EVALUATION OF POST-EMERGENCE HERBICIDE COMBINATIONS FOR WEED CONTROL, EFFICIENCY, WEED INDEX, AND YIELD IN DIRECT-SEEDED RICE (ORYZA SATIVA L.)

[1]Ravikesh Kumar Pal, [2]Ashish Srivastava, [3]Raghvendra Singh, [4]Mandeep Kumar and [5]Kartikay Bisen

Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur-209217,

Corresponding author: drravikesh.fas@ramauniversity.ac.in

Abstarct

Direct-seeded rice (DSR) has gained popularity as a cost-effective and labor-saving alternative to traditional transplanting methods. However, weeds pose a significant challenge to DSR productivity. A field experiment was conducted in a Randomized Block Design (RBD) with three replications to evaluate the efficacy of post-emergence herbicides and to assess their impact on weed control, yield, and economic returns. The study comprised ten treatments: T_1: Chlorimuron Ethyl 25% WP @ 37.05 g a.i./ha (PoE), T_2: Bispyribac sodium 20% + pyrazosulfuron 15% WDG @ 52.50 g a.i./ha + Spreadmax @ 0.5 ml/litre (PoE), T_3: Bispyribac sodium 20% + pyrazosulfuron 15% WDG @ 61.25 g a.i./ha + Spreadmax @ 0.5 ml/litre (PoE), T_4: Bispyribac sodium 10% SC @ 25 ml a.i./ha (PoE), T_5: Pyrazosulfuron 10% WP @ 215 g a.i./ha (PoE), T_6: Triafamone 20% + ethoxysulfuron 10% WG @ 66.5 g a.i./ha (PoE), T_7: Penoxsulam 1.02% + cyhalofop-butyl 5.1% OD @ 135 ml a.i./ha (PoE), T_8: Fenoxoprop (PE) fb Halosulfuron (56 fb 67 ml a.i./ha) (PoE), T_9: Hand weeding (20 and 40 DAS), and T_{10}: Untreated control. Among the treatments, T_3 (Bispyribac sodium 20% + pyrazosulfuron 15% WDG @ 61.25 g a.i./ha + Spreadmax @ 0.5 ml/litre) demonstrated superior weed control, enhanced growth parameters, and significantly improved yield, performing on par with T_2 (Bispyribac sodium 20% + pyrazosulfuron 15% WDG @ 52.50 g a.i./ha + Spreadmax @ 0.5 ml/litre). Additionally, T_7 (Penoxsulam 1.02% + cyhalofop-butyl 5.1% OD @ 135 ml a.i./ha) effectively managed Paspalum monspeliensis. The findings emphasize the importance of selecting appropriate herbicides and tailored weed management strategies based on local weed flora and farming conditions for optimizing DSR productivity.

Keywords:- DSR, Herbicide, RBD etc

Introduction

Rice (Oryza sativa L.) is the most widely cultivated cereal crop and serves as the primary source of nutrition for over half of the global population. Globally, rice production stands at 506.23 million tonnes from 163.26 million hectares, with a productivity rate of 3.10 tonnes per hectare (USDA, 2022-23). Asia dominates global rice production and consumption, accounting for approximately 90% of total production (FAO, 2014). It provides two-thirds of the daily calorie intake for Asian populations (Anonymous, 2017) and plays a critical role in global food security by supplying over 20% of calorie intake for more than half of the world's population (Fukagawa et al., 2019). Rice belongs to the Poaceae family, one of the most diverse groups of angiosperms worldwide (Ghahremaninejad et al., 2021).

As India's population grows and dietary preferences shift, the demand for rice is expected to increase. However, with limited agricultural land, enhancing the sustainability of rice ecosystems while increasing productivity and reducing resource use is imperative. Direct-seeded rice (DSR) has emerged as a labor-saving and cost-effective alternative to conventional transplanting. Unlike traditional methods, where seedlings are raised in nurseries and later transplanted into puddled fields, DSR involves direct seeding into prepared fields. This practice conserves resources, improves labor efficiency, and adapts well to various agroecosystems (Kachroo et al., 2011). Additionally, DSR facilitates early wheat crop establishment (Kachroo et al., 2011). Changes in agricultural practices influence weed prevalence and distribution (Ghahremaninejad et al., 2012). Weeds pose a significant threat to DSR crops (K Rao et al., 2007) by competing for essential resources such as sunlight, water, and nutrients. High weed infestation during the early growth stages of DSR can cause yield losses of up to 90%, making weeds the primary biological constraint in DSR production (Chauhan et al., 2011). The absence of standing water in DSR fields further exacerbates weed pressure, as both crop seedlings and weeds emerge simultaneously, leading to intense competition. The critical period for weed competition ranges from 20 to 50 days after sowing, and inadequate weed control can result in significant yield reductions.

Due to labor shortages and rising wages, chemical weed control is often preferred for its efficiency and cost-effectiveness. Effective weed management in DSR requires a strategic approach, including sequential applications of pre-emergence and post-emergence herbicides. Herbicidal weed management remains the most efficient method to control diverse weed populations in DSR. Post-emergence herbicides play a crucial role in modern weed control strategies, providing selective and timely interventions to manage weed infestations while maintaining crop health. Understanding the specific effects of post-emergence herbicides is vital for optimizing weed management practices in DSR (Saikia et al., 2024; Kumar et al., 2021). This study aims to evaluate the effectiveness of various post-emergence herbicide combinations for weed control, efficiency, weed index, and yield performance in direct-seeded rice. By assessing different herbicide treatments, this research seeks to identify the most effective strategies for managing weeds and enhancing the productivity of DSR systems.

Materials and methods

A field trial was conducted during the kharif season (2021-22) using a randomized block design (RBD) with three replications. The trial included ten treatments: T_1: Chlorimuron Ethyl 25% WP @ 37.05 g a.i./ha (PoE), T_2: Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 52.50 g a.i./ha + Spreadmaxa @ 0.5 ml/litre (PoE), T_3: Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 61.25 g a.i./ha + Spreadmaxa @ 0.5 ml/litre (PoE), T_4: Bispyribac sodium 10% SC @ 25 ml a.i./ha (PoE), T_5: Pyrazosulfuron 10% WP @ 215 g a.i./ha (PoE), T_6: Triafamone 20% + Ethoxysulfuron 10% WG @ 66.5 g a.i./ha (PoE), T_7:

Penoxsulam 1.02% + Cyhalofop-butyl 5.1% OD @ 135 ml a.i./ha (PoE), T_8: Fenoxoprop (PE) fb Halosulfuron @ (56 fb 67) ml a.i./ha (PoE), T_9: Hand weeding (20 and 40 DAS), and T_{10}: untreated control. The herbicide treatments were applied at 1 DAS and 20 DAS as pre-emergence and post-emergence applications, respectively.

The crop, direct-seeded on July 25, 2022, was of rice variety NDR-2064. A recommended dose of N, P, K, and Zn at 120:60:40:25 kg/ha was applied using fertilizers such as urea, diammonium phosphate, and muriate of potash. Post-emergence herbicides were sprayed 14 days after sowing using a knapsack sprayer. Rice plant biomass was measured by uprooting plants from a running meter of length and oven-drying them. Weed density and biomass were assessed using a $1m^2$ quadrat at two random locations per plot. Grain yield was recorded at 14% moisture content. Statistical analysis was performed using the Analysis of Variance (ANOVA) method as described by Gomez and Gomez (1984).This study aims to evaluate the effectiveness of various post-emergence herbicide combinations for weed control, efficiency, weed index, and yield performance in direct-seeded rice. By assessing different herbicide treatments, this research seeks to identify the most effective strategies for managing weeds and enhancing the productivity of DSR systems.

Result and discussion

The density of weed species and total weed population at all stages of plant growth were significantly influenced by different weed control strategies (Table 1). Among various weed management techniques, hand weeding resulted in zero weed density. Regarding herbicidal treatments, the sequential application of Fenoxaprop (PE) followed by Halosulfuron @ (56 fb 67) ml a.i./ha (PoE) significantly reduced weed density at 30 DAS and 60 DAS compared to other herbicide treatments. Additionally, Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 61.25 g a.i./ha + Spreadmaxa @ 0.5 ml/litre-1 (PoE) recorded lower weed density at 60, 90 DAS, and harvest stage, followed by Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 52.50 g a.i./ha + Spreadmaxa @ 0.5 ml/litre-1 (PoE) and Triafamone 20% + Ethoxysulfuron 10% WG @ 66.5 g a.i./ha (PoE). The lowest and highest weed densities were recorded in hand weeding (20 and 40 DAS) and untreated control plots, respectively. Similar findings were reported by Walia et al. (2012), Kumar and Singh (2016), and Saphi et al. (2018).

Data presented in Table 1 show that the highest weed control efficiency at 60 DAS was recorded for treatment T3: Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 61.25 g a.i./ha + Spreadmaxa @ 0.5 ml/litre-1 (PoE) (89.26%), followed by T2: Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 52.50 g a.i./ha + Spreadmaxa @ 0.5 ml/litre-1 (PoE) (77.74%), Fenoxaprop (PE) followed by Halosulfuron @ (56 fb 67) ml a.i./ha (PoE) (75.93%), and Penoxsulam 1.02% + Cyhalofop-butyl 5.1% OD @ 135 ml a.i./ha (PoE) (74.44%). A similar trend was observed at 90 DAS and at harvest. The highest weed control efficiency was recorded with T3 (85.82%), followed by T2 (80.60%), while at harvest, T3 (87.51%) and T2 (81.49%) were comparable to the hand weeding (20 and 40 DAS) treatment, which achieved 100% weed control at 30 and 60 DAS, and 94.28% at harvest.

This was due to the effective weed suppression in these treatments, leading to lower weed dry matter accumulation. These findings align with the research of Kaur et al. (2015) and Yadav et al. (2014).

Data in Table 2 further illustrate that different weed management strategies significantly influenced grain yield, straw yield, and total biological yield. The crop maintained with hand weeding (20 and 40 DAS) up to 60 DAS (T9) was statistically at par with T3 and T2 but produced the highest grain yield (60.10 q ha^{-1}), straw yield (80.96 q ha^{-1}), and total biological yield (141.06 q ha^{-1}) compared to other treatments. Among herbicidal treatments, Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 61.25 g a.i./ha + Spreadmaxa @ 0.5 ml/litre-1 (PoE) was at par with T2, T7, and T6 but significantly outperformed other treatments in terms of grain, straw, and total biological yield. The untreated control recorded the lowest grain yield (39.20 q ha^{-1}), straw yield (58.06 q ha^{-1}), and total biological yield (97.25 q ha^{-1}).

Table 2 data further revealed that weed management treatments did not significantly affect the harvest index. However, the highest harvest index (42.62%) was observed in the hand-weeding (20 and 40 DAS) treatment, followed by T3, T2, T6, T7, T5, and T1. The lowest harvest index (40.30%) was recorded in the untreated control. Similar trends were reported by Sharma et al. (2014), Gaire et al. (2019), Saikia et al. (2024), and Kumar et al. (2021).

The grain yield of the crop is influenced by nutrient availability, which in turn is affected by weed control efficiency. Effective weed management reduces crop-weed competition, ensuring better nutrient availability and improved yield attributes. In this study, hand weeding (20 and 40 DAS) up to 60 DAS resulted in lower weed density and weed dry weight, leading to enhanced nutrient availability for the crop, which ultimately improved growth, yield attributes, and overall yield. Among herbicide treatments, the application of Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 61.25 g a.i./ha + Spreadmaxa @ 0.5 ml/litre-1 (PoE) (T3) effectively controlled both narrow- and broad-leaved weeds, ensuring better nutrient uptake, enhanced crop growth, and improved yield attributes, whereas the untreated control experienced intense crop-weed competition, resulting in poor growth and lower yields. These findings are consistent with those reported by Walia et al. (2012), Kumar and Singh (2016), and Gaire et al. (2019).

Conclusion

The study demonstrates that effective weed management strategies significantly impact weed density, weed control efficiency, and crop yield in direct-seeded rice. Among the various treatments, hand weeding at 20 and 40 DAS achieved the highest weed control efficiency, leading to the lowest weed density and maximum grain yield. However, among herbicidal treatments, the application of Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 61.25 g a.i./ha + Spreadmaxa @ 0.5 ml/litre (PoE) provided the best weed suppression and yield performance, closely followed by Bispyribac sodium 20% + Pyrazosulfuron 15% WDG @ 52.50 g a.i./ha + Spreadmaxa @ 0.5 ml/litre (PoE) and Fenoxaprop (PE) followed by Halosulfuron @ (56 fb 67) ml a.i./ha (PoE). These findings highlight the importance of selecting appropriate herbicide combinations to manage weed infestations efficiently while optimizing rice yield. The study confirms that integrating chemical weed control with manual interventions can improve productivity and sustainability in DSR systems. Future research should explore long-term impacts of herbicide applications on soil health and weed resistance development, ensuring continued effectiveness of weed management strategies in rice cultivation.

IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research Paper , UGC CARE Listed (Group -I) Journal Volume 12, Iss 07, 2023

Table-1 Weeds Density(No./m^2), Weedcontrolefficiency % and Weedindex % asaffectedbyvariousWeed management practices at different growth stages of crop growth in direct seededrice.

Treatment		Density of weeds (No./m2) 90 DAS	Weed control efficiency % 60 DAS	Weed index %
T1	Chlorimuron Ethyl 25% WP @ 37.05 g a.i./ha (PoE)	6.75 (45.2)	74.07	23.54
T2	Bispyribac sodium 20% + pyrazosulfuron 15% WDG @ 52.50 g a.i./ ha+ Spreadmaxa@ 0.5 ml litre-1(PoE)	4.82 (22.7)	77.74	6.96
T3	Bispyribac sodium 20% + pyrazosulfuron 15% WDG @ 61.25 g a.i./ ha+ Spreadmaxa @ 0.5 ml litre-1(PoE)	4.55 (20.2)	89.26	4.35
T4	Bispyribac sodium 10% SC @ 25 ml a.i./ha (PoE)	5.13 (25.9)	64.07	16.52
T5	Pyrazosulfuron 10% WP@ 215g a.i./ha (PoE)	5.42 (29)	62.96	20.00
T6	Triafamone 20% + ethoxysulfuron10% WG @ 66.5 g a.i./ha (PoE)	5.2 (25.2)	72.59	14.26
T7	Penoxsulam 1.02% + cyhalofop-butyl 5.1% OD @ 135 ml a.i./ha (PoE)	5.21 (26.5)	74.44	9.57
T8	Fenoxoprop (PE) fb Halosulfuron @ (56 fb 67) ml a.i./ha (PoE)	6.83 (46.5)	75.93	12.17
T9	Hand weeding (20 and 40 DAS)	2.79 (7.3)	100.00	0.00
T10	Untreated (Control)	11.92 (142)	0	34.78

IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research Paper , UGC CARE Listed (Group -I) Journal Volume 12, Iss 07, 2023

SEm±	0.24	4.56	0.72
CD at 5%	0.72	13.69	9.61

Dataweresubjectedtosquareroot(√×+0.5)transformation;figuresinparenthesesareoriginalvalue

Table-2Grain yield,strawyield,biologicalyield,andharvest indexasaffectedbyvariousWeed management practicesat different stagesin direct seededrice

Treatment		Grain yield (q ha-1)	Straw yield (q ha-1)	Biological yield (q ha-1)	Harvest index (%)
T1	Chlorimuron Ethyl 25% WP @ 37.05 g a.i./ha (PoE)	47.39	68.83	116.23	42.06
T2	Bispyribac sodium 20% + pyrazosulfuron 15% WDG @ 52.50 g a.i./ ha+ Spreadmaxa@ 0.5 ml litre-1(PoE)	57.68	79.00	136.67	43.53
T3	Bispyribac sodium 20% + pyrazosulfuron 15% WDG @ 61.25 g a.i./ ha+ Spreadmaxa @ 0.5 ml litre-1(PoE)	59.30	80.56	139.86	43.73
T4	Bispyribac sodium 10% SC @ 25 ml a.i./ha (PoE)	51.75	72.62	124.37	42.92
T5	Pyrazosulfuron 10% WP@ 215g a.i./ha (PoE)	49.59	70.18	119.77	42.71
T6	Triafamone 20% + ethoxysulfuron10% WG @ 66.5 g a.i./ha (PoE)	53.15	73.86	127.01	43.16
T7	Penoxsulam 1.02% + cyhalofop-butyl 5.1% OD @ 135 ml a.i./ha (PoE)	56.06	77.08	133.14	43.43
T8	Fenoxoprop (PE) fb Halosulfuron @ (56 fb 67) ml a.i./ha (PoE)	54.44	75.81	130.25	43.11
T9	Hand weeding (20 and 40 DAS)	61.99	83.50	145.49	43.96

ISSN PRINT 2319 1775 Online 2320 7876
Research Paper **© 2012 IJFANS. All Rights Reserved**, UGC CARE Listed (Group -I) Journal Volume 12, Iss 07, 2023

T10	Untreated (Control)	40.43	59.88	100.30	41.57
SEm±		2.37	3.02	4.60	1.95
CD at 5%		7.19	9.15	13.93	NS

Reference

Anonymous (2017). Annual Research Report, Ministry of Agriculture& FarmersWelfare,GovernmentofIndia, Krishi Bhawan, New Delhi, pp 2.

Available:http://dx.doi.org/10.37273/chesci.cs205107020.
Chauhan BS, Johnson DE. Row spacing and weed control timing affect yield of aerobic rice. Field Crops Research. 2011;121(2):226-231.

DOI:10.3390/agronomy10091264
FAO (2014). FAOSTAT Database.Available from: Food and Agriculture Organization of the United Nations,Rome, http://faostat.fao.org/.

Fukagawa NK, Ziska LH. Rice: Importance for global nutrition.Journal of Nutritional Science and Vitaminology. 2019;65 (Supplement):S2-S3.

Fukagawa NK, Ziska LH. Rice: Importance for global nutrition.Journal of Nutritional Science and Vitaminology. 2019;65 (Supplement):S2-S3.

Gaire, A.,Amgain,L. P., &Gautam, D.V.(2019).Chemical weed control of dry direct-seeded rice under zero tillage in central mid-hill region of Nepal. Indian Journal of Weed Science, 51(3): 290-294.

Ghahremaninejad F, Hoseini E, Jalali S. The cultivation and domestication of wheat and barley in Iran, brief review of a long history.TheBotanicalReview.2021;87 (1):1-22.

Ghahremaninejad F, Hoseini E, Jalali S. The cultivation and domestication of wheat and barley in Iran, brief review of a long history.TheBotanicalReview.2021;87 (1):1-22.

Ghahremaninejad F, Shabkhiz R, Fereidounfar S. A floristic study on the weeds of wheat fields of Zanjan province, Iran.Pakistan Journal of Weed Science Research. 2012;18(3).

Kachroo D, Bazaya BR. Efficacy ofdifferent herbicides on growth and yield of direct wet seeded rice sown through drum seeder. Indian Journal of Weed Science. 2011;43(1 & 2):67-69

Kaur, simerjeet. and Singh, Surjit. 2015. Bio-efficacy of different herbicides for weedcontrolindirect-seededrice.IndianJ.WeedSci.47(2):106-109.

Khaliq A, Matloob A.Weed crop competition period in three fine rice cultivars under DSR culture. Pakistan Weed Science Research. 2011;17:229- 243.

KumarA,SinghRK,SinghJK,Aakash KumariS,ChandelSKS,JyothsnaK, SolankiA.EffectofCropEstablishment MethodsandIrrigationSchedulingon Growth and SoilNutrient Status of Wheat.Current Journal of Applied Science and Technology. 2023;42(47):32–42. Available:https://doi.org/10.9734/cjast/2023

Kumar, A., Kumar, S., Ashrafi, M.R., Raj, P., Pal, R.K. and Dutta, S.K. (2021). Performance of Chemical Herbicides on Weed Dynamics and Economics of Direct Seeded Rice. Biological Forum – An International Journal, 13(3a): 427-432.

Kumar, S., & Singh, R. K. (2016). Interaction effect of nitrogen schedule and weed management on yield of direct-seeded rice. Indian Journal of Weed Science, 48(4):372-377.

Pal R.K., Singh A. K., Kumar Arun, Kumar Pravesh, Hari Om (2024) Effect of Sowing Direction and Wheat Cultivars on Growth and Yield in Indo-Gangetic Plains of India Environment and Ecology 42 (2A) : 681—686,DOI: https://doi.org/10.60151/envec/JKRM9819 ISSN 0970-0420.

Pal, R. K., Maurya, D. K., Kumar, S., & Singh, R. (2023). Assessing the Influence of Nano Urea on the Growth and Yield of Irrigated Wheat (Triticum aestivum L.) Crop. International Journal of Environment and Climate Change, 13(12), 843-851.

Rai N, Choudhary SK, Athnere S, Aakash, Jamodkar V. Effect of herbicides on weed control measures of cotton crop. Chemical Science Review and Letters. 2021;10(37): 135-140.

Rao AN, Johnson DE, Sivaprasad B,Ladha JK, Mortimer AM. Weed management in direct seededed rice. Advances in agronomy. 2007;93:153-255.

Saikia, N., Singh, M. K., Lakshmi, D. U., Nithinkumar, K., Bagrecha, S., Biswakarma, N., ... & Kumar, V. (2024). Performance of Post-Emergence Herbicide Combinations on Weed Management and Crop Yield in Direct Seeded Rice (Oryza sativa L.). International Journal of Environment and Climate Change, 14(1), 91-96.

Saphi,D.K.,Yadav,D.R.,YadavR.K.,&Yadav,R.(2018). Yield and yield attributing characters of promisingrice genotypes under dry direct seeded conditions as affected by varieties and weed control methods. International Journal of Applied Sciences and Biotechnology, 6(4): 313-318.

Sharma, A. R., &Singh, V. P. (2014). Integrated weed management in conservation agriculture systems. Indian Journal of Weed Science, 46(1): 23-30.

ShekhawatK,RathoreSS,Chauhan BS.Weed management in dry direct- seeded rice: A review on challenges and opportunities for sustainable rice production. Agronomy. 2022;10:1264.

United State Department of Agriculture. World agricultural Production, 2020-21.

Walia, U. S., Walia, S. S., Sidhu A. S., & Nayyar, S. (2012). Bioefficacy of pre-and post-emergence herbicides in direct-seededrice inCentralPunjab. IndianJournal of Weed Science, 44(1): 30-33.

Yadav, R.I. singh, M.K. and Singh, R.K. 2014. Integrated weed management and cropestablishment method for higher yield in direct-seeded rice. Indian J. of Weed Sci. 46(2):166-168.