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Yield Attributes and Estimated Yield of Transplanted Hybrid Rice (*Oryza sativa*) as Affected by Nutrient and Weed Management Practices

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Abstract

During the *kharif* season of 2022–2023, a field experiment was carried out at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj. The yield attributes and yield of rice were significantly influenced by different nutrient and weed management practices. The number of panicles per unit area, which directly contributes to yield, was highest in 50% RDF + 50% vermicompost + two hand weedings (290.7 m^{-2}). The number of grains per panicle was found maximum in treatment 50% RDF + 50% FYM + two hand weedings (153.9), whereas the minimum was observed in 50% RDF + 50% FYM + weedy check. This indicates that FYM-based treatments also contributed to better grain filling. The test weight was highest in 50% RDF + 50% FYM + two hand weedings (22.8 g), suggesting improved grain development under FYM-based nutrient management. The grain yield, being the ultimate economic produce, was significantly influenced by treatments. The highest grain yield (5949 kg/ha) was recorded in 50% RDF + 50% vermicompost + two hand weedings, whereas the lowest yield (3657 kg/ha) was recorded in 50% RDF + 50% FYM + weedy check. The maximum estimated yield was recorded in treatment T_5 (50% RDF + 50% vermicompost + two hand weedings) with a value of 9719 kg/ha. The yield gap, defined as the difference between potential yield and actual realized yield, was also found to be highest in treatment 50% RDF + 50% vermicompost + two hand weedings (3811 kg/ha). On the other hand, the 50% RDF + 50% FYM + weedy check recorded comparatively lower estimated yield and yield gap due to poor crop performance.

***Key words*:** Rice, Yield validation, Yield gap, Actual yield, Estimated yield

The production of rice plays a very important part in our national economy. To ensure food security and meet future food needs, it is necessary that India attains at least 3% growth annually in rice productivity. Rice is a very important staple food in Asia and the Pacific region where more than 90% of the world's rice is produced and consumed. More than 161 million ha in over 100 countries in the world rice is one of the major food crops which are grown. More than 45 million ha of land is used for cultivation of rice in India where the average productivity is about 2.4 t/ha and the production is estimated to be about 121.46 MT [1]. Rice is a very important basic food for over two thirds of the population in India. The expression "rice is life" has more relevance since it forms one of the main sources of livelihood for millions of farmers and forms a very important part in ensuring the food security of our nation. In Asia, rice and its products provide 60-70% of the energy needs of over two billion people. As per studies conducted in Asia, losses due to weed interference in transplanted paddy were 50% and 12% of the total loss of crop yield was caused by the weeds only. Weeds pose a threat to crops by altering soil pH, reducing nutrient availability, which in turn decreases straw yield by 13-38% and grain yield by 25-47% [2]. It contributes substantially to food security, nutritional well-being, and rural livelihoods, particularly across Asia where nearly 90% of global rice is produced and consumed. With increasing population pressure, shrinking arable land, labour scarcity, and climate-induced production challenges, improving rice productivity through sustainable crop management has become a major research priority. Hybrid rice technology has emerged as an effective approach to enhance yield potential by exploiting heterosis, offering a yield advantage of approximately 15-25% over conventional high-yielding varieties when supported with appropriate agronomic management [3]. Among the various agronomic interventions, integrated nutrient management (INM) plays a pivotal role in sustaining rice productivity while maintaining soil fertility. Excessive dependence on chemical fertilizers has resulted in declining nutrient use efficiency, deterioration of soil physical and biological properties, and increased environmental concerns. Consequently, the integration of inorganic fertilizers with organic nutrient sources such as farmyard manure (FYM) and vermicompost has gained considerable importance. Organic manures improve soil

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structure, enhance microbial activity, increase nutrient availability, and promote balanced crop nutrition, thereby improving yield attributes, grain yield, and nutrient use efficiency in transplanted rice. Recent studies have demonstrated that combining recommended fertilizer doses with organic amendments significantly enhances panicle production, grain filling, test weight, and overall productivity compared with the sole application of chemical fertilizers [4].

Weed infestation remains another major constraint limiting rice productivity, particularly during the first 30–45 days after transplanting, which represents the critical period of crop–weed competition. Uncontrolled weeds compete aggressively for nutrients, moisture, light, and space, often causing yield losses ranging from 20% to more than 50%, depending on weed flora and management practices. Although manual weeding is highly effective, it is becoming increasingly expensive and impractical because of labour shortages during peak agricultural operations. Consequently, selective post-emergence herbicides such as triafamone + ethoxysulfuron and cyhalofop-butyl + penoxsulam have emerged as efficient alternatives, providing broad-spectrum weed control with reduced labour requirements. Integration of chemical weed control with cultural practices has been shown to improve weed control efficiency, nutrient availability, crop growth, and grain yield in transplanted rice [5]. The interaction between nutrient management and weed control is of particular importance because improved nutrient availability enhances crop vigour, whereas effective weed management ensures that these nutrients are utilized by the crop rather than by competing weeds. Integrated nutrient and weed management practices therefore complement each other by improving yield-contributing characters such as panicle density, grains per panicle, and test weight, ultimately increasing grain and straw yields. Furthermore, integrated management practices contribute to sustainable rice production through improved nutrient use efficiency, reduced environmental risks, and enhanced soil health [6]. Despite substantial progress in hybrid rice cultivation, information on the combined influence of integrated nutrient sources and modern post-emergence herbicides on yield attributes and estimated yield under transplanted hybrid rice ecosystems remains limited. Evaluating these interactions is essential for developing economically viable and environmentally sustainable production strategies. Therefore, the present investigation was undertaken to evaluate the effect of different integrated nutrient management practices in combination with weed management options on yield attributes, grain yield, straw yield, estimated yield, and yield gap of transplanted hybrid rice under irrigated conditions.

MATERIALS AND METHODS

The field experiment was conducted during Kharif season of 2022-2023 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.), which is located at 25024' 42" N latitude, 810 50' 56" E longitude and 98 m altitude above the mean sea level. The location of this place is on the right side of the river Yamuna by the side of Prayagraj Rewa Road about 5 km from Prayagraj city. The experimental site was sandy clay loam in texture, having 0.36% organic carbon, neutral in reaction (pH 7.1), low in available N (171.48 kg ha^{-1}), low in available P (15.2 kg ha^{-1}) and medium in available K (142.5 kg ha^{-1}). The experiment was laid out in a randomized block design with three replications. The plot size was 4×3 m. A set of twelve treatments comprising of T_1- 50% RDF + 50% Vermicompost + Bensulfuron methyl + pretilachlor, T_2- 50% RDF + 50% Vermicompost + Cyhalofop butyl + penoxsulam, T_3- 50% RDF + 50% Vermicompost + Triafamone + ethoxysulfuron, T_4- 50% RDF + 50% vermicompost + chlorimuron-ethyl + metsulfuron-methyl, T_5- 50% RDF + 50% vermicompost + two hand weedings, T_6- 50% RDF + 50% vermicompost + weedy check, T_7- 50% RDF + 50% FYM + bensulfuron methyl + pretilachlor, T_8- 50% RDF + 50% FYM + cyhalofop butyl + penoxsulam, T_9- 50% RDF + 50% FYM + triafamone + ethoxysulfuron, T_{10}- 50% RDF + 50% FYM + chlorimuron-ethyl + metsulfuron-methyl, T_{11}- 50% RDF + 50% FYM + two hand weedings, T_{12}- 50% RDF + 50% FYM + weedy check. Rice hybrid Arize 6444 sown with a spacing of 20×10 cm. Crop was fertilized with 120:60:60 kg NPK ha^{-1} through urea, single super phosphate and muriate of potash respectively.

RESULTS AND DISCUSSION

Number of panicles, number of grains and test weight

Data depicted in (Table 1) indicated that maximum panicle numbers, grain numbers, and test weight were obtained under the treatment of 50% RDF + 50% vermicompost in pooled data of different treatment combinations. After treatment with 50% RDF + 50% vermicompost + triafamone + ethoxysulfuron (280.5/m2), 50% RDF + 50% vermicompost + Cyhalofop butyl + penoxsulam (272.6/m^2) and 50% RDF + 50% FYM + two hand weeding on 20 and 45 DAT (268.6/m^2), minimum number of panicles (178.7/m^2) was recorded in the treatment 50% RDF + 50% FYM + Weedy check. This was because the use of FYM or vermicompost significantly increased panicle numbers m^{-2} in both the years compared to the control [7].

The number of grains per panicle was highest in the treatment of 50% RDF + 50% FYM + hand weedings twice (20 and 45 DAT) (153.9), 50% RDF + 50% vermicompost + cyhalofop butyl + penoxsulam (153.6), 50% RDF + 50% vermicompost + hand weedings twice (20 and 45 DAT) (152.4), and 50% RDF + 50% Vermicompost + Triafamone + ethoxysulfuron (141.3). A keen observation of data showed that 100% recommended NPK fertilizer combined with vermicompost @ 10 t/ha gave significantly high number of grains per panicle than 100% recommended NPK fertilizer alone [8]. The highest value of test weight (g) was found in the treatments of 50% RDF + 50% FYM + hand weedings twice (20 and 45 DAT) (22.8 g), 50% RDF + 50% FYM + chlorimuron-ethyl + metsulfuron-methyl (22.2 g) and 50% RDF + 50% vermicompost + weedy check (20.8 g). As per the results, rice gave better yield and test weight (g) under integrated nutrient sources than inorganic fertilizer alone [9].

Grain yield, straw yield

Data in (Table 2) indicated that in various combinations of treatments, maximum grain yield (t/ha) was obtained for 50% RDF + 50% vermicompost + two hand weedings (on 20 and 45 DAT) i.e. 5.94 t/ha followed by 50% RDF + 50% vermicompost + triafamone + ethoxysulfuron i.e. 5.74 t/ha, 50% RDF + 50% vermicompost + cyhalofop butyl + penoxsulam i.e. 5.57 t/ha and 50% RDF + 50% FYM + two hand weedings (on 20 and 45 DAT) i.e. 5.49 t/ha respectively while minimum grain yield (t/ha) for 50% RDF + 50% FYM + Weedy check i.e. 3.65 t/ha. Similarly, Kundu [10] mentioned that the combination of different nutrient sources for plants (e.g. FYM, vermicompost, crop residues etc.) plays a significant role in all the yield components and grain yield of rice either as a sole crop or as a component of cropping system involving three or four crops.

Higher straw yield (t/ha) was observed in treatment 50%

RDF + 50% vermicompost + hand weedings @ 20 and 45 DAT (6.86 t/ha) followed by treatment 50% RDF + 50% vermicompost + triafamone + ethoxysulfuron (6.50 t/ha), 50% RDF + 50% FYM + hand weedings @ 20 and 45 DAT (6.48 t/ha) and 50% RDF + 50% vermicompost + cyhalofop butyl + penoxsulam (6.33 t/ha) respectively while lowest straw yield (t/ha) was found in treatment 50% RDF + 50% FYM + weedy check (4.31 t/ha).

Both these treatments were at par with each other but significantly better than other treatments. It is because of the fact that there remained no weeds in the critical phases of crop growth thereby making all the nutrients available to the plants which gave them better growth and dry matter accumulation [11].

Table 1 Effect of nutrient and weed management practices on the yield attributes of transplanted hybrid rice

Treatments	2022			2023			Pooled data		
	No. of panicles m^{-2}	No. of grains per panicle	Test weight (g)	No. of panicles m^{-2}	No. of grains per panicle	Test weight (g)	No. of panicles m^{-2}	No. of grains per panicle	Test weight (g)
50% RDF + 50% vermicompost + Bensulfuron methyl + pretilachlor	237.4	145.4	21.3	242.4	146.9	20.7	239.9	146.2	21.0
50% RDF + 50% vermicompost + Cyhalofop butyl + penoxsulam	265.6	149.7	21.4	279.5	157.6	22.6	272.6	153.6	22.0
50% RDF + 50% Vermicompost + Triafamone + ethoxysulfuron	282.0	152.3	21.5	279.0	149.1	22.4	280.5	150.7	21.9
50% RDF + 50% Vermicompost + Chlorimuron-ethyl + metsulfuron-methyl	202.1	139.9	21.2	195.7	132.6	20.5	198.9	136.2	20.9
50% RDF + 50% Vermicompost + Two hand weedings	298.5	154.8	21.6	282.8	149.9	20.2	290.7	152.4	20.9
50% RDF + 50% Vermicompost + Weedy check	190.4	138.1	21.2	200.4	145.4	20.3	195.4	141.7	20.8
50% RDF + 50% FYM + Bensulfuron methyl + pretilachlor	213.9	141.7	21.3	229.6	147.6	22.0	221.8	144.7	21.6
50% RDF + 50% FYM + Cyhalofop butyl + penoxsulam	218.6	142.5	21.3	223.7	139.5	21.5	221.1	141.0	21.4
50% RDF + 50% FYM + Triafamone + ethoxysulfuron	244.4	146.5	21.4	257.8	140.4	21.2	251.1	143.4	21.3
50% RDF + 50% FYM + Chlorimuron-ethyl + metsulfuron-methyl	195.1	138.8	21.2	193.5	130.1	23.2	194.3	134.4	22.2
50% RDF + 50% FYM + Two hand weedings	272.6	150.8	21.5	264.6	157.1	24.0	268.6	153.9	22.8
50% RDF + 50% FYM + Weedy check	183.3	137.0	21.2	174.1	145.6	23.2	178.7	141.3	22.2
F-Test	S	S	NS	S	S	NS	S	S	NS
SEd	9.55	1.47	0.32	9.34	2.07	0.31	9.36	1.61	0.16
CD (P=0.05)	19.80	3.05	NS	19.37	4.29	NS	19.41	3.33	NS

Table 2 Effect of nutrient and weed management practices on the yield of transplanted hybrid rice

Treatments	2022		2023		Pooled data	
	Grain yield (t/ha)	Straw yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)
50% RDF + 50% vermicompost + Bensulfuron methyl + pretilachlor	4.85	5.49	4.96	5.54	4.90	5.52
50% RDF + 50% vermicompost + Cyhalofop butyl + penoxsulam	5.43	6.17	5.72	6.50	5.57	6.33
50% RDF + 50% Vermicompost + Triafamone + ethoxysulfuron	5.77	6.57	5.71	6.43	5.74	6.50
50% RDF + 50% Vermicompost + Chlorimuron-ethyl + metsulfuron-methyl	4.13	4.63	4.00	4.39	4.07	4.51
50% RDF + 50% Vermicompost + Two hand weedings	6.10	6.97	5.78	6.75	5.94	6.86
50% RDF + 50% Vermicompost + Weedy check	3.09	3.35	3.28	3.66	3.18	3.50
50% RDF + 50% FYM + Bensulfuron methyl + pretilachlor	4.37	4.92	4.69	5.12	4.53	5.02
50% RDF + 50% FYM + Cyhalofop butyl + penoxsulam	4.47	5.03	4.57	4.93	4.52	4.98
50% RDF + 50% FYM + Triafamone + ethoxysulfuron	5.00	5.66	5.27	5.42	5.13	5.54
50% RDF + 50% FYM + Chlorimuron-ethyl + metsulfuron-methyl	3.99	4.46	3.95	4.18	3.97	4.32
50% RDF + 50% FYM + Two hand weedings	5.58	6.34	5.41	6.61	5.49	6.48
50% RDF + 50% FYM + Weedy check	2.95	3.18	2.89	3.55	2.92	3.36
F-Test	S	S	S	S	S	S
SEd	1.95	2.32	1.91	2.34	1.92	2.31
CD (P=0.05)	4.05	4.81	3.96	4.84	3.97	4.79

Estimated yield and Yield gap

The significantly higher estimated yield recorded under 50% RDF + 50% vermicompost + two hand weedings at 20 and 45 DAT (9719 kg ha^{-1}), followed by 50% RDF + 50% vermicompost + triafamone + ethoxysulfuron and 50% RDF + 50% vermicompost + cyhalofop butyl + penoxsulam, may be

attributed to the synergistic effect of integrated nutrient management and effective weed control (Fig 1). Vermicompost, in combination with inorganic fertilizers, ensured a balanced and sustained supply of nutrients, improved soil physical and biological properties, and enhanced nutrient use efficiency, while timely weed management minimized crop–weed competition during the critical growth stages, resulting in better crop growth and higher yield potential. Similar findings have been reported by Davari and Sharma [12], Didawat *et al*. [13], who observed that integrated nutrient management coupled with efficient weed control significantly improved rice productivity. The higher yield gap observed under the superior-performing treatments reflects the substantial difference between the estimated attainable yield and the actual harvested yield, indicating that despite improved management practices, further scope exists to enhance productivity by minimizing biotic and abiotic constraints. Conversely, the lowest estimated yield and yield gap under the weedy check treatment were mainly due to severe weed competition, which reduced nutrient uptake, crop growth, and yield potential [14]. The results demonstrate that integrating 50% RDF with 50% vermicompost and effective weed management, particularly two hand weedings or suitable post-emergence herbicides, is an efficient and sustainable strategy for maximizing the productivity and yield potential of transplanted hybrid rice.

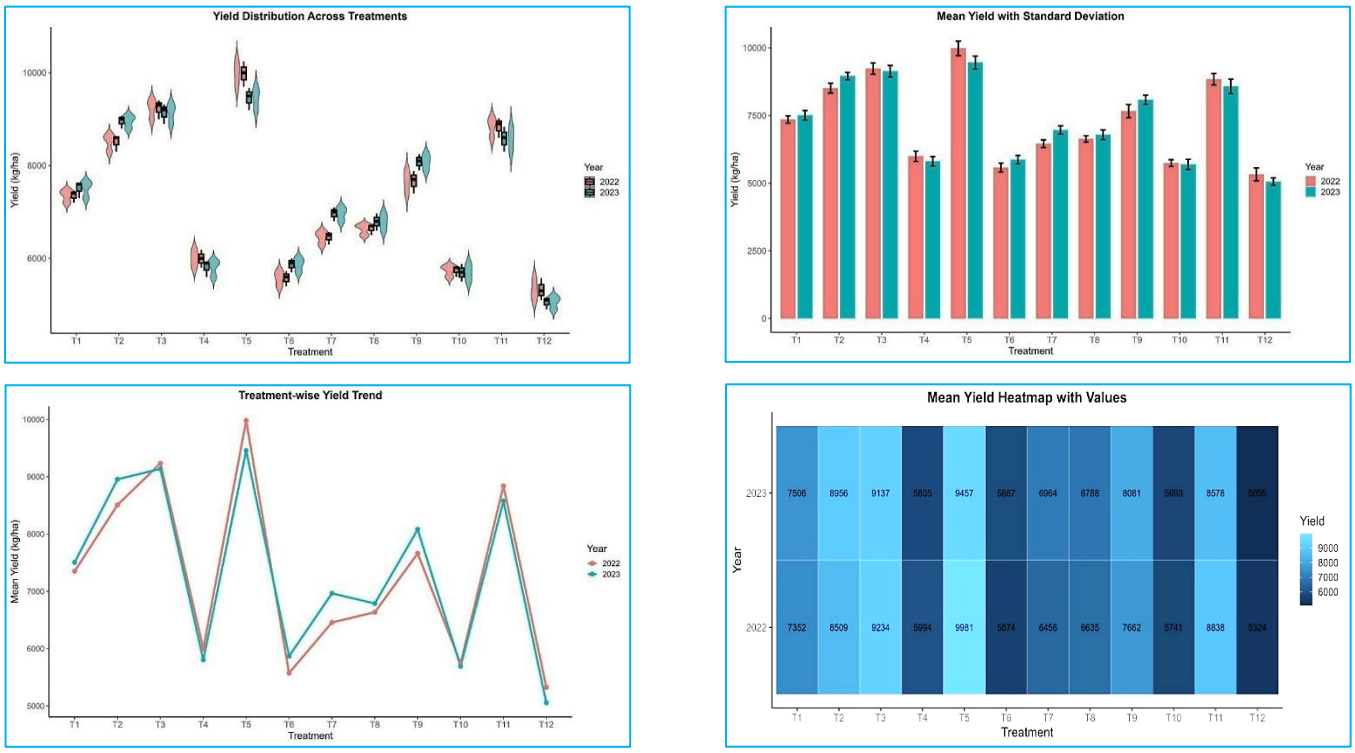

Fig 1 Effect of nutrient and weed management practices on the yield trends

Table 3 Effect of nutrient and weed management practices on the yield estimation & yield gap of transplanted hybrid rice

Treatments	2022		2023		Pooled data	
	Estimated grain yield (kg/ha)	Yield gap (kg/ha)	Estimated grain yield (kg/ha)	Yield gap (kg/ha)	Estimated grain yield (kg/ha)	Yield gap (kg/ha)
50% RDF + 50% vermicompost + Bensulfuron methyl + pretilachlor	7352	2494	7506	2520	7429	2507
50% RDF + 50% vermicompost + Cyhalofop butyl + penoxsulam	8509	3074	8956	3235	8732	3155
50% RDF + 50% Vermicompost + Triafamone + ethoxysulfuron	9234	3462	9137	3389	9186	3426
50% RDF + 50% Vermicompost + Chlorimuron-ethyl + metsulfuron-methyl	5994	1857	5805	1760	5900	1808
50% RDF + 50% Vermicompost + Two hand weedings	9981	3872	9457	3750	9719	3811
50% RDF + 50% Vermicompost + Weedy check	5574	1678	5867	1766	5720	1722
50% RDF + 50% FYM + Bensulfuron methyl + pretilachlor	6456	2079	6931	2166	6693	2122
50% RDF + 50% FYM + Cyhalofop butyl + penoxsulam	6635	2162	6788	2117	6712	2139
50% RDF + 50% FYM + Triafamone + ethoxysulfuron	7662	2660	8081	2549	7871	2604
50% RDF + 50% FYM + Chlorimuron-ethyl + metsulfuron-methyl	5741	1749	5693	1639	5717	1694
50% RDF + 50% FYM + Two hand weedings	8838	3258	8578	3394	8708	3326
50% RDF + 50% FYM + Weedy check	5324	1572	5055	1670	5190	1621
F-Test	S	S	S	S	S	S
SEd	384	189	372	188	376	188
CD (P=0.05)	797	392	771	390	780	390

CONCLUSION

The present investigation demonstrated that integrating nutrient management with effective weed control significantly enhanced the growth and productivity of rice. Across all treatment combinations, the application of 50% recommended dose of fertilizers (RDF) + 50% vermicompost consistently improved major yield attributes, including panicle number, grains per panicle, and test weight, compared with treatments receiving FYM or inorganic fertilizers alone. The superiority of vermicompost-based integrated nutrient management was further amplified when combined with timely weed control, particularly two hand weedings at 20 and 45 DAT or the application of triafamone + ethoxysulfuron and cyhalofop butyl + penoxsulam, which effectively minimized weed competition during the critical crop growth stages. Among all treatments, 50% RDF + 50% vermicompost + two hand weedings (20 and 45 DAT) proved to be the most effective, recording the highest grain yield (5.94 t ha^{-1}), straw yield (6.86 t ha^{-1}), and estimated yield (9719 kg ha^{-1}), along with superior yield-contributing characters. Conversely, the weedy check treatment resulted in the poorest crop performance, emphasizing the detrimental effect of uncontrolled weeds on rice productivity. Overall, the study establishes that integrating 50% recommended dose of fertilizers (RDF) with 50% vermicompost, coupled with efficient weed management, is a sustainable and productive strategy for enhancing rice yield and yield attributes while improving nutrient use efficiency and maintaining soil health. This integrated approach can therefore be recommended for achieving higher rice productivity under similar agro-ecological conditions while reducing dependence on chemical fertilizers.

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