The Pharma Innovation Journal 2023; 12(3): 3621-3624

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(3): 3621-3624

www.thepharmajournal.com
Received: 01-12-2022
Accepted: 07-01-2023

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Effect of carfentrazone-ethyl on weed flora, growth and productivity in wheat

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Abstract
A field experiment was conducted at the Research Farm, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during *Rabi* 2020–21 to assess the efficacy of different doses of carfentrazone-ethyl against complex weed flora in wheat. The experimental field was infested with *Medicago denticulate* (28.97%), *Melilotus indica* (27.02%), and *Cichorium intybus* (14.82%). However, other weeds like *Anagallis arvensis*, *Chenopodium album*, *Convolvulus arvensis* and *Phalaris minor* were also found to be associated in lesser numbers during the study. Application of herbicides significantly reduced the weed population and dry weight of weeds compared to weedy check at 60 DAS. Carfentrazone-ethyl at different doses provides better weed control than 2,4-D amine. Significant variation in wheat yield was recorded due to the application of different herbicides compared with the control. The number of tillers/m^2 (382), grains/earhead (53) and grain yield (5.3 t/ha) were significantly higher with carfentrazone at 40 g/ha followed by carfentrazone at 24 g/ha. Also, there were no symptoms of phytotoxicity in the crop.

Keywords: Carfentrazone-ethyl, grain yield, weed flora, weed index, wheat

Introduction
Wheat (*Triticum aestivum* L.) is the most frequently produced food crop in the world, and it is India's second most important staple food, after rice. Globally, it is grown on an area of about 217.02 million hectares with a production of 766.5 million tonnes (FAO, 2020) [5]. India is the second-highest wheat-producing country in the world after China. In 2019–20, wheat was grown in India on an area of about 31.45 million hectares with a production of 107.59 million tonnes. In Madhya Pradesh, wheat is produced on about 10.02 million hectares, producing 16.52 million tonnes of grain with a productivity of 3298 kg/ha (IIWBR, 2020 and Sisodiya *et al.*, 2022) [6, 16]. Wheat production depends on several factors, including severe weed competition, which limits crop yield. Weeds compete for water, nutrients, space, and sunlight with wheat crops, resulting in a 29% reduction in yield (Pandey *et al*., 2006) [10]. Weed management techniques play a crucial role in improving the productivity of wheat. If weeds sprout with the emerging crop seedlings and are not controlled in the early phases of crop growth, yields can be reduced by 10 to 40%, depending on the area's intensity and kind of weeds (Verma *et al*., 2022) [17]. Wheat yield was reduced by more than 60% due to a mixed population of *Phalaris minor* and *Chenopodium album* (Singh & Singh, 2005) [13]. Both monocot and dicot weeds are commonly found in wheat fields and are the principal weeds that infest wheat (Chhokar *et al*., 2002) [2]. Therefore, control of the mixed weed flora of wheat is most important for enhancing the wheat yield.
Control of these weeds at an early stage yields more benefits. Regarding crop-weed competition, the early stage of crop growth, up to 25–45 days following sowing, is considered critical for wheat (Chopra & Singh, 1999) [3]. To avoid further losses in agro-inputs and crop output, weed control is required in wheat. Herbicides are used to retain weed-free conditions, during the early stage of growth, either by cultural or mechanical means or through pre-planting, pre-emergence and post-emergence herbicide applications (Verma *et al*., 2022) [17]. Carfentrazone-ethyl is a novel herbicide that claims to be efficient against broad-leaved weeds (Singh *et al*., 2004 and Walia & Singh, 2007) [14, 19]. However, very meager information is available on the bio-efficacy of carfentrazone-ethyl against weeds in wheat for the Kymore Plateau and Satpura Hills zone. Therefore, the present investigation evaluated the bio-efficacy of carfentrazone-ethyl against weed flora and yield in wheat.

Materials and Methods

The field experiment was conducted during the *Rabi* season of 2020–21 at the Research Farm, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The soil of the Jabalpur region is broadly classified as vertisol based on the United States classification of soil. It was medium in organic carbon (0.70%), available nitrogen (292.75 kg/ha), available phosphorus (17.55 kg/ha), and available potassium (256.42 kg/ha). The experiment was carried out in a randomized block design with three replications and eight treatments, comprising carfentrazone-ethyl at 12, 16, 20, 24, and 40 g/ha, 2,4-D Amine salt at 750 g/ha as post-emergence herbicides, hand weeding once and weedy check. The wheat variety GW-273, having a good germination percentage was sown with the help of a ferti seed drill at 22.5 cm row spacing using 100 kg seed/ha on December 2020 in a gross plot size of 5.0 m × 3.60 m^2. Urea, single superphosphate, and murate of potash were used as nitrogen, phosphorus and potassium sources, respectively. A uniform dose of 120:60:40 N:P: K kg/ha was applied uniformly at the time of sowing, and the remaining 60 kg N was top-dressed in two equal splits, each after the first and second irrigations. Five irrigations were given to critical growth stages of the crop and 6 cm of water was applied per irrigation. All the herbicides were applied with the help of a knapsack sprayer with a flat fan nozzle using a spray volume of 500 l/ha. The density and dry weight of weeds were observed at 60 DAS. The weed index was calculated using the standard formula. Data on weed density was recorded from an area enclosed in a quadrate of 0.25/ m^2 randomly selected at four places in each plot. Weed species were separately counted from each sample, and their density was recorded. The oven-dry weight of weeds was recorded at 70 °C for 48 hr. Data on growth parameters and grain yield at harvest were studied. Data collected on various parameters were analyzed statistically.

Results and Discussion

Weed flora

The weed species associated with the wheat crop in the experimental area were *Medicago denticulate* (28.97%), *Melilotus indica* (27.02%) and *Cichorium intybus* (14.82%). However, other weeds like *Anagallis arvensis Chenopodium album, Convolvulus arvensis* and *Phalaris minor* were also found to be associated in a lesser number. Almost similar weed flora associated with wheat was also reported by Nirala *et al*., 2022; Kantwa *et al*., 2019 and Jha *et al*., 2014.

Effect on weeds

The density and dry weight of different weeds were affected by different weed control treatments at 60 DAS (Tables 1-2). The weed density and dry weight were highest in weedy check plots where no weed control measures were adopted. However, their density was suppressed when weed control measures were adopted. Carfentrazone-ethyl applied as a post-emergence herbicide at the lowest dose (12 g/ha) resulted in considerable weed density and dry weight reductions over weedy check plots. However, its efficacy was inched up with the corresponding increase in application rates being higher when it was applied at 20 g/ha or higher rates (24 and 40 g/ha) and proved significantly superior over carfentrazone-ethyl applied at 12 g/ha, 16 g/ha and 2,4-D amine salt at 750 g/ha.

On the other hand, the herbicide 2,4-D amine salt at 750 g/ha caused less reduction in the density and dry weight of dicot weeds than carfentrazone-ethyl. Hand weeding surpassed all the herbicidal treatments as it reduced the density of weeds to the maximum extent and proved significantly superior over herbicidal treatments. However, carfentrazone-ethyl at 40 g/ha was superior to effectively reducing weed density because it eliminated all sorts of weeds (Patel *et al*., 2023 and Dhawan *et al.*, 2009) [11, 4].

The weed index indicates the loss in yield due to weeds compared to hand weeding (Figure 1). Application of carfentrazone-ethyl at 20 g/ha or higher doses (24 and 40 g/ha) obstructed the yield reduction to 7.31 to 7.26% due to the control of all sorts of weeds effectively. It proved significantly superior over carfentrazone-ethyl at 12 g/ha, carfentrazone-ethyl at 16 g/ha and 2,4-D amine salt at 750 g/ha. The lowest weed index was observed with the application of carfentrazone-ethyl at 40 g/ha. These results align with the findings of Yadav *et al.*, 2009 [20] and Chauhan *et al*., 2017 [1].

Table 1: Influence of weed control treatments on weed density at 60 DAS in wheat

Treatments	Density of weeds (no./m^2)						
	Medicago denticulata	***Melilotus indica***	***Cichorium intybus***	***Anagallis arvensis***	***Chenopodium album***	***Convolvulus arvensis***	***Phalaris minor***
Carfentrazone-ethyl at 12 g/ha	4.2 (17.5)	4.7 (21.6)	3.4 (11.5)	2.8 (7.3)	2.7 (6.9)	1.5 (2.0)	2.3 (5.0)
Carfentrazone-ethyl at 16 g/ha	3.8 (14.6)	3.7 (13.6)	2.8 (7.6)	2.6 (6.3)	2.2 (4.3)	1.4 (1.5)	2.3 (5.0)
Carfentrazone-ethyl at 20 g/ha	2.7 (7.1)	2.8 (7.3)	2.3 (5.0)	1.9 (3.3)	1.6 (2.3)	1.1 (1.0)	2.2 (4.5)
Carfentrazone-ethyl at 24 g/ha	2.7 (6.7)	2.6 (6.6)	2.2 (4.3)	1.9 (3.1)	1.6 (2.1)	1.2 (0.9)	2.2 (4.)
Carfentrazone-ethyl at 40 g/ha	2.3 (5.0)	2.3 (4.8)	1.9 (3.2)	1.6 (2.3)	1.4 (1.5)	1.0 (0.5)	2.3 (5.0)
2,4-D amine salt at 750 g/ha	3.6 (13.0)	3.5 (12.3)	2.7 (7.1)	2.5 (6.0)	2.0 (3.6)	1.4 (1.4)	2.3 (4.9)
Hand weeding	1.6 (2.3)	1.5 (1.7)	1.5 (2.0)	1.0 (0.6)	1.0 (0.6)	0.8 (0.2)	1.2 (1.0)
Weedy check	8.4 (70.6)	8.2 (67.4)	6.7 (44.6)	6.0 (36.5)	4.8 (22.7)	2.6 (6.2)	2.3 (5.0)
LSD (P=0.05)	0.09	0.09	0.07	0.04	0.04	0.09	0.38

Table 2: Influence of weed control treatments on weed dry weight at 60 DAS in wheat

Treatments	Dry weight of weeds (g/m^2)						
	Medicago denticulata	***Melilotus indica***	***Cichorium intybus***	***Anagallis arvensis***	***Chenopodium album***	***Convolvulus arvensis***	***Phalaris minor***
Carfentrazone-ethyl at 12 g/ha	2.7 (7.2)	3.0 (8.8)	3.6 (12.7)	2.8 (7.3)	1.8 (2.8)	1.5 (2.0)	2.3 (5.0)
Carfentrazone-ethyl at 16 g/ha	2.5 (6.0)	2.4 (5.6)	2.9 (8.2)	2.6 (6.2)	1.5 (1.7)	1.4 (1.5)	2.3 (5.0)
Carfentrazone-ethyl at 20 g/ha	1.8 (2.9)	1.8 (3.0)	2.3 (5.2)	1.9 (3.2)	1.2 (0.9)	1.1 (1.0)	2.2 (4.5)
Carfentrazone-ethyl at 24 g/ha	1.8 (2.7)	1.8 (2.7)	2.2 (4.4)	1.8 (2.9)	1.1 (0.8)	1.2 (0.9)	2.2 (4.7)
Carfentrazone-ethyl at 40 g/ha	1.6 (2.0)	1.5 (1.9)	1.9 (3.1)	1.6 (2.1)	1.0 (0.6)	1.0 (0.5)	2.3 (5.0)
2,4-D amine salt at 750 g/ha	2.4 (5.3)	2.3 (5.0)	2.8 (7.6)	2.5 (5.8)	1.4 (1.5)	1.4 (1.4)	2.3 (4.9)
Hand weeding	1.2 (0.9)	1.1 (0.7)	1.1 (0.8)	0.8 (0.2)	0.8 (0.2)	0.8 (0.2)	1.2 (1.0)
Weedy check	5.4 (28.9)	5.3 (27.6)	4.3 (18.3)	3.9 (14.9)	3.1 (9.3)	2.6 (6.2)	2.3 (5.0)
LSD (P=0.05)	0.06	0.06	0.06	0.04	0.16	0.09	0.08

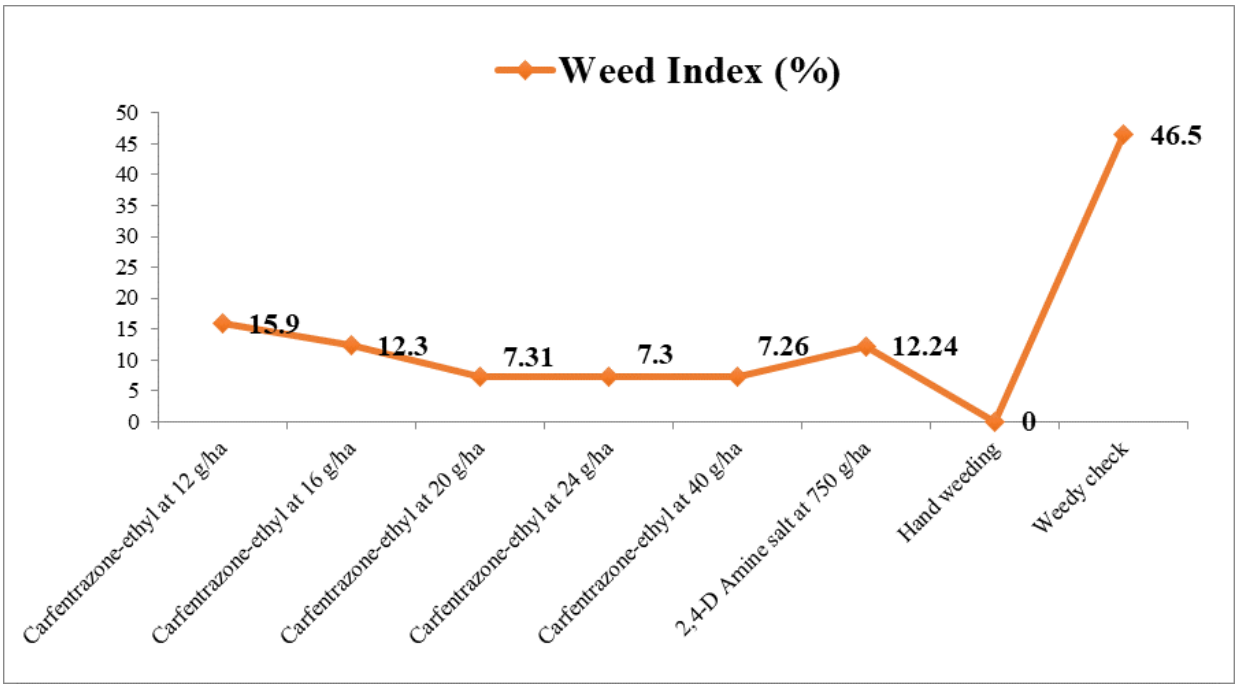

Fig 1: Effect of weed control treatments on weed index

Effect on crop

All the weed control measures recorded significantly higher growth parameters (plant height, effective tillers and grains per ear head) over the control treatment (Table 3). Among the weed control treatments, the weedy check treatment recorded the lowest values for all the growth parameters due to the high degree of crop-weed competition. In comparison, higher values of these parameters were recorded in hand-weeding treatments. Among the herbicidal treatments, the application of carfentrazone-ethyl at 40 g/ha significantly produced higher plant height (66.89 cm), effective tillers (382) and grains/ear head (53.00). Tremendous growth and development of the crop in a weed-free environment during a vital stage of crop growth may have resulted in more effective tillers and grains per ear head (Singh *et al*., 2013) [15].

Grain yield differs significantly under different weed control treatments (Table 3). Weedy check treatment recorded the lowest grain yield (3.0 t/ha) due to poor values of growth parameters and yield-attributing traits. A significant increase in grain yield was observed with herbicidal treatments. Among the herbicides, carfentrazone-ethyl at 40 g/ha produced the higher grain yield (5.3 t/ha) and proved significantly superior over carfentrazone-ethyl at 12 g/ha, carfentrazone-ethyl at 16 g/ha, carfentrazone-ethyl at 20 g/ha, carfentrazone-ethyl at 24 g/ha and 2, 4-D amine salt at 750 g/ha. However, hand-weeding treatment produced the highest grain yield (5.7 t/ha) among all the treatments due to superior values of growth parameters and yield-attributing traits under weed free environment (Punia *et al*., 2018) [12].

Table 3: Influence of weed control treatments on growth parameters and yield in wheat

Treatments	**Plant height (cm)**	**Effective tillers**	**Grains/ ear head**	**Grain yield (t/ha)**
Carfentrazone-ethyl at 12 g/ha	62.80	361	45.33	4.8
Carfentrazone-ethyl at 16 g/ha	64.75	370	47.67	5.0
Carfentrazone-ethyl at 20 g/ha	66.60	379	51.33	5.2
Carfentrazone-ethyl at 24 g/ha	66.85	380	52.66	5.2
Carfentrazone-ethyl at 40 g/ha	66.89	382	53.00	5.3
2,4-D amine salt at 750 g/ha	64.80	372	50.66	5.0
Hand weeding	69.10	401	55.67	5.7
Weedy check	54.99	251	36.33	3.0
LSD (P=0.05)	1.62	6.37	2.06	0.27

Conclusion

It can be concluded that the post-emergence application of carfentrazone at 40 g/ha was found most suitable for effective weed management in wheat with higher grain yield and net returns.

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