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Efficacy of herbicides against canary grass and wild oat in wheat and their residual effects on succeeding greengram in coastal Bengal

Hirak Banerjee*, Sourav Garai[1], Sukamal Sarkar[1], Dibakar Ghosh[2], Subhasis Samanta and Manimala Mahato[1]

Regional Research Station (CSZ), BCKV, South 24 Parganas, West Bengal 743 347, India
[1]Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal 741 252, India
[2]ICAR-Directorate of Weed Research, Jabalpur, Madhya Pradesh 482 004, India
**Email: hirak.bckv@gmail.com*

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ABSTRACT

A field trial was conducted at Regional Research Station (coastal saline zone), BCKV, Akshaynagar, Kakdwip, South 24 Parganas (WB) during winter seasons of 2016-17 and 2017-18 to study the bio-efficacy of pinoxaden against the canary grass (*Phalaris minor*) and wild oat (*Avena ludoviciana*) in wheat and its effects on succeeding greengram crop. Application of pinoxaden at 352.9 g/ha recorded significantly greater reduction of targeted weed populations; however, it was statistically at par with its two lower doses of 156.86 and 176.47 g/ha. The higher dose of pinoxaden had greater weed control efficiency (WCE). Pinoxaden at 352.94 g/ha resulted in significantly higher grain yield compared to other treatments. Lower doses of pinoxaden at 156.9 and 176.5 g/ha were at par with hand weeding for grain yield. Therefore, the application of pinoxaden 352.94 g/ha at 30 days after sowing (DAS) can be a good option for canary grass and wild oat management in wheat - greengram sequence in coastal Bengal.

INTRODUCTION

Rice production in coastal Bengal is not satisfactory mainly because of water crisis in winter season. Realizing rapid population growth, it is generally understood that rice alone could not meet the food requirements of this region. Wheat, preferably short duration cultivar, was therefore chosen as an alternative winter food crop. Furthermore, dietary preferences of local people are also changing and wheat is becoming a highly desirable food supplement to rice. However, weeds cause substantial losses in yield and quality of wheat crop in this part of the State. In wheat, weeds alone account for 10 to 80% yield losses depending upon weed species, severity and duration of weed infestation (Jat *et al.* 2003). *Phalaris minor* and *Avena ludoviciana* are major problematic grass weeds causing large scale reductions in wheat grain yield (Chhokar *et al.* 2012). To attain economic wheat yield, weeds must be removed during critical period of competition which falls in between 0 to 30 days of sowing (Saha *et al.* 2016). In other words, if the weeds are not controlled at the critical stages of crop growth, they may cause reduction in crop yield upto 66% (Kumar *et al.* 2011). For controlling weeds in wheat, farmers mostly rely on herbicides due to cost and time effectiveness.

Recently, many new molecules have been developed by different agro-chemicals industries. Pinoxaden, which belongs to phenyl-pyrazolin group has been introduced to tackle the problem of *P. minor* (Kaur *et al.* 2017). However, their efficacy needs to be tested. Every herbicide has an optimum dose, under a set of environments, for effective control of weeds. 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 (Pawar *et al.* 2017). Taking due cognizance of above facts, a field experiment was conducted with the objectives to determine the effect of pinoxaden against *P. minor* (canary grass) and *A. ludoviciana* (wild oat) in wheat crop and to study the effect of pinoxaden on micro-flora of soil in cropped area besides determining the residual effect of herbicides if any on succeeding greengram crop.

MATERIALS AND METHODS

Field trial was set up at Regional Research Station (Coastal Saline Zone), Bidhan Chandra Krishi

Viswavidyalaya, Akshaynagar, Kakdwip, South 24 Parganas, West Bengal during winter season of 2016-17 and 2017-18. The farm is situated at 22°40´ N latitude, 88°18´ E longitude and 7 m above mean sea level. The land topography is referred as medium where the water stagnation never went beyond 30 cm. The soil was having clayey texture, pH of 7.31, organic carbon 0.64%, EC (1:2.5 :: soil:water) 1.79 dS/m, available N 156.0 kg/ha, available P 100.5 kg/ha and available K 321.3 kg/ha. The experimental plots were laid out in a randomized block design with seven treatments consisting of pinoxaden at 156.86 g/ha; pinoxaden at 176.47 g/ha; pinoxaden at 352.94 g/ha; fenoxaprop-p-ethyl at 12.90 g/ha; clodinafop propargyl at 26.67 g/ha; hand weeding at 15 and 30 DAS (days after sowing) and control or weedy plot with three replications. The individual plot size was 5 × 5 m. All the herbicides were applied at 30 DAS, when both the target weed species were at 3-4 leaf stage. The herbicides were sprayed with knapsack sprayer fitted with flat fan nozzle by dissolving in 300 liters water per hectare.

Before starting of present investigation, rice was continuously grown for the last five years during both rainy and winter seasons. Pre-sowing irrigation followed by ploughing with disc harrow, tiller and leveler was done for optimum seed germination. Before sowing, wheat seeds (cv. '*HD 2967*') were treated with tebuconazole at 1.0 g/kg of seed. In both years of experiment, seeds were sown on November 2 at 100 kg/ha at the distance of 20 × 5 cm in both the years of study. The recommended fertilizer dose of 60:80:40 kg N, P_2O_5 and K_2O/ha were applied. Full dose of P_2O_5 and K_2O plus 1/3rd N were applied as basal (at sowing time) and rest 1/3rd N at maximum tillering stage and 1/3rd at panicle initiation stage. Rouging of experimental plots is done to remove off-type and diseased plants. As per recommendation, rouging operation was done thrice at vegetative stage, 75% ear emergence and maturity stage. Apart from pre-sowing irrigation, five irrigations were given starting at 20 days after sowing (DAS) and thereafter, at 20 days interval. The test crop took 115 days for maturity and was harvested on February 24 in both the years of study. After harvesting of wheat, greengram (cv. '*Samrat*') was sown on March 1 and March 3 and harvested on April 30 and May 2 in 1st and 2nd years of study respectively. Standard agronomic management suitable for that region was provided to the succeeding crop.

An area of 0.25 m^2 was selected randomly at two spots by throwing a quadrate of 0.5 x 0.5 m, weed species were counted from that area and density was expressed in number per m^2. The collected weeds were first sun-dried and then kept in an electric oven at 70°C till the weight became constant and dry weight was expressed as g/m^2. The data on crop growth parameters and yield were also recorded both for wheat and succeeding greengram crops.

To assess the bio-efficacy of different herbicides on crops and weeds, weed control efficiency (WCE) was worked out using following equations respectively as suggested by Banerjee *et al.* (2018):

$$WCE = \frac{WDM_c - WDM_T}{WDM_C} \times 100$$

Where, WDM_C is the weed dry matter weight (g/m^2) in control plot; WDM_T is the weed dry matter weight (g/m^2) in treated plot.

The total monetary returns (gross return) of the economic produce obtain from wheat crop were calculated based on minimum support prices (` 15.25/kg) of Government of India for wheat. The gross return is expressed per hectare basis using following equation:

Gross return = Wheat yield ×minimum support prices

Net return per hectare basis was calculated by subtracting the total cost of cultivation from the gross returns. Benefit: cost ratio (B : C ratio) was calculated as follows:

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

As wide variation existed in data, number and dry weight of weeds were transformed through square-root ($\sqrt{x+0.5}$) method before analysis of variance. The germination parentage values for green gram were subjected to angular transformation ($\text{Sin}^{-1}\sqrt{x}$) before statistical analysis. All the collected data were analyzed statistically by the analysis of variance (ANOVA) technique using the STAR Software version 2.0.1 of International Rice Research Institute, Philippines, 2013. The differences between treatments means were tested on the significance level of $p \leq 0.05$.

RESULTS AND DISCUSSION

Effect on weed density, biomass and weed control efficiency

Weed flora in the experimental field was dominated by *P. minor* and *A. ludoviciana*, irrespective of the dates of observations, before as well as 15, 30 and 45 days after herbicide application.

The weedy plots were infested with the highest densities of above weed species at all dates of observations (**Table 1**). The densities of these two major weed species were significantly ($p \leq 0.05$) reduced by the applications of pinoxaden at all three doses (156.9, 176.5 and 352.9 g/ha), even with greater efficacy than other two popular tested herbicides like fenoxaprop-p-ethyl and clodinafop propargyl. The application of clodinafop propargyl was not effective against *P. minor* and *A. ludoviciana* populations. The herbicidal treatment with pinoxaden at 352.9 g/ha caused greater reduction of targeted weed populations; however, it was statistically at par with its two lower doses (156.9 and 176.5 g/ha). Other investigators also found effective control of *P. minor* and *A. ludoviciana* (Chhokar *et al.* 2007, Kaur *et al.* 2017) either with sole pinoxaden or pre-mixture of pinoxaden and clodinafop.

The biomass of these two weed species also differed significantly ($p \leq 0.05$) between herbicide treatments and followed a trend like that of weed density (**Table 2**). The herbicide pinoxaden, irrespective of the dose, was superior to other herbicide applications in reducing weed biomass. The highest dose of pinoxaden (352.9 g/ha) resulted in higher reductions in dry weight at 15, 30 and 45 days after herbicide applications. Applications of standard check fenoxaprop-p-ethyl and clodinafop propargyl exhibited considerably lower reduction in weed biomass and were statistically inferior to the pinoxaden.

Higher the dose of pinoxaden greater was the weed control efficiency (WCE). Hence, the greater WCE against both *P. minor* and *A. ludoviciana* was recorded with pinoxaden at 352.94 g/ha at all dates of observations, followed by its lower doses (156.9 and 176.5 g/ha) (**Table 3**).

Effect on yield components and yield of wheat

Yield components of wheat namely, number of effective tillers/m^2 and grains/ear were found to be the highest under two hand weeding done at 15 and 30 DAS in both the years of study, closely followed by the higher dose of pinoxaden (352.9 g/ha). For other components like ear length and test weight, the highest values were obtained with pinoxaden at 352.9 g/ha in both the years. All the measured yield components were recorded lowest under control (weedy) treatment during both the years (**Table 4**).

Different herbicidal treatments resulted in significant variations ($p \leq 0.05$) in grain yield of wheat (**Table 4**). Crop growth and grain yield were inversely related with weed interference. Hence, the wheat grain yield differences among different treatments were reflected in differential efficacy against *P. minor* and *A. ludoviciana*, and the treatments which gave better efficacy recorded the highest grain yield and vice-versa. Significantly highest grain yield was

Table 1. Population of targeted weeds (no./m^2) under different weed control treatments in wheat (mean data of 2 years)

Treatment	*Phalaris minor*				*Avena ludoviciana*			
	BHA	15 DHA	30 DHA	45 DHA	BHA	15 DHA	30 DHA	45 DHA
Pinoxaden at156.86 g/ha	3.12 (9.3)	1.44 (1.7)	2.38 (5.3)	2.66 (6.7)	2.97 (8.3)	1.46 (1.7)	2.48 (5.7)	2.80 (7.3)
Pinoxaden at 176.47 g/ha	3.03 (8.7)	1.05 (0.7)	1.34 (1.3)	2.02 (3.7)	3.02 (8.7)	0.88 (0.7)	1.46 (1.7)	1.86 (3.0)
Pinoxaden at 352.94 g/ha	3.07 (9.0)	0.88 (0.3)	1.05 (0.7)	1.56 (2.0)	2.94 (8.3)	1.05 (0.7)	1.05 (0.7)	1.34 (1.3)
Fenoxaprop-p-ethyl at 12.90 g/ha	2.97 (8.3)	1.46 (1.7)	2.74 (7.0)	3.23 (10.0)	2.97(8.3)	1.95 (3.3)	2.42 (5.3)	3.29 (10.3)
Clodinafop propargyl at 26.67 g/ha	2.97 (8.3)	1.56 (2.0)	2.96 (8.3)	3.36 (11.0)	2.97 (8.3)	1.77 (2.7)	2.79 (7.3)	3.43 (11.3)
Hand weeding at 15 and 30 DAS	0.71 (0)	0.71 (0)	0.88 (0.3)	1.34 (1.3)	0.71 (0)	0.71 (0)	0.88 (0.3)	1.05 (0.7)
Control (weedy)	3.18 (9.7)	3.53 (12.0)	4.17 (17.0)	4.67 (21.3)	2.96 (8.3)	3.34 (10.7)	4.17 (17.0)	4.77 (22.3)
LSD (p=0.05)	0.43	0.30	0.62	0.71	0.52	0.37	0.39	0.45

Original figures in parentheses were subjected to square-root transformation $\sqrt{x+0.5}$ before statistical analysis; DAS= Days after sowing; BHA= before herbicide application; DHA= Days after herbicide application

Table 2. Dry weight of targeted weeds (g/m^2) under different weed control treatments in wheat (mean data of 2 years)

Treatment	*Phalaris minor*				*Avena ludoviciana*			
	BHA	15 DHA	30 DHA	45 DHA	BHA	15 DHA	30 DHA	45 DHA
Pinoxaden at156.86 g/ha	11.7 (3.49)	3.8 (2.07)	6.4 (2.64)	9.3 (3.14)	12.8 (3.65)	3.5 (2.00)	7.8 (2.88)	12.3 (3.58)
Pinoxaden at 176.47 g/ha	12.2 (3.56)	1.5 (1.41)	3.5 (2.00)	7.9 (2.89)	15.0 (3.94)	1.7 (1.47)	5.1 (2.36)	9.5 (3.16)
Pinoxaden at 352.94 g/ha	11.9 (3.53)	1.0 (1.22)	2.3 (1.68)	6.1 (2.57)	13.4 (3.73)	2.4 (1.69)	2.0 (1.59)	6.3 (2.61)
Fenoxaprop-p-ethyl at 12.90 g/ha	12.8 (3.65)	3.9 (2.10)	8.2 (2.14)	12.8 (3.64)	11.5 (3.47)	4.9 (2.32)	9.2 (68.18)	13.7 (58.2)
Clodinafop propargyl at 26.67 g/ha	12.0 (3.53)	4.1 (2.14)	15.4 (3.99)	24.7 (5.02)	15.7 (4.03)	6.4 (2.63)	17.3 (4.22)	22.1 (4.75)
Hand weeding at 15 and 30 DAS	0 (0.71)	0 (0.71)	1.0 (1.22)	7.2 (2.77)	0 (0.71)	0 (0.71)	0.97 (1.21)	3.0 (1.87)
Control (weedy)	13.8 (3.78)	16.6 (4.14)	24.7 (5.02)	33.5 (5.83)	12.6 (3.62)	17.3 (4.22)	29.0 (5.43)	32.8 (5.77)
LSD (p=0.05)	3.50	1.52	5.24	5.68	2.57	2.86	6.17	3.76

Original figures in parentheses were subjected to square-root transformation $\sqrt{x+0.5}$ before statistical analysis. DAS= Days after sowing; BHA= Before herbicide application; DHA= Days after herbicide application

Table 3. Weed control efficiency (%) against targeted weeds as influenced by different weed control treatments (mean data of 2 years)

Treatment	*Phalaris minor*			*Avena ludoviciana*		
	15 DHA	30 DHA	45 DHA	15 DHA	30 DHA	45 DHA
Pinoxaden at156.86 g/ha	77.11	73.92	72.15	79.73	73.17	62.38
Pinoxaden at 176.47 g/ha	90.96	85.85	76.51	90.33	82.52	71.04
Pinoxaden at 352.94 g/ha	93.97	90.58	81.70	86.28	93.00	80.80
Fenoxaprop-p-ethyl at 12.90 g/ha	76.51	66.96	61.88	71.80	68.18	58.23
Clodinafop propargyl at 26.67 g/ha	75.30	37.73	26.27	62.77	40.45	32.62
Hand weeding at 15 and 30 DAS	100.00	95.96	78.60	100.00	96.66	90.85
Control (weedy)	-	-	-	-	-	-

DAS= Days after sowing, DHA= Days after herbicide application

Table 4. Yield of wheat as influenced by different weed control treatments

Treatment	No. of effective tillers/m^2			Ear length (cm)			No. of grain/ear			Test weight (g)			Grain yield (t/ha)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Pinoxaden at156.86 g/ha	337.0	342.2	339.6	11.7	11.9	11.8	39.3	40.3	39.8	45.6	45.8	45.7	2.79	2.93	2.86
Pinoxaden at 176.47 g/ha	346.3	351.4	348.8	11.4	11.6	11.5	40.0	40.2	40.1	46.1	45.9	46.0	3.09	3.27	3.18
Pinoxaden at 352.94g/ha	351.7	359.8	355.4	12.5	12.8	12.6	42.0	42.5	42.2	47.1	46.9	47.0	3.18	3.29	3.24
Fenoxaprop-p-ethyl at 12.90 g/ha	318.7	328.0	323.4	11.3	11.6	11.4	37.7	39.3	38.5	46.0	46.6	46.3	2.75	2.84	2.80
Clodinafop propargyl at 26.67 g/ha	301.0	313.8	307.8	11.2	11.5	11.3	37.3	38.3	37.8	44.3	44.5	44.4	2.19	2.34	2.27
Hand weeding at 15 and 30 DAS	366.0	374.5	370.2	12.3	12.5	12.4	42.3	43.6	43.0	44.1	44.5	44.3	3.36	3.48	3.42
Control (weedy)	237.0	246.3	241.7	10.0	10.2	10.1	37.0	38.9	38.0	42.4	42.8	42.6	1.70	1.79	1.75
LSD (p=0.05)	13.81	19.70	11.04	1.1	0.9	0.6	4.6	3.9	2.7	1.8	2.7	1.5	1.09	1.21	1.16

DAS= Days after sowing

Table 5. Economics of wheat cultivation as influenced by different weed control treatments

Treatment	Gross return (x10^3 `/ha/year)		Net return (x10^3`/ha/year)		B:C ratio	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Pinoxaden at156.86 g/ha	42.55	44.68	12.48	14.61	1.42	1.49
Pinoxaden at 176.47 g/ha	47.12	49.87	17.00	19.74	1.56	1.66
Pinoxaden at 352.94g/ha	48.49	50.17	18.14	19.82	1.60	1.65
Fenoxaprop-p-ethyl at 12.90 g/ha	41.94	43.31	11.46	12.83	1.38	1.42
Clodinafop propargyl at 26.67 g/ha	33.40	35.68	2.81	5.09	1.09	1.17
Hand weeding at 15 and 30 DAS	51.24	53.07	16.67	18.50	1.48	1.54
Control (weedy)	25.92	27.30	-3.33	-1.95	0.89	0.93

recorded with hand weeding (HW) treatment while weedy check plots recorded lowest grain yield of wheat on both the years. Among the herbicidal treatments, the pinoxaden at 352.9 g/ha resulted in significantly higher grain yield as compared to weedy and other herbicide treatments followed by pinoxaden at 156.9 and 176.5 g/ha being statistically at par with the yield obtained with HW treatment. Application of pinoxaden (352.9 g/ha) controlled weeds better for 45 days or more and helped wheat plants to grow in less weedy situations. In lesser weed environments, improved resource-use due to herbicide treatments might have led to a significant yield advantage, increased uptake of nutrients and might have provided better rooting and ground cover as well as higher water-use efficiency (Banerjee *et al.* 2018). Also, the weed management treatments might have significantly reduced the uptake of nutrients by weeds, which concurrently provided better environment for crop growth characteristics and yield attributes (Kien *et al.* 2016). Pawar *et al.* (2017) also obtained the higher grain yield of wheat with pinoxaden due to lower weed density and weed biomass, which might have caused less weed competition with wheat and resulted in the production of higher yield attributes and grain yield.

Economics of wheat cultivation

In terms of monetary returns, all the weed control treatments were superior over control (weedy) treatment during both the years (**Table 5**). The highest net return and B:C ratio were fetched by pinoxaden at 352.9 g/ha, closely followed by its lower dose (176.5 g/ha). Weedy plots resulted in lowest monetary returns in both the years due to poor crop yield realized at this growing situation.

Phytotoxicity of herbicides on wheat

The wheat plants were critically examined for phytotoxic symptoms at 1, 3, 5, 7 and 10 days after

Table 6. Soil micro-flora (cfu × 10^6/g of soil) at 0-15 cm depth (mean data of 2 years)

Treatment	Before spray at 30 DAS			After spray at 60 DAS		
	Bacteria	Fungi	Actinomycetes	Bacteria	Fungi	Actinomycetes
Pinoxaden at156.86 g/ha	75.88	23.97	20.63	77.20	24.23	23.00
Pinoxaden at 176.47 g/ha	78.19	27.02	21.26	78.42	27.86	22.73
Pinoxaden at 352.94 g/ha	88.74	31.68	22.96	88.81	33.09	22.03
Fenoxaprop-p-ethyl at 12.90 g/ha	75.68	23.77	19.68	71.10	25.50	19.09
Clodinafop propargyl at 26.67 g/ha	65.81	22.38	18.27	68.11	24.40	19.81
Hand weeding at 15 and 30 DAS	67.01	21.66	20.81	67.27	22.34	21.40
Control (weedy)	74.77	24.37	23.31	77.76	25.51	25.00
LSD (p=0.05)	9.17	2.93	NS	7.15	2.98	NS

DAS= Days after sowing; NS= Non-significant

Table 7. Effect of different herbicide treatments on growth and yield of greengram

Treatment	Germination (%)			Plant height (cm)			Grain yield (kg/ha)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Pinoxaden at156.86 g/ha	77.1 (95.0)	85.3 (99.0)	81.8 (97.0)	57.3	60.6	59.0	780.0	975.3	788.3
Pinoxaden at 176.47 g/ha	80.7 (97.0)	86.7 (99.0)	82.0 (98.0)	60.2	62.3	61.3	858.3	832.3	845.0
Pinoxaden at 352.94 g/ha	82.3 (97.3)	87.3 (99.3)	85.7 (98.3)	62.9	64.5	63.7	888.7	873.3	881.3
Fenoxaprop-p-ethyl at 12.90 g/ha	82.8 (97.7)	83.9 (98.3)	83.4 (98.0)	52.9	53.9	53.4	688.3	702.7	696.3
Clodinafop propargyl at 26.67 g/ha	83.0 (97.7)	83.0 (97.7)	83.0 (97.7)	56.9	52.5	54.7	731.7	708.3	720.0
Hand weeding at 15 and 30 DAS	82.3 (97.3)	87.3 (99.3)	85.7 (98.3)	64.3	62.4	63.4	919.0	901.3	910.3
Control (weedy)	76.6 (94.7)	74.5 (92.7)	75.5 (93.7)	52.3	49.4	50.9	619.0	592.7	606.0
LSD (p=0.05)	NS	NS	NS	6.9	5.6	6.1	74.0	53.6	24.1

Original figures in parentheses were subjected to angular transformation (Sin^{-1} $\sqrt{x}$) before statistical analysis; DAS= Days after sowing; NS= Non-significant

herbicide application. The level of phytotoxicity was estimated by visual assessment based on Phytotoxicity Rating Scale (PRS) 0 to 10, where 0 = No crop injury while 10 = Heavy injury or complete destruction of test crop. No phytotoxicity was found like epinasty, hyponasty, necrosis, vein clearing, wilting and leaf injury on tip/surface in the plants treated with pinoxaden at 156.9, 176.5 and 352.9 g/ha in wheat, which indicated safety of this herbicide. No phytotoxicity on wheat crop treated either with sole pinoxaden or pre-mixture of pinoxaden and clodinafop was also observed by Kaur *et al.* (2017) and Sasode *et al.* (2017).

Effect on soil micro-flora

Herbicide treatments did not cause significant inhibition in soil fungal populations (**Table 6**). The herbicides were applied at 30 DAS, and observations were recorded at 60 DAS. By that time, herbicides might have undergone degradation by micro-organisms, and their effects got mitigated (Banerjee *et al.* 2018). The pinoxaden at 352.9 g/ha resulted in significantly ($p \leq 0.05$) greater fungal populations (bacteria and fungi) compared to other treatments, except the pinoxaden at 176.5 g/ha. The actinomycetal populations were similar between weedy and all tested herbicides.

Effect on growth and yield of succeeding greengram crop

The data on germination of the succeeding greengram crop (cv. Samrat) was recorded at 15 DAS in both the years, and it did not show any significant variation amongst the different herbicidal treatments applied in the previous wheat crop. The plant height of greengram varied significantly ($p \leq 0.05$) among the treatments, and it was higher with pinoxaden at 352.9 g/ha; being statistically at par with the height obtained with HW treatment (**Table 7**). The application of tested herbicides at different doses in the previous wheat crop did not leave any phytotoxic effect on the succeeding crop greengram.

Herbicidal treatments applied in wheat resulted in significant improvements ($p \leq 0.05$) in seed yield of succeeding crop greengram in both the years of study (**Table 7**). The treatments which gave best efficacy in wheat field also resulted the highest seed yield of greengram. The maximum seed yield was recorded with hand weeding treatment. Amongst the herbicidal treatments, application of pinoxaden at 352.9 g/ha resulted in significantly higher seed yield of greengram compared to weedy situation and other herbicide treatments in both the years. Probably, due to longer persistence in soil (half-life 23.7 days), the pinoxaden was found to have some residual effects on weeds in the succeeding greengram crop. In contrary, severe weed interference could result in much lower seed yield in unweeded plots, emphasizing the need for weed control either in preceding wheat crop or succeeding greengram crop.

The present investigation conclusively inferred that all the three doses of pinoxaden applied at 30 DAS were more effective against *P. minor* and *A. ludoviciana* than other tested herbicides. But the highest dose of pinoxaden (352.9 g/ha) brought about the maximum weed suppression, leading to highest yield of wheat and succeeding greengram crop. This offered slight residual weed control in succeeding greengram crop. The herbicide pinoxaden was found to be non-phytotoxic to wheat plant. It did not leave any phytotoxicity to the succeeding crop greengram as well. Therefore, the application of pinoxaden at 352.9 g/ha at 30 DAS may be recommended for better weed management in wheat followed by greengram in coastal Bengal.

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