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Bioefficacy of pinoxaden against little seed canary grass in wheat and its residual effect on succeeding crops

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ABSTRACT

To study the bioefficacy and phytotoxicity of new herbicide pinoxaden against isoproturon resistant population of *Phalaris minor* in wheat and its residual effect on succeeding rice and sorghum crops, field experiments were conducted at Chaudhary Charan Singh Haryana Agricultural University, Hisar during winter season of 2005 and 2006 and at Barhi (Ambala) and Chanarthal (Kurukshetra) during *rabi* 2007-08 and 2008-09. Little seed canary grass (*Phalaris minor* Retz.), the dominant grassy weed was very effectively controlled by post emergence (35 DAS) application of pinoxaden at 45-50 g/ha. At Hisar, pinoxaden at 45 g/ha provided 98.7 and 100% control of *P. minor* during 2005 and 2006, respectively, which was at par with clodinafop at 60 g/ha and sulfosulfuron and better than the performance of fenoxaprop. Grain yield of wheat with use of pinoxaden at 45 g/ha was 4450 and 4650 kg/ha during first and second year of experimentation, which was significantly higher than its lower doses of 35 and 40 g/ha but statistically at par with its higher dose of 50g/ha and already recommended herbicides clodinafop-propargyl and sulfosulfuron. Post emergence use of pinoxaden at 50 g/ha was able to control clodinafop resistant population of *P. minor* at farmers fields in Barhi (Ambala) and Chanarthal (Kurukshetra). Results of 13 and 20 on farm trials conducted during 2007-08 and 2008-09,respectively in various districts of state revealed that pinoxaden at 50 g/ha gave 10.6 and 9.6% higher grain yield over recommended clodinafop at 60 g/ha. No carry over effect of this herbicide at any of doses tested was observed on succeeding sorghum and rice crops grown in succession after wheat.

Key Words: Pinoxaden, Clodinafop, Sulfosulfuron, Resistant, Herbicide carry over, *Phalaris minor,* Wheat.

Little seed canary grass (*Phalaris minor*) is a very serious weed of wheat in rice-wheat cropping system in N-W India has developed resistance against isoproturon (Malik and Singh 1995). To tackle the resistance problem, clodinafop, fenoxaprop and sulfosulfuron have been recommended during 1997 and still provide excellent control of grassy weeds in wheat (Chhokar and Malik 2002). Continuous use of same herbicide for many years results in to development of resistance against some weeds which happened in case of isoproturon. Therefore, alternate herbicides will remain a key for resistance management and their evaluation is urgently needed. Moreover some complaints of poor efficacy of fenoxaprop, clodinafop and sulfosulfuron against resistant population of isoproturon are also being received from farmers' fields. Earlier studies on cross resistance in isoproturon *P. minor* against alternate herbicides (clodinafop, fenoxaprop and sulfosulfuron) conducted in Punjab and Haryana revealed that efficacy of clodinafop has decreased from 100% during 2004-05 to 78.1% during 2006-07 (Walia *et al.* 2007). In Haryana, GR 50 values of fenoxaprop and sulfosulfuron in 2002-03 have increased 6.2 and 2.3 times as compared to 1996-97 (Yadav and Malik 2007). Therefore, a new novel grassy herbicide pinoxaden 5 EC of phenylpyrazoline group developed by Syngenta India Ltd. was evaluated and compared with recommended herbicides against grassy weeds in wheat.

MATERIALS AND METHODS

Expt.1: Evaluation of pinoxaden 5 EC against grassy weeds in wheat.

An experiment to evaluate the bioefficacy of pinoxaden against grassy weeds in wheat and its residual effect on succeeding crops was conducted at CCS HAU Hisar during *kharif* and *rabi* seasons of 2005-06 and 2006-07, at Agronomy Research Area of CCS Haryana Agricultural University, Hisar. The experimental soil was sandy loam (Typic Ustochrepts) with 61% sand, 22.1% silt and 19.1% clay, medium in fertility with 0.29% organic carbon and pH of 8.2. Wheat variety *PBW-343* was drilled on November 21, 2005 and November 14, 2006 during first and second year, respectively by FIRBS method, in a plot size of 6.0 x 2.1 m^2, by using seed rate of 87.5 kg/ha. The study was arranged in randomized block design and was replicated thrice. Recommended dose of fertilizers and irrigations were applied uniformly. The treatments comprising of pinoxaden (5 EC) at 30, 40, 45, 50, 100 and 200 g/ha, sulfosulfuron at 25 g/ha, fenoxaprop at 100 g/ha, clodinafop at 60 g/ha, ready mix combination of sulfosulfuron + metsulfuron (Total) and mixture of meso + iodosulfuron (Atlantis) were applied at 35 DAS by flat fan nozzle delivering 375 l/ha volume. Surfactant A12127 R at 0.5% was used in a treatment of pinoxaden 10 EC as pinoxaden 5 EC has in-built surfactant. Observations for weed population and their dry matter accumulation were recorded at 30 and 75 DAT with the help of random quadrate (0.5 x 0.5 m) at four places in a plot and then converted in to per m^2.This data was subjected to square root ($\sqrt{x+1}$) transformation to normalize their distribution before analysis. Data on per cent visual control by herbicides at 0-100 scale, yield attributes and grain yield was recorded at harvest which was statistically analyzed using analysis of variance.

Expt.2: Effect of pinoxaden 5 EC against clodinafop resistant population of *P. minor* in wheat.

To study the bioefficacy of pinoxaden (Axial 5 EC) against clodinafop resistant population of *P. minor*, field experiments were conducted at farmers' fields at one site in village Barhi (Ambala) and two sites in village Chanarthal (Kurukshetra) during 2007-08 and 2008-09. Experiment at each site was conducted in randomized block design with three replications keeping a plot size of 250 m^2. Pinoxaden at 50 g/ha was compared with already recommended herbicides clodinafop 15% WP at 60 g/ha, fenoxaprop 10 EC + surfactant (0.2%) at 100 g/ha, ready mixture of sulfosulfuron 75% WP + metsulfuron 20% WP at 32 g/h, sulfosulfuron 75% WP and ready mix combination of mesosulfuron 3% + iodosulfuron 0.6% at 15 g/ha. Data on weed dry weight, per cent control of *P. minor* and grain yield was recorded from both locations and analyzed statistically. In addition to this bioefficacy of this herbicide on seven biotypes of *P. minor* showing poor efficacy against clodinafop, fenoxaprop and sulfosulfuron was studied in pot experiments at RRS Uchani (Karnal).

Expt 3: Residual effect of pinoxaden on succeeding rice and sorghum crops

To study the residual behaviour of pinoxaden on succeeding crops, plots treated with different doses of pinoxaden during *rabi* 2005-06 and 2006-07 were slightly disked after harvest of wheat. Rice and sorghum crops as per recommended package of practices were planted in the same layout with out any disturbance. Data on plant height, yield attributes and grain/fodder yield was recorded to assess the residual effect of different treatments applied in wheat.

Expt.4: On farm trials on evaluation of pinoxaden in wheat

After two years testing at Research farm, the efficacy of pinoxaden against *P. minor* was compared with recommended herbicides in use with the farmers. Large scale demonstration were conducted at farmers fields in rice-wheat zone of Haryana during *rabi* season of 2007-08 and 2008-09, in each a plot size of 1000 m^2. Data on per cent control of *P. minor* and grain yield of wheat was recorded at all the sites.

RESULTS AND DISCUSSION

Expt.1: Evaluation of pinoxaden 5 EC against grassy weeds in wheat

P. minor was the most important weed grassy weed present in the experimental area constituting 68-73% of total weed flora in the weedy check treatment during both the years. Among broadleaf weeds, *C. album* was the major weed constituting 9-12% of total weeds.

All herbicide treatments significantly reduced the population of *P. minor* and dry weight of weeds. Pinoxaden irrespective of dose proved very effective in controlling *P. minor* during both the years but its application at 50 g/ha was more effective than lower doses (Table 1). Per cent control of *P. minor* increased with increase in dose of pinoxaden from 35 to 200 g/ha. Pinoxaden at 45 g/ha provided 98.7 and 100% control of *P. minor* during 2005-06 and 2006-07, respectively which was at par with clodinafop at 60 g/ha, sulfosulfuron and more than fenoxaprop. Plant height, grain yield and yield attributes of wheat varied significantly due to application of different herbicides. Grain yield of wheat with use of pinoxaden at 45 g/ha was 4450 and 4650 kg/ha during first and second year of experimentation, which was significantly higher than its lower doses of 35 and 40 g/ha but statistically at par with its higher dose of 50 g/ha and already recommended herbicides clodinafop-propargyl and sulfosulfuron.

During 2006-07, maximum grain yield (4680 kg/ha) was obtained with pinoxaden at 50 g/ha which was more than pinoxaden at 35 and 40 g/ha (Table 2). Pinoxaden at 100 and 200 g/ha although was very effective in minimizing density of *P. minor* but caused slight suppression(10-20%) to wheat crop resulting in less number of earheads/m^2 and grain yield. These results were in strong conformity with the findings of Walia *et al.* (2007) at Ludhiana who reported excellent efficacy of pinoxaden at 45-50 g/ha against *P. minor* in wheat. Even lower dose of 35 g/ha is very effective against isoproturon resistant population of *P. minor* and *A. ludoviciana* without any toxicity in wheat (Chhokar *et al*. 2008).

Table1. Effect of pinoxaden 5 EC on density, weed dry weight, visual weed control and grain yield of wheat during 2005-06

Treatment	Dose (g/ha)	Density (no./m^2) *P. minor* 30 DAT	Density (no./m^2) *P. minor* 75 DAT	Dry weight 30 DAT	*P. minor* (g/m^2) 135 DAT	No. of earheads/m^2	Visual control (%)	Plant height (cm)	Crop injury (%)	Grain yield (kg/ha)
Pinoxaden 5EC	35	3(8)	1.6(1.5)	0.9	4.7	400	80	100.3	0	4029
Pinoxaden 5EC	40	2(3)	1.6(1.5)	0.7	3.7	412	84	100.0	0	4221
Pinoxaden 5EC	45	1(0)	1(0)	0	0	416	99	98.7	0	4450
Pinoxaden 5EC	50	1(0)	1(0)	0	0	419	99	99.3	0	4484
Pinoxaden 5EC	100	1(0)	1(0)	0	0	385	100	97.0	20	4165
Pinoxaden 5EC	200	1(0)	1(0)	0	0	375	100	97.3	20	3935
Pinoxaden 10EC+S	35+S	2.7(6)	2.2 (4)	0.5	0	386	85	100.3	0	4054
Sulfosulfuron	25	1.29(0.7)	1.6(1.5)	1.1	0	424	98	98.7	0	4498
Fenoxaprop	100+S	1.7(2)	1.6(1.5)	0.7	4.3	398	84	99.5	0	4010
Clodinafop (Topik)	60	1(0)	1(0)	0.0	0.0	423	100	100.2	0	4440
Weed free	-	1(0)	1(0)	0.0	0.0	423	100	99.8	0	4420
Weedy check	-	4.8(22)	5.2(25.2)	13.4	146.5	274	0	97.3	0	3100
LSD (P= 0.05)		0.7	0.7	2.5	6.8	26	6	NS	-	196

Note: Herbicide treatments were applied 35 days after wheat sowing. *Transformed values ($\sqrt{x+1}$), original values are given in parenthesis. S = Surfactant A12127R

Table 2. Effect of pinoxaden 5 EC on density, weed dry weight, percent control of weeds and grain yield of wheat during 2006-07

Treatment	Dose (g /ha)	Density (No./m^2) *P. minor* 30 DAT	Density (No./m^2) *P. minor* 75 DAT	Dry weight 30 DAT	*P.minor* (g/m^2) 135 DAT	No. of earheads/m^2	Visual control (%)	Plant height (cm)	Crop injury (%)	Grain yield (kg/ha)
Pinoxaden 5EC	35	*3.0(8)	*2.4(5)	1.24	8.2	398	78	101.0	0	4150
Pinoxaden 5EC	40	2.4(5)	2.4(5)	1.52	9.5	405	80	100.5	0	4250
Pinoxaden 5EC	45	1 (0)	0(0)	0	0	417	100	99.5	0	4650
Pinoxaden 5EC	50	1(0))	1(0)	0	0	415	100	99.3	0	4680
Pinoxaden 5EC	100	1(0)	1(0)	0	0	410	100	97.5	10	4510
Pinoxaden 5EC	200	1(0)	1(0)	0	0	411	100	97.3	10	4535
Pinoxaden 10EC+S	35+S	3.3(10)	2.8(7)	2.25	25.6	395	76	100.0	0	4054
Sulfosulfuron	25	1(0)	1(0)	0	0	415	100	98.0	0	4700
Fenoxaprop	100+S	1(0)	1.3(1.48)	0	2.3	410	95	99.1	0	4610
Clodinafop (Topik)	60	1(0)	1(0)	0.0	0.0	416	100	99.7	0	4640
Weed free	-	1(0)	1(0)	0.0	0.0	415	100	100.2	0	4620
Weedy check	-	6.1(36)	6.5(42)	13.4	146.5	339	0	98.2	0	3600
LSD (P= 0.05)		0.61	0.45	0.91	1.5	17	-	1.2	0	124

Note: Herbicide treatments were applied 35 days after wheat sowing. *Transformed values ($\sqrt{x+1}$), original values are given in parenthesis. S = Surfactant A12127R

Expt.2: Efficacy of pinoxaden (Axial 5 EC) against resistant population of clodinafop

During, 2007-08 at Barhi (Ambala), pinoxaden at 50 g/ha provided complete control of *P. minor* where as clodinafop at 60 g/ha could control only 30% population of *P. minor*. At Chanarthal-1 (Kurukshetra) 95% control of *P. minor* was achieved with the use of pinoxaden which was similar to use of meso+iodosulfuron (RM) at 15 g/ha but 65% more than clodinafop at 60 g/ha. At Chanarthal-2 (Kurukshetra), per cent control of *P. minor* with pinoxaden 50 g/ha was 86% resulting 4820 kg/ha grain yield of wheat significantly higher than clodinafop, fenoxaprop and sulfosulfuron (Table 3). During 2008-09, pinoxaden had an edge over clodinafop 60 and 120 g/ha, fenoxaprop and sulfosulfuron in terms of percent control of *P. minor* and grain yield but at par with ready mixtures of sulfosulfuron + metsulfuron at 32 g/ha and meso + iodosulfuron at 15 g/ha at all the three sites. (Table 3). Pinoxaden at 50 g/ha provided 88-90% control of *P. minor* which was at par with ready mixture of sulfosulfuron + metsulfuron at 32 g/ha and meso + iodosulfuron at 15 g/ha. Clodinafop at 60 g/ha was able to control only 28-40% of *P. minor* population. Even 2 X (double the recommend) dose of clodinafop 120 g/ha could provide only 32-45% control of this weed at all the sites. At Barhi maximum grain yield (4420 kg/ha) was obtained with use of meso+iodosulfuron at 15 g/ha and sulfosulfuron + metsulfuron at 32 g/ha which was at par with pinoxaden at 50 g/ha. Similar pattern was also observed at other two sites in Chanarthal. Kaur *et al.* (2007) and Punia *et.al*. (2008) also reported excellent efficacy of pinoxaden at 50 g/ha against resistant populations of clodinafop and fenoxaprop.

Pot experiments conducted at RRS Karnal revealed that efficacy of pinoxaden was higher than clodinafop, fenoxaprop and sulfosulfuron in all biotypes. Pinoxaden at 50 g/ha gave 95-100% control of Kachwa (Karnal), Zarifabad (Karnal), Khanoda (Kaithal), Syonti (Kurukshetra) biotypes where as clodinafop at 60 g/ha could provide 65-70% control of these biotypes of *P. minor* on an average of seven biotypes, pinoxaden at 50 g/ha, provided 95% control of *P. minor* against 75.4% with the use of clodinafop at 60 g/ha (Table 4)

Expt. 3: Residual phyto-toxicity of wheat herbicide pinoxaden 5 EC on the succeeding crops

There was no residual phyto-toxicity of the new herbicides *viz.,* pinoxaden 5EC applied in wheat during *rabi*, 2005-06 and 2006-07 on the succeeding rice crop (Variety HKR 47), at recommended as well as double in recommended doses at RRS Karnal. Number of effective tillers/ m.r.l., panicle length, plant height and grain yield of rice was same in untreated and pinoxaden treated plots (Table 5). Similarily, at Hisar no residual toxicity was observed on succeeding crop of sorghum during both the years of study. Plant height, no. of sorghum plants/m.r.l. and sorghum yield was same in pinoxaden treated and untreated control plots (Table 6). Kaur *et al*. 2007 also reported no residual phytotoxicity of clodinafop in any of the kharif crop planted in succession after wheat in a study at PAU Ludhiana. Hence, this herbicide is safe for use in wheat rice and wheat-sorghum-cotton cropping sequences followed in the state.

Expt.4: On farm trials on evaluation of pinoxaden in wheat

In this study also, pinoxaden at 50 g/ha showed its superiority over other herbicides with 98 and 92% during 2007-08 and 2008-09 as against 81.3 and 80% control provided by clodinafop at 60 g/ha. Sulfosulfuron and fenoxaprop showed poor efficacy (68-74%). Maximum grain yield 4970 and 4450 kg/ha was obtained by pinoxaden at 50 g/ha which was 106 and 8.2% higher than clodinafop at 60 g/ha during 2007-08 and 2008-09, respectively (Table 7).

Based on four years study at multiple sites, it can be concluded that post emergence (35-40 DAS) application of pinoxaden 5 EC at 50g/ha can safely be used to control *P. minor* in wheat crop with out any phytotoxicity on wheat crop and no residual effect on succeeding sorghum and rice crops. Efficacy of pinoxaden at 50 g/ha is more than already recommended herbicides clodinafop, sulfosulfuron and fenoxaprop-p-ethyl in resistant biotypes.

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Table 3. Efficacy of pinoxaden (Axial 5 EC) against resistant population of clodinafop in Haryana during 2007-08 and 2008-09

Treatment	Dose g/ha	*Phalaris minor* control (%)						Grain yield of wheat(kg/ha)					
		Barhi		Chanarthal I		Chanarthal 2		Barhi		Chanarthal I		Chanarthal 2	
		2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Pinoxaden	50	100	90	95	88	86	90	4500	4400	4900	4500	4820	4200
Clodinafop	60	30	25	30	40	40	28	2600	2450	2500	2960	3450	2900
Clodinafop	120	-	32	40	45	35	35	-	2600	2700	3100	3400	2980
Sulfosulfuron	25	70	62	60	67	95	70	4150	3550	4000	3450	4860	3640
Fenoxaprop	100	25	0	35	40	35	25	2800	2600	2400	2700	3300	2880
Sulfosulfuron+ metsulfuron	32	95	93	85	90	100	90	4300	4420	4650	4580	4880	4300
Meso+iodosulfuron	15	95	95	92	100	100	95	4550	4420	4900	4620	4900	4260
Weedy check	-	0	0	0	0	0	0	2450	2200	1800	2600	2600	2550
LSD (P= 0.05)		-	-	-	-	-	-	242	134	117	98	280	225

Table 4. Per cent control of different biotypes of *Phalaris minor* collected from various places by different herbicides in pot studies at Karnal (*rabi*, 2007-08)

Treatment	Dose (g/ha)	Name of places of collection of biotypes							Mean
		Kachwa	Zarifabad	Khanoda	Kathwar	Teek	Syonti	Uchani	
Clodinafop	60	70	65	70	80	100	65	80	75.4
Clodinafop	120	100	100	99	100	100	90	98	8.1
Fenoxaprop	120	85	98	45	85	30	60	80	69.0
Sulfosulfuron	25+S	85	80	50	95	25	90	95	74.2
Pinoxaden	50	95	95	85	100	95	95	100	95

S - Surfactant

Table 5. Residual phytotoxicity of pinoxaden 5EC applied in wheat during *rabi*, 2005-06 and 2006-07 on succeeding rice crop

Treatment	Dose (g/ha)	Residual phyto-toxicity (0-10 scale)		Plant height (cm)		Effective tillers/mrl		Panicle length (cm)		Grain yield (kg/ha)	
		2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Pinoxaden 5EC	50	0	0	85.6	104.3	72.0	82.0	21.8	23.0	6460	7180
Pinoxaden 5EC	100	0	0	86.8	102.5	70.5	84.3	22.2	21.9	6420	7200
Untreated check	-	0	0	87.7	103.8	73.5	81.9	21.4	22.6	6400	7220

Table 6. Residual effect of different herbicides applied in wheat on succeeding sorghum crop at 30 DAS (Hisar)

Treatment	Dose (g/ha)	No. of plants/m^2		Plant height (cm)		Green fodder yield (kg/ha)	
		2005 -06	2006 -07	2005 -06	2006 -07	2005 -06	2006 -07
Pinoxaden 5EC	40	22	24	134	127	3850	36200
Pinoxaden 5EC	45	20	25	136	128	3800	35800
Pinoxaden 5EC	50	21	23	136	129	3820	36100
Pinoxaden 5EC	100	20	25	134	128	3870	36000
Pinoxaden 5EC	200	21	22	137	127	3900	36200
Sulfosulfuron	25	5.3	4.2	23	24	3800	2560
Clodinafop	60	22	25	132	130	3880	36600
Weedy	-	20	26	133	129	3860	35900
LSD (P= 0.05)	-	0.9	1.6	2.8	127	3500	5800

Table 7. Per cent weed control and grain yield of wheat as affected by different herbicides at farmers' fields during 2007-08 and 2008-09 (mean)

Treatment	No. of locations		Percent weed control *P. minor*		Percent weed control Broadleaf weeds		Grain yield (kg/ha)	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Pinoxaden at 50 g/ha	13	20	99	92	0	0	4970	4450
Clodinafop at 60 g/ha	11	20	81	80	0	0	4490	4080
Meso+iodo (Atlantis) 15 g/ha	3	4	97	90	68	65	4880	4200
Sulfosulfuron at 25 g/ha	5	8	70	74	55	48	4530	3960
Fenoxaprop 100 g/ha	4	2	70	68	0	0	4450	3850
Sulfosulfuron+metsulfuron at 32 g/ha	5	10	94	90	84	80	4730	4400

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