

Original Research Article

Evaluation of Bentazone as post-emergence against weed flora of direct seeded rice (*Oryzasativa* L.)

ABSTRACT

A field experiment was conducted at the Breeder Seed Production Unit, Adhartal, Jawaharlal Nehru KrishiVishwaVidyalaya, Jabalpur (M.P.) during the *Kharif* season of 2016 to evaluate the effectiveness of various doses of Bentazon herbicide in direct-seeded rice. The experimental soil was clayey with a neutral pH of 7.2, medium organic carbon content (0.62%), available nitrogen (365 kg/ha), available phosphorus (16.34 kg P₂O₅/ha), and high available potassium (327.16 kg K₂O/ha). Weed control treatments included Bentazon at 600, 800, 1000, 1200, 1600, 1800, and 2000 g/ha; 2,4-D at 380 g/ha; two hand weedings at 20 and 40 days after sowing (DAS); and an unweeded control. These treatments were arranged in a randomized block design with three replications. The primary weeds in the experimental field were monocots (*Echinochloacolona*, *Dinebraretroflexa*), sedges (*Cyperusiria*), and broad-leaved weeds (*Mollugopentaphylla*, *Alternantheraphiloxeroides*). The post-emergence application of Bentazone at 1600 g/ha was found to be the most economically effective for controlling dicot weeds in direct-seeded rice, resulting in the lowest weed index. This treatment also improved growth parameters (such as plant height, number of tillers per square meter, and plant dry weight), yield attributes (such as grains per panicle), and grain yield compared to other weed control treatments. Therefore, Bentazon at 1600 g/ha is recommended to farmers for achieving higher economic returns and effective weed control in direct-seeded rice.

Keywords: *Bentazon, Direct-seeded rice, Grain yield, Herbicides, Weeds, Weed index*

1. INTRODUCTION

Rice (*Oryza sativa* L.) serves as a staple food for over 60% of the world's population and is primarily grown as a kharif crop [1]. It is cultivated in various agro-ecosystems and soil conditions. India ranks as the second largest producer and consumer of rice globally. Rice provides 50-80% of the daily calorie intake for many consumers [2]. In India, it is grown in nearly 43.39 m ha area with the production of 104.32 MT and productivity of 2404 kg/ha. In Madhya Pradesh, it occupies an area of 2.02 m ha with the production of 3.58 MT and productivity of 1768 kg/ha [3].

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The transplantation method of rice cultivation is widespread in various parts of India but is labor-intensive, costly, and requires substantial water for puddling, transplanting, and establishing seedlings. Many farmers in Madhya Pradesh are marginal and face difficulties with these operations. Additionally, unpredictable and insufficient monsoon rains significantly impact rice productivity. Therefore, Direct Seeding of Rice (DSR) offers several advantages over traditional transplanting, including easier planting, timely sowing, reduced labor, earlier crop maturity by 7 to 10 days, lower water requirements, improved soil conditions for subsequent crops, lower production costs, and higher profits [4].

Weeds present a significant challenge by competing for nutrients, light, space, and moisture from the moment they emerge and throughout the entire growing season[5,6,7,8]. Weeds are the primary challenge in direct-seeded rice, as the natural weed control provided by standing water during crop establishment is absent. High weed infestation in direct-seeded rice can lead to grain yield losses of up to 90%[9]. Weeds germinate alongside rice seeds and compete for resources from the initial stages, leading to reduced crop yields, increased cultivation costs, decreased input efficiency, interference with agricultural operations, impaired crop quality, and adverse effects on the ecosystem, native biodiversity, human, and cattle health[10,11,12]. The shift from transplanting to direct seeding alters the weed community, with species such as *Dactylocteniumaegyptium*, *Digitariaciliaris*, *Eragrostis spp.*, *Eleusineindica*, *Acrachneracemosa*, *Commelinabenghalensis*, *Cyperuscompressus*, *Cyperusrotundus*, *Digeraarvensis*, *Phyllanthusniruri*, *Amaranthusviridis*, and *Trianthemaportulacastrum* becoming more prevalent, alongside traditional weeds like *Echinochloacrusgalli*, *Echinochloacolona*, *Leptochloachinensis*, *Cyperusiria*, *Cyperusdifformis*, *Eclipta alba*, and *Sphenochloazeylanica*. Consequently, new weed management strategies are needed to address the more competitive weed flora in direct-seeded rice. A weed-free period of the first 25-45 days after sowing is crucial to prevent yield loss in dry direct-seeded rice[13].

Hand weeding, while environmentally friendly and effective, is labor-intensive and often hindered by labor shortages during peak periods[14,15]. Early-stage weeding is particularly challenging due to the morphological similarity between rice seedlings and weeds. Identifying herbicides with broad-spectrum weed control capabilities is essential for efficient and economical weed management, which is crucial for enhancing crop potential [16,17,18]. Pre-emergence herbicides like Pretachlor, Butachlor, Anilophos, and post-emergence herbicides like 2,4-D and Almix are commonly used to

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control grassy and broadleaf weeds in direct-seeded rice. Although effective, these herbicides are usually specific to a narrow range of weed species, and continuous application can lead to shifts in weed flora and herbicide resistance. This necessitates ongoing research to develop and evaluate new and alternative herbicides to address herbicide resistance. Bentazon, a post-emergence herbicide effective against broadleaf weeds in soybeans, is being investigated for its efficacy in direct-seeded rice under the central zone.

2. MATERIALS AND METHODS

A field experiment was conducted at the Breeder Seed Production Unit, Adhartal, Jawaharlal Nehru KrishiVishwaVidyalaya, Jabalpur (M.P.), to evaluate the effectiveness of Bentazon against weeds in direct-seeded rice during the *kharif* season of 2016. The study took place under the specific edaphic and climatic conditions of Jabalpur (M.P.), located at 23°9' North latitude and 79°58' East longitude, with an altitude of 411.78 meters above mean sea level. The climate in this region is typically sub-humid and sub-tropical, characterized by hot, dry summers and cool, dry winters. Weather conditions during the experiment were generally favorable for rice growth and development. The monsoon began in the first week of June and ended in the fourth week of September, with total rainfall of 926.50 mm distributed over 34 rainy days from the last week of July to the first week of November. The mean minimum and maximum temperatures ranged from 27.0 to 33.0 °C, while relative humidity varied from 87 to 93% in the morning and 24 to 91% in the evening. The mean daily sunshine duration ranged from 1.3 to 9.3 hours. The soil of the experimental field was clayey, neutral in reaction (pH 7.2), with medium organic carbon content (0.62%), available nitrogen (365 kg/ha), and available phosphorus (16.34 kg P₂O₅/ha), and high available potassium (327.16 kg K₂O/ha). Ten treatments were tested: Bentazon at 600, 800, 1000, 1200, 1600, 1800, and 2000 g/ha; 2,4-D at 380 g/ha; hand weeding at 20 and 40 DAS; and a weedy check. These treatments were arranged in a randomized block design with three replications. Seeds were sown on July 26th, 2016, using a seed drill, with rows spaced 20 cm apart at a depth of 2-3 cm, then covered with fine soil. All herbicides were applied post-emergence in the standing paddy crop. Nitrogen (80 kg/ha) was applied in three equal splits, while phosphorus (40 kg/ha) and potassium (30 kg/ha) were applied at seedbed preparation by broadcasting. Data were collected on weed population and dry matter, crop growth, and yield. Weed index and benefit-cost ratio were calculated. Weed data were square-root

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transformed before statistical analysis. A pooled analysis over ~~two years~~ was conducted, and comparisons were made at the 5% significance level.

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$$\text{Weed index (\%)} = \frac{(X - Y)}{X} \times 100 \text{ (1)}$$

Where,

X = Yield from weed free plot ~~and~~

Y = Yield from treated plot

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3. RESULTS AND DISCUSSION

3.1 Weed density and weed dry weight

During the ~~investigation study~~, rice was primarily infested ~~with grassy weeds such as~~ by *Echinochloa colona*, *Dinebraretroflexa*, *Cyperus iria*, *Mullogopentaphylla*, and *Altemantheraphiloxeroides*. The emergence of these weed species is mainly attributed to factors such as the initial soil weed seed bank, variations in tillage intensity during land preparation, previous cropping systems, weather conditions during crop growth, and favorable soil environments. ~~Among these emerged monocot weeds~~ Among the monocot weeds, *Echinochloa colona* was the most dominant, contributing ~~25.99%~~ of the relative weed density. ~~Among the dicot weeds,~~ *Mullogopentaphylla* was the most ~~dominant dicot weeds~~ dominant, contributing ~~25.27%~~ of the relative weed density. ~~Other notable weeds included~~ *Dinebraretroflexa* (17.32%), *Cyperus iria* (16.65%), and *Altemantheraphiloxeroides* (14.77%), although they were present in smaller numbers [19].

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The highest weed density and dry weight were observed in the weedy check plots ~~due to the lack of weed control measures~~ (Table 1 & 2). However, the application of herbicides and hand weeding significantly reduced both the density and dry weight of these weeds. ~~Bentazon, applied as a post-emergence treatment at 1800 and 2000 g/ha, was particularly effective in reducing the density and dry weight of broad-leaved weeds, followed by Bentazon at 1600 g/ha. While Bentazon at different doses and 2,4-D at 380 g/ha did not significantly reduce the density and dry weight of grassy weeds, -~~ The higher doses of Bentazon (1600, 1800, and 2000 g/ha) significantly reduced the density and dry weight of broad-leaf weeds compared to lower doses (600, 800, 1000, 1200 g/ha) and 2,4-D at 380 g/ha.

The effectiveness of Bentazon is attributed to its inhibition of the ACCase enzyme, which is crucial for the biosynthesis of fatty acids. This inhibition reduces the level of cuticle waxes, exposing weed plants to more desiccation and heat injury, resulting in yellowing leaves and eventual weed mortality. Furthermore, Bentazon inhibits the plant enzyme acetolactate synthase (ALS), which is essential for

the synthesis of branched-chain amino acids (valine, leucine, and isoleucine). This inhibition disrupts cell division and leads to the death of susceptible weeds. Similar observations were reported by [20,21,22].

Hand weeding twice, at 20 and 40 DAS, resulted in the maximum reduction of weed density and dry weight compared to herbicidal treatments, as it eliminated all types of weeds during the weeding process. This observation aligns with findings by [23,24] who also reported minimal weed density and dry weight under hand weeding conditions.

Table 1. Weed density (no./m²) of grasses, sedges and broad-leaf weeds as influenced by different weed control treatments at 15 DAA

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Treatments	Grassy weeds		Sedges	Broad-leaf weeds	
	<i>Echinochloa colona</i>	<i>Dinebraretr oflexa</i>	<i>Cyperu siria</i>	<i>Mullogopenta phylla</i>	<i>Alternantheraphilo xeroides</i>
Bentazon 600g/ha	6.76 (45.53)	5.16 (26.15)	4.71 (21.69)	4.99 (24.40)	3.12 (9.25)
Bentazon 800g/ha	6.73 (45.30)	5.09 (25.40)	4.70 (21.56)	4.96 (24.15)	3.11 (9.18)
Bentazon 1000g/ha	6.72 (44.73)	5.21 (26.69)	4.58 (20.47)	4.82 (22.69)	2.97 (8.31)
Bentazon 1200g/ha	6.67 (44.06)	5.19 (26.42)	4.72 (21.73)	4.68 (21.42)	2.78 (7.25)
Bentazon 1600g/ha	6.79 (45.67)	5.02 (24.73)	4.70 (21.56)	4.38 (18.73)	2.60 (6.26)
Bentazon 1800g/ha	6.70 (44.83)	5.10 (25.50)	4.71 (21.68)	4.10 (16.33)	2.39 (5.23)
Bentazon 2000g/ha	6.73 (45.37)	5.08 (25.31)	4.69 (21.53)	3.63 (12.68)	2.16 (4.18)
2,4-D380g/ha	6.75 (45.68)	5.04 (24.94)	4.69 (21.53)	4.47 (19.46)	2.77 (7.15)
Handweeding(20 &40DAS)	2.29 (4.87)	1.40 (1.46)	1.67 (2.28)	2.79 (7.28)	1.68 (2.31)
Weedy check	6.78 (45.60)	5.04 (24.93)	4.70 (21.61)	6.64 (43.62)	5.10 (25.53)
SEm±	0.39	0.02	0.01	0.02	0.01
CDat5%	1.15	0.05	0.04	0.07	0.03

Table 2. Weed dry weight (g/m²) of grasses, sedges and broad-leaf weeds as influenced by different weed control treatments at 15 DAA

Treatments	Grassy weeds	Sedges	Broad-leaf weeds
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	<i>Echinochloa colona</i>	<i>Dinebraretr oflexa</i>	<i>Cyperu siria</i>	<i>Mullogopenta phylla</i>	<i>Alternantheraphilo xeroides</i>
Bentazon 600g/ha	6.44 (40.98)	4.43 (19.09)	4.29 (17.93)	3.14 (9.36)	1.96 (3.33)
Bentazon 800g/ha	6.42 (40.76)	4.36 (18.54)	4.28 (17.83)	3.08 (8.99)	1.95 (3.31)
Bentazon 1000g/ha	6.38 (40.21)	4.47 (19.49)	4.17 (16.92)	3.06 (8.87)	1.87 (2.99)
Bentazon 1200g/ha	6.35 (39.85)	4.45 (19.29)	4.30 (17.97)	2.89 (7.85)	1.76 (2.61)
Bentazon 1600g/ha	6.45 (41.07)	4.31 (18.06)	4.28 (17.82)	2.57 (6.12)	1.66 (2.26)
Bentazon 1800g/ha	6.41 (40.58)	4.37 (18.62)	4.29 (17.92)	2.29 (4.75)	1.54 (1.88)
Bentazon 2000g/ha	6.41 (40.63)	4.36 (18.48)	4.28 (17.80)	2.16 (4.17)	1.42 (1.51)
2,4-D380g/ha	6.46 (41.29)	4.33 (18.21)	4.28 (17.80)	2.79 (7.27)	1.75 (2.57)
Handweeding(20 & 40 DAS)	2.24 (4.52)	1.25 (1.06)	1.54 (1.88)	1.88 (3.03)	1.15 (0.83)
Weedy check	6.47 (41.45)	4.32 (18.20)	4.29 (17.86)	5.69 (31.89)	3.11 (9.19)
SEm±	0.07	0.03	0.02	0.05	0.02
CDat5%	0.20	0.09	0.07	0.13	0.06

3.2 Growth parameters, yield attributing traits and grain yield

Significantly taller plants, more tillers per square meter, and the maximum plant dry weight were observed with the application of Bentazon at 1600 g/ha compared to the weedy check at 30 DAS (Table 3). This improvement was attributed to the enhanced availability of growth resources, especially nitrogen and space, which facilitated the growth of taller plants and a greater number of tillers per square meter. The increased plant dry weight was due to the reduced weed competition resulting from effective weed control, promoting better growth and development of the rice plants. These findings align with those of [25,26]. However, these treatments were still significantly inferior to hand-weeded plots. Hand weeding twice provided excellent weed control, creating an almost weed-free environment during the critical period of crop-weed competition. This optimal condition led to superior growth and development of the crop plants, resulting in greater plant height and more tillers per square meter [27].

A significantly higher number of total grains per panicle was recorded with both hand weeding twice and Bentazon at 1600 g/ha (Table 3). This increase was due to the better suppression of weeds, creating a weed-free environment that allowed more nutrients for the formation and development of grains. These results are consistent with the findings of [28,29].

The lowest grain yields were recorded in the weedy check plots, where weeds were allowed to grow throughout the crop season (Table 3). This led to severe competition for growth resources between the crop and weeds, resulting in poor growth and yield attributes, and suboptimal partitioning of dry matter among leaves, stems, and panicles. Consequently, these plots produced the lowest yields. Significant increases in grain yield were observed with various doses of Bentazon at 600, 800, 1000, 1200, 1800, and 2000 g/ha, and with 2,4-D at 380 g/ha when applied post-emergence, with the highest yield (5.35 t/ha) at 1600 g/ha. Hand weeding twice resulted in even higher yields (6.16 t/ha) compared to all other treatments. The increased yields were due to the elimination of weeds, which enhanced the availability of nutrients, space, sunlight, and water, leading to better growth and development of crop plants. This resulted in improved yield attributes and greater dry matter accumulation, ultimately producing the highest yields. These results corroborate the findings of [30,31].

Table 3. Growth parameters, yield attributing traits and grain yield as influenced by different weed control treatments

Treatments	Plant height (cm)	Tillers/m ²	Plant dry weight (g/m ²)	Grains/panicle	Grain yield (t/ha)
	30 DAS	30 DAS	30 DAS		
Bentazon 600g/ha	31.12	502.15	9.93	56.71	3.43
Bentazon 800g/ha	31.86	543.23	9.95	56.90	3.65
Bentazon 1000g/ha	33.20	526.50	9.93	57.51	3.99
Bentazon 1200g/ha	34.79	621.64	10.96	58.25	4.09
Bentazon 1600g/ha	42.97	742.83	10.97	58.81	5.35
Bentazon 1800g/ha	38.26	710.41	10.94	57.76	4.93
Bentazon 2000g/ha	37.86	637.54	10.94	57.71	4.92
2,4-D380g/ha	35.53	628.29	10.95	57.97	4.63
Handweeding(20&40DAS)	46.77	762.34	10.97	59.10	6.16
Weedy check	26.41	372.45	9.91	54.60	2.89
SEm±	0.28	7.58	0.78	0.14	0.15
CDat5%	0.83	21.77	NS	0.52	0.48

3.3 Weed index (%)

The greatest yield reduction (53.1005%) was observed in the weedy check plots, where weeds were present throughout the crop season (Figure 1). In contrast, the application of Bentazon at 1600 g/ha reduced yield loss to just 13.22%. This significant reduction in yield loss is attributed to the effective control of weeds, which minimized weed stress during the critical period of crop growth. Similar findings have been reported by [32;33].

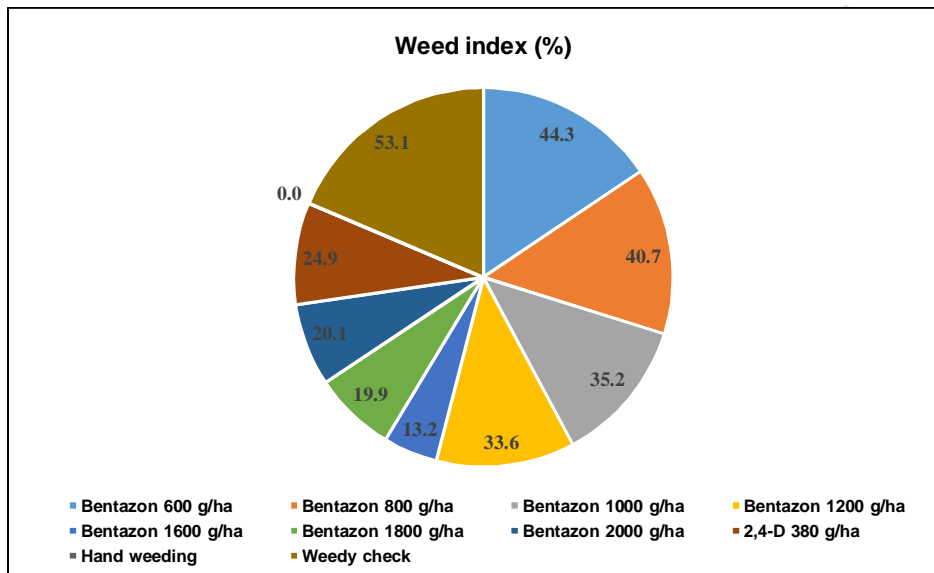


Figure 1. Weed index (%) as influenced by different weed control treatments

4. CONCLUSION

In conclusion, Bentazon at 1600 g/ha proved to be the most effective weed control treatment for direct-seeded rice, achieving the lowest weed index. Bentazon at 1600 g/ha successfully controlled broadleaf weeds and increased rice grain yield but it was not effective in controlling grasses and sedges. However, higher doses of Bentazon showed slight phytotoxicity to the rice crop.

REFERENCES

1. Shukla, S., Agrawal, S. B., Verma, B., Anjna, M., & Ansari, T. 2022. Evaluation of Different doses and Modes of Application of Ferrous Ammonium Sulfate for Maximizing Rice Production. International Journal of Plant & Soil Science, 34(23), 1012-1018.
2. Toppo Oscar, Kewat ML, Jha AK, Yadav PS and Verma B. 2023. Effect of Sowing time and weed management practices on weed dynamics, productivity and economics of direct-seeded rice. Eco. Env. & Cons. 29 (3): 80-85.

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3. Anonymous. 2016. Annual Report. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Govt. of India, New Delhi.
4. VermaBadal, Bhan Manish, Jha AK, PorwalMuskan and Patel Raghav. 2023. Assessment of different herbicides for effective weed management in direct seeded rice technology. *Ecology, Environment and Conservation Journal*. 29 (3): 211-217.
5. Bhalse, L., Jha, A., Verma, B., Raghuvamshi, S., Porwal, M., &Sahu, M. (2023). Efficacy of pyoxasulfone and its combinations against weeds in wheat (*Triticumaestivum*). *Indian Journal of Agronomy*, 68(4), 443-446.
6. Sairam, G., Jha, A. K., Verma, B., Porwal, M., Dubey, A., &Meshram, R. K. (2023). Effect of mesotrione 40% SC on weed growth, yield and economics of maize (*Zea mays L.*). *International Journal of Environment and Climate Change*, 13(7), 608-616.
7. Tanisha Nirala, Jha AK, BadalVerma, Pushpendra Singh Yadav, MahendraAnjna, LakhanBhalse. Bio efficacy of pinoxaden on weed flora and yield of wheat (*Triticumaestivum L.*). *Biological Forum – An International Journal*. 2022; 14(4):558-561.
8. Porwal, M., Kantwa, S. R., Singh, S. S., Govindasamy, P., Verma, B., &Ramakrishnan, S. (2024). Effect of intercropping and zinc management on weed density and fodder yield in oats. *Range Management and Agroforestry*, 45(01), 171-174.
9. VermaBadal, Bhan Manish, Jha AK, Singh Vikash, Patel Rajendra, Sahu MP and Kumar Vijay. 2022. Weed management in direct-seeded rice through herbicidal mixtures under diverse agroecosystems. *AMA, Agricultural Mechanization in Asia, Africa and Latin America*. 53(4): 7299-7306.
10. Raghav, P., Jha, A. K., Badal, V., Rahul, K., &Richa, S. (2023). Bioefficacy of pinoxaden as post-emergence herbicide against weeds in wheat crop. *Pollution research*, 42(1), 115-117.
11. Swati, S., Agrawal, S. B., Badal, V., Singh, Y. P., Richa, S., Muskan, P., ...&Raghav, P. (2023). Weed dynamics and productivity of chickpea as affected by weed management practices. *Pollution Research*, 42(2), 21-24.
12. Tomar, D. S., Jha, A. K., Verma, B., Meshram, R. K., Porwal, M., Chouhan, M., &Rajpoot, A. (2023). Comparative Efficacy of Different Herbicidal Combinations on Weed Growth and Yield Attributes of Wheat. *International Journal of Environment and Climate Change*, 13(8), 889-898.
13. VermaBadal, Bhan Manish, Jha AK and PorwalMuskan. 2023. Influence of weed management practices on direct-seeded rice grown under rainfed and irrigated agroecosystems. *Environment Conservation Journal*. 24 (3): 240-248.
14. Pahade, S., Jha, A. K., Verma, B., Meshram, R. K., Toppo, O., &Shrivastava, A. (2023). Efficacy of sulfentrazone 39.6% and pendimethalin as a pre emergence application against weed spectrum of soybean (*Glycine max L. Merrill*). *International Journal of Plant & Soil Science*, 35(12), 51-58.
15. Sahu, V., Kewat, M. L., Verma, B., Singh, R., Jha, A. K., Sahu, M. P., &Porwal, M. (2023). Effect of carfentrazone-ethyl on weed flora, growth and productivity in wheat. *The Pharma Innovation Journal*, 12(3), 3621-3624.
16. Patel, R., Jha, A. K., Verma, B., Porwal, M., Toppo, O., &Raghuvamshi, S. (2023). Performance of pinoxaden herbicide against complex weed flora in wheat (*Triticumaestivum L.*). *International Journal of Environment and Climate Change*, 13(7), 339-345.
17. Tomar, D. S., Jha, A. K., Porwal, M., Verma, B., Tirkey, S., Khare, Y., ...&Chouhan, M. (2023). Efficacy of Halauxifen-methyl+ Florasulam against Complex Weeds in Wheat under Kymore Plateau and Satpura Hill Zone of Madhya Pradesh, India. *International Journal of Plant & Soil Science*, 35(15), 161-171.
18. Sairam, G., Jha, A. K., Verma, B., Porwal, M., Sahu, M. P., &Meshram, R. K. (2023). Effect of pre and post-emergence herbicides on weed flora of maize. *International Journal of Plant & Soil Science*, 35(11), 68-76.

19. VermaBadal, Bhan Manish, Jha AK, KhatoonShahiba, Raghuwanshi Monika, BhayalLalita, Sahu MP, Patel Rajendra and Singh Vikash. 2022. Weeds of direct-seeded rice influenced by herbicide mixture. *Pharma Innovation* 11(2):1080-1082.
20. Tiwari BK and Mathew R. 2002. Influence of post emergence herbicides on growth and yield of soybean. *JNKVV Research Journal* 36 (1/2): 17-21.
21. Christopher LT, Blouin DC, Webster EP. 2005. Fenoxaprop interactions for barnyardgrass (*Echinochloa crus-galli*) control in rice. *Weed Technol.* 19,293e297
22. Rahman M, Juraimi AS, Suria J, Azmi B, Manand AP. 2012. Response of weed flora to different herbicides in aerobic rice system. *Scientific Research and Essays*, 9 January 2012, 7(1):12-23.
23. Rekha KB, Raju MS and Reddy MD. 2002. Effect of herbicides in transplanted rice. *Indian Journal of Agronomy*. 24(1/2): 123 - 125.
24. Singh AP, Singh AK, Chaturvedi S, Singh S and Mishra OP. 2012. Bio - Efficacy of sulfonylurea herbicides on mixed weed flora in transplanted rice. *Indian Journal of Agricultural Research* 46 (1): 9 – 15.
25. Chauhan BS and Opena J. 2013. Weed management and grain yield of rice sown at low seeding rates in mechanized dry-seeded systems. *Journal of Field Crops Research* 141:9 – 15.
26. Kumhar, B. L., Agrawal, K. K., Jha, A. K., Rai, H. K., Kumar, V., Choudhary, M., & Kantwa, S. R. (2022). Productivity and economical viability of grass-based cropping systems. *Range Management and Agroforestry*, 43(1), 167-171.
27. VermaBadal, Bhan Manish, Jha AK, Agrawal KK, Kewat ML and PorwalMuskan. 2023. Weed management in direct-seeded rice (*Oryza sativa*) in central India. *Indian Journal of Agronomy*. 68 (2): 217-220.
28. Chandra S and Solanki OS. 2003. Herbicidal effect on yield attributing characters of rice in direct seeded puddled rice. *Agricultural Science Digest* 23(1): 75-76.
29. Ameta, H. K., Ranjan, J. K., Kakani, R. K., Mehta, R. S., Solanki, R. K., Panwar, A., & Kumhar, B. L. (2016). Genetic variability studies in Coriander (*Coriandrum sativum* L.). *International Journal of Seed Spices*, 6, 103-105.
30. Chauhan BS and Opena J. 2013. Weed management and grain yield of rice sown at low seeding rates in mechanized dry-seeded systems. *Journal of Field Crops Research* 141:9 – 15.
31. Kumar RS, Durairaj SN, Daisy M and Archana HA. 2014. Studies on weed management practices in transplanted rice. *Trends in Biosciences* 7(23): 3882-3885.
32. Mahajan G, Chauhan BS, Johnson DE. 2009. Weed management in aerobic rice in northwestern Indo-Gangetic Plains. *J. Crop Improv.* 4, 366e382.
33. Ahmed S, Muhammad S and Chauhan BS. 2014. Effect of Weed Management and Seed Rate on Crop Growth under Direct Dry Seeded Rice Systems in Bangladesh. *PLoS One*. 2014; 9(7): e101919.