemical weed control method is preferred over other weed control methods because it is rapid, more effective and relatively cheaper and all the herbicides decreased weed population and significantly increased the yield and yield components of wheat as compared to control (Chaudhry et al. 2008). Earlier in India, due to sub optimum and continuous use of particular herbicide led to development of herbicidal resistance particularly in *Phalaris minor* in some parts of Indo-Gangetic plains. In order to tackle the resistance problem, some alternative herbicides have been tested for weed control in irrigated wheat (Dhaliwal et al. 1998). Recently many new products have been developed by different agrochemical industries. However, their efficacy needs to be tested. Under or over dose of herbicide is not desirable as under dose may be less effective and may facilitate development of resistance in weeds, while over dose may result into phytotoxicity. Keeping the above points in view, the present study was carried out to study the efficacy of post-emergence herbicide Markclodina against wide range of weeds in wheat crop through field demonstrations at various locations of Himachal Pradesh.

Materials and methods

The field experiment was conducted at Research farm of Department of Agronomy, Forages and Grassland Management CSK HPKV, Palampur ($32^0$6' N latitude, $76^0$3' E longitude and 1290.8 m attitude) during *Rabi* 2015-16 to determine the efficacy of post emergence application of markclodina at 0.060 kg/ha under sub-temperate climate of north-western Himalayas against weed flora in wheat. The soil of the experimental field was silty clay loam in texture, medium in organic carbon (0.67%), acidic in reaction with 306 kg available N/ha, 22.1 kg available P/ha and 294 kg available K/ha with pH 5.7 and bulk density 1.32 g/cc. Experiment was carried out in randomized block design with three replications. Wheat cultivar "HPW-236' was sown on November 20, 2015 using seed rate of 100 kg/ha and fertilized 120 kg N, 60 kg P_2O_5 and 40 kg K_2O. Herbicides were applied by using a knapsack sprayer fitted with flat-fan nozzle with water volume of 750 l/ha. Observations on weed density, dry weight of weeds were taken at 60 DAS (days after sowing), 90 DAS, 120 DAS and at harvest in each plot and expressed as No./m^2 and g/m^2, respectively. A quadrate of 1m × 1m was placed randomly and weed species within the quadrate were identified and their number was counted species wise. The collected weeds were first dried in the sun and then in an electric oven for at 70±2 °C till constant dry weight. The data on weed density and weed biomass were analyzed after subjecting to square root transformation $\sqrt{x+0.5}$) before statistical treatment for comparison.

Meteorological Data

Agro-climatically, the experimental site falls in the mid hills sub humid zone of the state. This area is characterized by mild summers, severe winters and experiences occasional snowfall during winters. Mean monthly maximum temperature (30.5 °C) during crop season was in may month and mean monthly minimum temperature (3.7 °C) was in month January during crop season. Maximum rainfall (140 mm) was received during March month with highest of 10 rainy days. Highest evaporation (6.8 mm) was recorded during May month as compared to other growing months. The weather parameters were conducive for the growth and development of wheat crop. Hence good yield of wheat was harvested from the experiment.

Results and discussion

Effect on weeds

Wheat field was infested with both grassy and broad-leaved weeds during crop season. However, the flora was dominated by grassy weeds *Avena ludoviciana* (34.30 %), *Phlaris minor* (25.26 %), *Lolium temulentum* (15.14 %), *Vicia sativa* (10.79 %), *Anagallis arvensis* (9.80 %), *Coronopus didymus* (4.71 %). Data on weed count (90 DAS) and weed dry weight (90 DAS) at maximum population and dry matter stage respectively have been given in Table 1. The data presented in Table 1 revealed that weed control treatments gave significant suppression of all the grassy weeds viz., *Avena ludoviciana*, *Phalaris minor* and *Lolium temulentum* over weedy check. All weed control treatments were significantly superior to weedy check in reducing the count and dry weight of grassy weeds. Most herbicide treatments were as good as hand weeding twice in reducing count and dry weight of weeds. However, new test herbicides Markclodina as post emergence had better efficacy in controlling weed count and biomass accumulation of *Phalaris minor*, *Avena fatua* and *Lolium temulentum* as evidenced which remains statistically at par with clodinofop propargyl and hand weeding twice from significantly less number of weeds at all the stages of observations. The effective control of *Phalaris minor* with clodinofop has been documented (Angiras et al. 2008). Effective control of *Avena ludoviciana* with clodinofop has been documented (Malik et al. 2001).

Table 1. Effect of weed control treatments on maximum weed density (g/m^2) and weed biomass (g/m^2) at 90 DAS.

Treatment	Dose (Kg/ha)	Time of application	Weed Species					
			Avena ludoviciana	*Phlaris minor*	*Lolium temulentum*	*Vicia sativa*	*Anagallis arvensis*	*Coronopus didymus*
Weed count								
Pendimethalin	1.0	Pre	(22.4) 4.8	(8.3) 3.0	(3.0) 2.0	(6.9) 2.8	(3.0) 2.0	(3.9) 2.2
Clodinofop propargyl	0.060	Post.	(8.7) 3.1	(9.7) 2.6	(7.1) 2.8	(7.1) 2.8	(2.4) 1.84	(4.9) 2.4
Markclodina	0.060	Post.	(5.4) 2.5	(3.5) 2.1	(5.7) 2.6	(5.2) 2.6	(2.0) 1.7	(4.0) 2.2
Isoproturon+2,4-D	1.0+0.5	Post	(17.9) 4.3	(10.8) 3.4	(9.8) 3.3	(5.3) 2.6	(3.3) 2.1	(5.2) 2.5
Hand weeding twice	-	30 &60 DAS	(9.1) 3.2	(7.5) 2.9	(6.4) 2.7	(6.1) 2.7	(3.1) 2.0	(2.5) 1.9
Weedy check	-	-	(65.5) 8.1	(28.7) 5.4	(20.4) 4.6	(17.9) 4.3	(18.7) 4.4	(9.0) 3.2
CD (P=0.05)			0.51	0.32	0.23	0.13	0.12	0.36
Weeds dry weight								
Pendimethalin	1.0	Pre	(26.9) 5.3	(18.2) 4.5	(8.0) 3.0	(3.5) 2.1	(2.5) 1.8	(5.5) 2.5
Clodinofop propargyl	0.060	Post.	(16.6) 4.2	(12.3) 3.6	(9.6) 3.3	(6.9) 2.8	(5.9) 2.6	(8.9) 3.1
Markclodina	0.060	Post.	(8.5) 3.1	(9.3) 3.2	(6.5) 2.7	(4.1) 2.3	(3.9) 2.2	(3.8) 2.2
Isoproturon+2,4-D	1.0+0.5	Post	(19.5) 5.5	(13.5) 3.8	(11.2) 3.5	(6.1) 2.66	(7.6) 2.9	(7.5) 2.9
Hand weeding twice	-	30 and 60 DAS	(14.8) 3.9	(11.5) 3.5	(5.4) 2.5	(3.9) 2.2	(3.4) 2.1	(3.5) 2.1
Weedy check	-	-	(70.5) 8.5	(55.6) 7.5	(22.3) 4.8	(11.4) 3.5	(12.5) 3.6	(18.6) 4.4
CD (P=0.05)			1.1	0.90	0.28	0.03	0.41	0.62

Markclodina behaving statistically alike to post-emergence application of isoproturon + 2,4-D and hand weeding resulted in significantly lower population and biomass accumulation of *Vicia sativa* during maximum weed growth period. In case of *Coronopus didymus*, hand weeding twice was superior in reducing weed population and dry weight followed by markclodina and pendimethalin. Dry weight and count recorded at all the stages of observations under other herbicides were comparable to hand weeding twice. The test herbicide (markclodina) also significantly reduced the count and dry weight of broad leaf weeds at all the stages of observation. The test herbicide markclodina proved superior to all the treatments in reducing the total weed count and dry weight in present experimentation. Data with respect to weed control efficiency calculated at 60 and 90 DAS showed that the application of markclodina applied at 0.060 kg/ha had highest WCE i.e 92.2% at 60 DAS followed by 80.5% at 90 DAS (Table 2).

Table 2. Effect of treatments on total weed count (90 DAS) and total weed dry weight (90 DAS) and weed control efficiency at 60 and 90 days after sowing of wheat.

Treatments	Dose (Kg/ha)	Time of application	Total weed population (No/m^2)	Total dry weight (g/m^2)	Weed control efficiency (%) at	
					60 DAS	90 DAS
Pendimethalin	1.0	Pre	(47.5) 6.96	(60.6) 7.84	75.4	66.0
Clodinofop propargyl (market sample)	0.060	Post.	(39.9) 6.39	(49.2.7) 7.0	82.2	71.4
Markclodina	0.060	Post.	(25.8) 5.17	(36.1) 6.09	92.1	80.5
Isoproturon+2,4-D	1.0+0.5	Post	(52.3) 7.3	(55.4) 7.50	79.2	71.9
Hand weeding twice	-	30 and 60 DAS	(34.7) 5.97	(43.8) 6.69	100	76.4
Weedy check	-		(160.2) 12.70	(190.9) 13.85.0	-	-
CD (P=0.05)			0.40	1.23	-	-

Crop Studies

The crop data (Table 3) revealed that all the herbicide treatments under experimentation had significantly highest No. of effective tillers, No. of spikelets/spike, spike length/spike grain weight/ spike, 1000-grain weight and grain and straw yield over weedy check. The application of markclodina at 0.06 kg/ha remaining at par with clodinofop propargyl (market sample) at 0.06 kg/ha, isoproturon + 2,4-D at 1.0 + 0.5 kg/ha produced significantly higher grain yield. The magnitude of increase in yield due to markclodina over weedy check was 68.9 per cent. The increase in grain yield due to markclodino applied at 0.06 kg/ha over clodinofop propargyl (0.06 kg/ha), isoproturon + 2,4-D (1.0 + 0.5 kg/ha), and pendemethalin (1.0 kg/ha) was 9.42, 8.51 and 20.6 per cent, respectively. Saini and Singh (2001) have reported clodinofop at 0.10 and 0.20 kg/ha, the most effective in reducing weed population and dry weight and enhancing yield and yield components of wheat. This shows the effectiveness of new test herbicide markclodina for controlling weeds in wheat crop under mid hill conditions of Himachal Pradesh.

Table 3. Effect of treatments on yield attributes and grain yield of wheat.

Treatments	Dose (Kg/ha)	Time of application	No of effective tillers/m^2	No of spikelets /spike	Spike length (cm)	Grains/ spike	Grain weight/spike (g)	1000-grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
Pendimethalin	1.0	Pre	178	12.3	11.0	38.6	2.0	42.4	3540	4812
Clodinofop propargyl(market sample)	0.060	Post.	206a	13.5	13.9a	47.1	2.7a	47.7a	3903a	5233a
Markclodina	0.060	Post.	216a	15.7	14.0a	48.9a	2.9a	48.1.a	4271a	5416a
Isoproturon+2,4-D	1.0+0.5	Post	212a.	15.2	13.6a	46.2	2.6	47.0	3936a	5122a
Hand weeding twice	30 &60	30 &60 DAS	201.a	15.4	13.7a	47.0b	2.6	48.0a	4021a	5310a
Weedy check	-	-	119	0.30	10.9	24.1	1.2	33.2	2528	3411
CD (P=0.05)	-	-	15.0	0.30	0.40	0.60	0.20	1.1	368	400

Economics

Because of higher yield, weed control treatments resulted in higher gross returns over weedy check. Cost of weed control in herbicidal treatments was much lower than hand weeding twice. Accordingly, gross returns due to weed control, net returns due to weed control and marginal benefit cost ratio (MBCR) were highest in post emergence application of markclodina (Table 4) due to low cost of herbicide.

Table 4. Effect of different treatments on economics of wheat.

Treatment	Dose (g/ha)	Time of application	Gross returns (INR/ha)	Cost of cultivation (INR /ha)	Gross return due to weed control (INR /ha)	Cost of weed control (INR /ha)	Net returns due to weed control (INR /ha)	MBCR
Pendimethalin	1.0	Pre	80640	24841	23192	2344	20848	8.8
Clodinofop propargyl	0.060	Post.	88448	24222	31000	1725	29275	16.9
Markclodina	0.060	Post.	95336	24222	37888	1725	36163	20.9
Isoproturon+2,4-D	1.0+0.5	Post	88476	24430	31028	1933	29095	15.1
Hand weeding twice	30 &60	30 & 60 DAS	90836	32397	33388	10400	22988	2.2
Weedy check	-	-	57448	22497	0	0	0	0

This was followed by post-emergence clodinofop propargyl and isoproturon + 2,4-D. The superior performance of above treatments was ascribed to higher grain and straw yield of wheat crop. Angiras et al. (2008) obtained higher net profit and marginal benefit: cost in wheat with application of clodinofop propargyl at 0.06 kg/ha.

Field demonstrations

The five field demonstrations were also laid at five diverse locations to visualise the bio -efficacy of the new chemical (Table 5). It was found that the application of markclodina at 0.060kg/ha proved effective and superior against isoproturon + 2,4-D at (1.0 + 0.5 kg/ha) at farmers field. The increase in yield was ranged from 11.6 to 19.7.8 per cent at farmers field.

Table 5. Field demonstrations on the performance of Markclodina at under different conditions of Himachal Pradesh.

S.No	Name of the farmer	Grain yield kg/ha		% Increase in grain yield over control
		Markclodina	Farmers' practice	
1	Sh Rajinder Kumar V.P.O Garh Jamula Teh. Palampur. Distt. Kangra H P	3985	3413	16.8
2	Joginder Singh Village Nalvi Post office Aaghar, Tehsil Bhoranj Distt. Hamirpur H P	3793	3228	17.5
3	Jatinder Kumar V.P.O Garh Jamula Palampur Distt. Kangra H P	3479	3107	11.9
4	Sh. Divender Kumar,V.P.O Bani Tehsil: Barsar Hamirpur H P	3953	3301	19.7
5	Sh Bihari Lal Village Kharot Post office Paroure Teh. Pal ampur Distt. Kangra H P	3219	2883	11.6

Conclusion

Application of the test herbicide markclodina at 0.060 kg/ha has been found to be an effective alternative to isoproturon+2,4-D for controlling wide range of weeds in wheat. Keeping effectiveness of the herbicide, therefore, it can be recommended for effective weed management in wheat crop for harnessing good yields.

Conflict of Interest

Authors declare no conflict of interest.

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