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Performance of Pinoxaden Herbicide against Complex Weed Flora in Wheat (*Triticum aestivum* L.)

Raghav Patel [a], A. K. Jha [a], Badal Verma [a*], Muskan Porwal [a], Oscar Toppo [a] and Sourabh Raghuwanshi [b]

[a] Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP) 482004, India.
[b] Department of Soil Science, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (MP) 474002, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *rabi* season (2020-21) at AICRP on Wheat, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP), India, to study the effect of pinoxaden on weeds and the yield of wheat. The field experiment was laid out in a randomized block design with seven treatments and replicated thrice. Treatments included applying different doses of pinoxaden at 40, 45, and 90 g *a.i*. ha^{-1}, clodinafop propargyl at 90 g *a.i*. ha^{-1}, sulfosulfuron at 25 g *a.i*. ha^{-1} as post-emergence along with hand weeding at 30 DAS and weedy check. The experimental field was dominated by *Phalaris minor* (15.6%) among monocot weeds, while *Medicago denticulata* (30.82%), *Cichorium intybus* (29.94%), *Chenopodium album* (15.32%), and *Anagallis arvensis* (8.30%) among the dicot weeds throughout the crop growing period. Among the different herbicidal treatments, pinoxaden at 90 g *a.i.* ha^{-1} effectively controlled the monocot and

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**Corresponding author: E-mail: badalv82282@gmail.com;*

dicot weeds and recorded higher weed control efficiency and the lowest weed index. However, the highest value of growth parameters, yield attributes, and grain yield was recorded with the application of pinoxaden at 45 g *a.i*. ha^{-1} among all the herbicidal treatments.

Keywords: Herbicidal treatments; pinoxaden; weeds; weed control efficiency; wheat.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop that plays a vital role in food and nutritional security [1]. In recent years, its production in India has reached a plateau, and there is an urgent need to raise its productivity. Wheat is grown in 217.02 million hectares, producing 765 million metric tons worldwide. In India, it is grown in an area of 31.45 million hectares with a production of 107.592 million metric tons and productivity of 3420 kg ha^{-1} [2]. In Madhya Pradesh, wheat is grown in a 10.02 million hectares area with a production of 16.52 million metric tons and productivity of 3298 kg ha^{-1} [3]. The wheat crop benefits farmers because it saves land preparation time which often delays the wheat sowing [4]. Weed competition for soil moisture, mineral nutrients, and solar radiation in wheat, along with unhealthy nutrient management practices, is a significant constraint in enhancing wheat productivity [5,6].

The lower productivity of wheat can also be attributed to several other limiting factors. However, the most important among these has been poor weed management, which poses a significant threat to crop productivity [7]. The wheat crop is badly infested with grasses as well as broad-leaf weeds [8]. Therefore, timely weeding is most important to minimize the losses in crop yields, especially during the critical period of crop-weed competition [9,10]. Management of weeds with the intervention of herbicides is very effective and economical compared to that realized with manual or mechanical methods in various crops [11,12], including wheat. Protecting arable crops against adverse yield effects from weeds is well recognized to sustain global agricultural food production [13]. Several authors have demonstrated the positive impact of weed control on harvested cereal grain yield enlargement [14]. In economic terms, the value of the grass control herbicide among the total cereal herbicide available in the market is estimated to be around 70% [15]. This reflects the importance of successfully managing grass weed infestations in cereal crops. Therefore, there is an urgent need to find out the cheap and suitable weed control measures to address the weed problem in wheat. Many herbicides like Sulfoslfuron, Metribuzin, Metsulfuron are being used as post-emergence herbicides for controlling weeds in wheat; however, they have not been found effective in controlling all types of weeds. A new herbicide, pinoxaden, has been demonstrated to be effective for controlling wheat composite weed flora. However, the information on its efficacy is unavailable for the Kymore Plateau and Satpura Hill zone of Madhya Pradesh. Therefore, a comprehensive study was carried out to find out the suitable dose of pinoxaden herbicide for the effective control of weeds.

2. MATERIALS AND METHODS

A field experiment was conducted at AICRP on Wheat, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP.) during *rabi* season 2020-2021. Jabalpur is situated at 23°9' North latitude and 79°58' East longitudes with an altitude of 411.78 meters above the mean sea level. The seedbed was prepared by ploughing the field with a disc harrow, followed by one pass with a field cultivator and two plankings. The wheat variety “MP 3382” was sown manually on 13 November 2020 using a seed rate of 100 kg ha^{-1} in 20 cm spaced rows. The seeds were treated before sowing with vitavex 2.5 g kg^{-1} of seed to make them free from seed-borne diseases. Seven treatments, including doses of pinoxaden at 40, 45, and 90 g *a.i*. ha^{-1}, clodinafop propargyl at 90 g *a.i* ha^{-1}, sulfosulfuron at 25 g *a.i*. ha^{-1}, hand weeding (30 DAS), and weedy check were assigned in a randomized complete block design with three replication. The texture of the soil of the experimental field was clay. It was medium in organic carbon (0.64%), available nitrogen (372 kg N ha^{-1}), and available phosphorus (17 kg P_20_5 ha^{-1}) but high in available potassium (298 kg K_20 ha^{-1}). The soil was nearly neutral in reaction (7.3 pH), and the concentration of soluble salts (0.31 ds m^{-1}) was below the harmful limit. The crop was given a recommended dose of fertilizers, i.e.120 kg N, 60 kg P_2O_5, and 40 kg K_2O ha^{-1} through urea, single super phosphate, and murate of potash, respectively. Irrespective of herbicide dosage, it was sprayed as post-emergence 25 days after sowing of wheat. Before spraying, the measured amount of herbicide and water for each plot was well mixed. Herbicides were administered to the plots with a backpack sprayer equipped with a flat fan nozzle. Each time, a new solution was prepared for each plot separately. Observations on plant growth and yield were recorded, and economics was calculated after that. The analysis of variance (ANOVA) method was used for statistical analysis in standard statistical software, and a comparison of treatment means was made for a 5% level of significance using critical differences (CD). Weed control efficiency (WCE) was calculated by using the following formula suggested by [16] and expressed in percentage:

$$WCE = \frac{DMC - DMT}{DMC} x\,100$$

Where,

DMC is the dry matter of weeds in the control (unweeded) plot
DMT is the dry matter of weeds in the treated plot.

3. RESULTS AND DISCUSSION

3.1 Weed Flora

The experimental field was entirely invaded with mixed weed flora consisting of dicots and monocots. Among the total weeds, dicots weeds (84.4%) were more prominent than monocots (15.6%). Major weeds observed in the experimental field were *Phalaris minor* (15.6%) among monocot weeds while *Medicago denticulata* (30.82%), *Cichorium intybus* (29.94%), *Chenopodium album* (15.32%), and *Anagallis arvensis* (8.30%) were the most common in dicot weeds.

3.2 Effect on Weeds

Complete data analysis revealed a significant reduction in concerning weed density by the application of all the weed control treatments at 30 DAS (Table 3). The density of grassy weed *Phalaris minor* decreased with the corresponding increase in the dose of pinoxaden. Pinoxaden at its higher dose at 90 g *a.i.* ha^{-1} reduced the density of *Phalaris minor* (2.34 m^{-2}) significantly more than its lower doses at 40 and 45 g *a.i*. ha^{-1} and all the weed control treatments also reduced the weed density of broad-leaved weeds viz., *Medicago denticulata*, *Cichorium intybus*, *Chenopodium album*, and *Anagallis arvensis* significantly, but pinoxaden at 90 g *a.i.* ha^{-1} was more effective in reducing weed density than other treatments, followed by pinoxaden at 45 g *a.i*. ha^{-1} and pinoxaden at 40 g *a.i.* ha^{-1}. However, hand weeding was superior among all the weed control treatments in reducing weed growth, and it might be because of the removal of most weed flora.

Similarly, significant variation in weed dry weight existed between treatments at 30 DAS (Table 4). The significantly lowest weed dry weight of grassy and broad-leaved weeds resulted from hand weeding and pinoxaden at 90 g *a.i.* ha^{-1} as compared to other treatments followed by pinoxaden at 45 g *a.i*. ha^{-1} and pinoxaden at 40 g *a.i*. ha^{-1}. The reduced weed biomass was due to the lower weed population recorded under these treatments, which could be attributed to the effective weed control. The weedy treatment recorded significantly the highest dry weight of weeds might be due to uncontrolled conditions favoured luxurious weed growth leading to increased dry matter accumulation [17]. The minimum dry weight of weeds recorded in the hand weeding plots might be due to broad-spectrum (broad-leaved and grassy weeds) weed control that resulted in less space for weed development, better competition of wheat crop for development resource, crop growth rate, early space covering, and light interception in a narrow row as compared to wide row spacing. [18] recorded that a combination of closer spacing with broad-spectrum herbicide reduced the dry weight of weeds compared to narrow-spectrum herbicide and weedy check. These findings agree with the findings of [19].

3.3 Weed Control Efficiency

The effect of weed management practices on weed control efficiency was given in Fig. 1. The highest weed control efficiency (87.69 %) was registered under hand weeding treatment, followed by treatment pinoxaden at 90 g *a.i*. ha^{-1} with (47.00%) and pinoxaden at 45 g *a.i*. ha^{-1} with (39.32%). The lowest weed control efficiency was observed under weedy check treatment. These results closely conform to those of [20].

3.4 Effect on Crop

Weed management treatments significantly affected wheat growth parameters and yield attributes (Table 5). Significantly highest plant height (27.42 cm) was recorded with hand weeding treatment, followed by treatment of

Pinoxaden at 45 g *a.i*. ha^{-1} and Sulfosulfuron at 25 g *a.i.* ha^{-1} while, the weedy plots exhibited low-statured plants, which rose in plots receiving either herbicidal treatments or cultural measures [21].

The number of tillers m^{-2} changed dramatically according to the herbicidal treatment. Compared to the weedy control plots, the post-emergence application of all herbicidal treatments resulted in a significantly more number of tillers. Over herbicidal treatments, the application of pinoxaden at 45 g *a.i*. ha^{-1} resulted in the highest number of tillers (262.58 m^{-2}), which were at par with hand weeding, followed by pinoxaden at 90 g *a.i*. ha^{-1} and sulfosulfuron at 25 g *a.i*. ha^{-1}.

Table 1. Properties of herbicides used in experimental study

Herbicides	Chemical family	Trade name	Molecular formula	Translocation	Mode of action
Pinoxaden	Phenylpyrazolin	Axial	$C_{23}H_{32}N_2O_4$	Systemic	Inhibition of the fatty acid biosynthesis
Clodinafop Propargyl	Oxyphenoxy acid ester	Maachis	$C_{17}H_{13}ClFNO_4$	Systemic	Inhibits fatty acid synthesis. Inhibition of acetyl CoA carboxylase (ACCase)
Sulfosulfuron	Sulfonylurea	Leader	$C_{16}H_{18}N_6O_7S_2$	Systemic	ALS inhibitor

All the herbicidal treatments applied as a post emergence application

Table 2. Infesting species of weeds in the experimental plot

Name	English name	Scientific name	Family	Morphological type
Gehusa	Canary grass	*Phalaris minor*	Gramineae	Grass
Maina	Toothed bur clover	*Medicago denticulata*	Fabaceae	Broad leaved
Kashni	Blue daisy	*Cichorium intybus*	Asteraceae	Broad leaved
Bathua	Common lambsquarter	*Chenopodium album*	Chenopodiaceae	Broad leaved
Billi booti	Blue pimpernel	*Anagallis arvensis*	Primulaceae	Broad leaved

Table 3. Influence of weed control treatments on the density of weeds in wheat at 30 DAS

Treatments	Density of weeds (no./m^2)				
	Phalaris minor	***Medicago denticulata***	***Cichorium intybus***	***Chenopodium album***	***Anagallis arvensis***
Pinoxaden at 40 g *a.i*. ha^{-1}	2.80 (7.67)	3.75 (13.55)	3.76 (13.65)	2.84 (7.56)	2.60 (6.25)
Pinoxaden at 45 g *a.i*. ha^{-1}	2.73 (6.98)	3.84 (14.21)	3.71 (13.25)	2.60 (6.25)	2.55 (6.00)
Pinoxaden at 90 g *a.i*. ha^{-1}	2.34 (5.00)	3.57 (12.26)	3.54 (12.00)	2.37 (5.11)	2.41 (5.33)
Clodinafop Propargyl at 60 g *a.i*. ha^{-1}	2.85 (7.65)	3.75 (13.54)	3.82 (14.10)	2.79 (7.29)	2.60 (6.25)
Sulfosulfuron at 25 g *a.i*. ha^{-1}	3.08 (9.00)	3.84 (14.25)	3.80 (13.96)	2.71 (6.85)	2.52 (5.85)
Hand weeding	1.41 (1.50)	1.51 (1.79)	1.93 (3.24)	1.40 (1.45)	1.16 (0.85)
Weedy check	3.98 (15.34)	5.63 (31.21)	5.63 (31.24)	3.98 (15.32)	2.94 (8.12)
SEm±	0.03	0.03	0.02	0.03	0.01
LSD (P=0.05)	0.08	0.09	0.08	0.08	0.04

Original data given in parenthesis was subjected to square root transformation (√x+1)

Table 4. Influence of weed control treatments on the dry weight of weeds in wheat at 30 DAS

Treatments	Dry weight of weeds (g/m^2)				
	Phalaris minor	***Medicago denticulata***	***Cichorium intybus***	***Chenopodium album***	***Anagallis arvensis***
Pinoxaden at 40 g *a.i.* ha^{-1}	4.98 (24.32)	3.55 (12.11)	3.99 (15.40)	2.15 (4.12)	2.59 (6.20)
Pinoxaden at 45 g *a.i.* ha^{-1}	5.04 (24.95)	3.43 (11.25)	3.95 (15.10)	2.12 (4.00)	2.57 (6.10)
Pinoxaden at 90 g *a.i.* ha^{-1}	4.87 (23.22)	2.92 (8.00)	3.70 (13.21)	1.94 (3.25)	2.54 (5.95)
Clodinafop Propargyl at 60 g *a.i.* ha^{-1}	5.15 (26.00)	3.65 (12.85)	4.09 (16.23)	2.15 (4.13)	2.57 (6.12)
Sulfosulfuron at 25 g *a.i.* ha^{-1}	5.10 (25.55)	3.61 (12.54)	4.09 (16.24)	2.18 (4.25)	2.59 (6.23)
Hand weeding	2.24 (4.50)	1.45 (1.60)	2.18 (4.27)	1.16 (.85)	1.32 (1.24)
Weedy check	5.48 (29.52)	4.31 (18.12)	5.71 (32.11)	3.27 (10.20)	3.43 (11.24)
SEm±	0.03	0.02	0.03	0.01	0.02
LSD (P=0.05)	0.09	0.08	0.09	0.03	0.06

Original data given in parenthesis was subjected to square root transformation (√x+1)

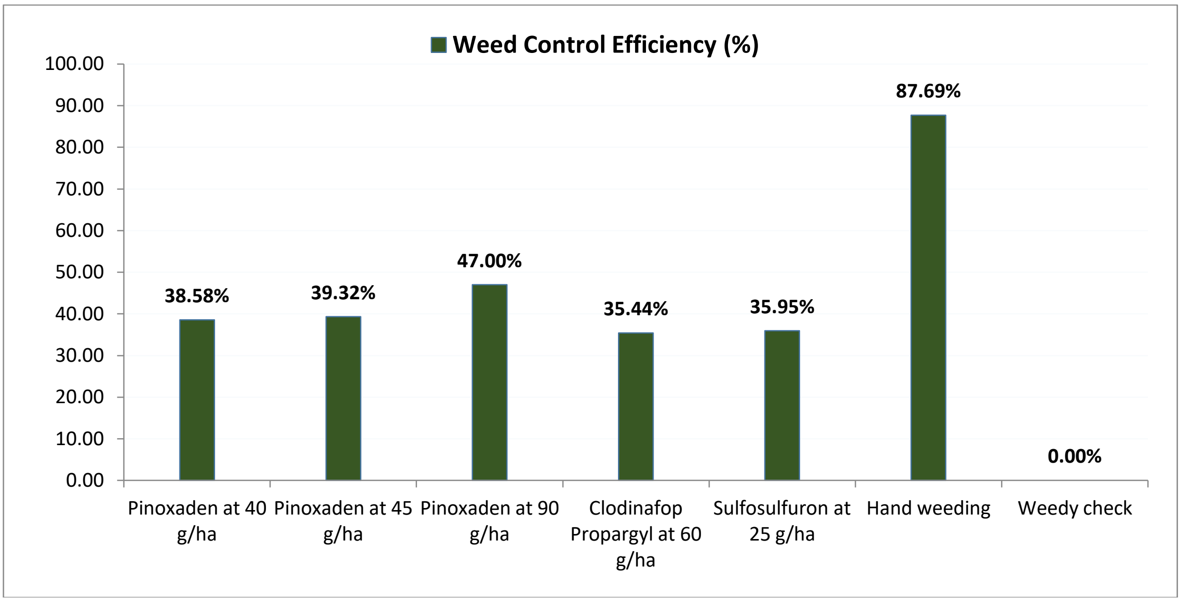

Fig. 1. Influence of weed control treatments on weed control efficiency in wheat at 30 DAS

Yield attributes and wheat yield also followed the identical trend of growth attributes under various doses of pinoxaden. However, different treatments resulted in significant differences in the grains ear head^{-1}. For example, among the herbicidal treatments, pinoxaden at 45 g *a.i.* ha^{-1} produced the most grains ear head^{-1} (50.21) and was comparable to clodinafop propargyl at 60 g *a.i.* ha^{-1}. However, among all the weed control treatments, hand weeding yielded the highest grains ear head^{-1}.

Grain yield varied dramatically as a result of weed control treatments. Under weedy check control plots, where weeds were allowed to grow throughout the crop season, it was at a minimum. However, in plots where weeds were managed chemically or mechanically, different treatments resulted in considerable differences in grain production. All herbicidal treatments applied post-emergence yielded significantly better grain yield than weedy control plots. The use of pinoxaden at 45 g *a.i.* ha^{-1} resulted in the higher

Table 5. Influence of weed control treatments on growth parameter, yield attributes and yield of wheat

Treatments	Plant height (cm)	Number of tillers/m^2	Grains/ear head	Grain yield (kg/ha)
	30 DAS	30 DAS		
Pinoxaden at 40 g *a.i.* ha^{-1}	25.00	253.38	42.20	4630
Pinoxaden at 45 g *a.i.* ha^{-1}	26.67	262.58	50.21	5368
Pinoxaden at 90 g *a.i.* ha^{-1}	25.11	255.46	42.78	5013
Clodinafop Propargyl at 60 g *a.i.* ha^{-1}	25.32	254.15	44.20	5230
Sulfosulfuron at 25 g *a.i.* ha^{-1}	26.00	255.31	43.21	5125
Hand weeding	27.42	271.51	52.76	5810
Weedy check	24.00	243.16	37.67	3216
SEm±	0.40	3.34	0.56	90.14
LSD (P=0.05)	1.24	10.30	1.74	277.75

grain yield (5368 kg ha^{-1}), comparable to clodinafop propargyl at 60 g *a.i.* ha^{-1} and superior to all other herbicidal treatments, while hand weeding treatment produced the highest grain yield (5810 kg ha^{-1}) among all the weed control treatments. These results closely conform to the earlier findings of [22,23].

4. CONCLUSION

Based on the above findings, it may be concluded that application of pinoxaden at 90 g *a.i.* ha^{-1} was the best treatment for effectively controlling weeds, while pinoxaden at 45 g *a.i.* ha^{-1} recorded the highest growth parameters and grain yield compared to all other herbicidal treatments and obtained higher net profit and benefit from the cost involved in wheat cultivation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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