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# Weed Dynamics and Productivity of Transplanted Hybrid Rice (*Oryza sativa)* as Affected by Nutrient and Weed Management Practices

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**A B S T R A C T**

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. A variety of weeds including grasses, sedges, and broadleaf weeds were present in the experimental field. Treatments had a major impact on weed biomass and density, which increased with crop growth stages. Treatment with 50% RDF + 50% vermicompost + two hand weedings and 50% RDF + 50% FYM + two hand weedings had the lowest weed density and biomass, indicating successful weed control through manual weeding. There was intense competition because the application of 50% RDF + 50% FYM + weedy check had the highest weed infestation. These results were further confirmed by the Herbicide efficiency index, Crop resistance index and Weed index. Application of 50% RDF + 50% vermicompost + triafamone + ethoxysulfuron had lower WI. The treatment that included 50% RDF + 50% FYM + weedy check had the highest weed index, indicating that unchecked weed competition during the crop period caused yield loss. In contrast, the treatment that included 50% RDF + 50% vermicompost + two hand weedings had higher values for the Herbicide efficiency index and the crop resistance index. Better conversion of tillers into productive tillers was indicated by the largest number of panicles per unit area in 50% RDF + 50% vermicompost + two hand weedings. In FYM-based treatments like 50% RDF + 50% FYM + two hand weedings, the number of grains per panicle and test weight were significantly greater, indicating improved grain filling because of prolonged nutrient release.

## Introduction

Rice production has pivotal role in our national economy. In order to maintain current food security and fulfill future food demands, India must achieve an annual growth rate in rice yield of at least 3%. Rice is an essential food in Asia and the Pacific, with more 90 % of the rice in the world being produced and eat up within the Asia-Pacific area. Over 161 m.ha in more than 100 nations worldwide, rice is a major food crop that is

cultivated. About 45 m.ha of rice is cultivated in India, with an average yield of 2.4 t/ha and a production of 121.46 m.t (Ministry of agriculture, Government of India, 2020-21). In India, rice is the most significant basic food for over two thirds of the population. The phrase "rice is life" is most relevant because it provides a key source of income for millions of rural households and contributes significantly to the food security of our country.

In Asia, rice and its byproducts provide 60-70% of the energy needed by over two billion people. In India, rice is generally grown by transplanting in puddled soils. According to estimates in Asia, yield loss due to uncontrolled weeds in transplanted paddy fields was 50% and 12% of the total loss of crop yields has been attributed to the weeds alone. Weeds become detrimental to crops by changing the pH of soil, decreasing the nutrient availability, which inturn reduces straw yield by 13-38 % and grain yield by 25-47 % (Manandhar *et al.,* 2007).

## Materials and Methods

The field experiment was carried out 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.

This area is situated on the right side of the river Yamuna by the side of Prayagraj Rewa Road about 5 km away from Prayagraj city. The experimental site was sandy clay loam, 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 x 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 x 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

### Weed flora

The predominant weed species observed in the experimental field were *Echinochloa colonum* and *Panicum repens* among grasses, *Commelina banghalensis* and *Eclipta alba* among the broad leaved weeds and *Cyprus species* among sedges were the dominant weed species in the weedy check plot.

Among non-grassy weeds, *Eclipta alba* was the pre-dominant weed species and its density was found highest *fb C. Banghalensis* throughout the growing period of crop. Among the grasses, *Echinochloa colona* was the pre-dominant weed species and its density found higher *fb Panicum repens* at all the growth stages of rice.

### Plant height, number of tillers and dry matter accumulation

Highest plant height, number of tillers and dry matter production was noticed with 50% RDF + 50% vermicompost + two hand weedings on 20 and 45 DAT which was however, on par with 50% RDF + 50% vermicompost + triafamone + ethoxysulfuron (Table 1). The maximum plant height at all stages (30, 60, 90 and 120 DAT) was recorded with treatment 50% RDF + 50% vermicompost + two hand weedings with values of 54.4, 93.2, 100.1 and 96.2 cm respectively. The number of tillers at different stages of crop growth showed that, all weed management techniques considerably boosted the number of tillers.

The number of tillers, which is a critical yield determining parameter, was significantly higher in 50% RDF + 50% vermicompost + two hand weedings, recording 262, 366, 371 and 379 $m^{-2}$ at different growth stages. This was closely followed by treatments 50% RDF + 50% Vermicompost + Triafamone + ethoxysulfuron and 50% RDF + 50% Vermicompost +

Cyhalofop butyl + penoxsulam, whereas the lowest tiller count was recorded under 50% RDF + 50% FYM + Weedy check. Similarly, dry matter accumulation increased steadily with crop growth and was found maximum in treatment 50% RDF + 50% vermicompost + two hand weedings (1794, 6870, 9948 and 12253 kg $ha^{-1}$ at successive stages), which was significantly superior over other treatments. This indicates improved photosynthetic efficiency and biomass production under integrated nutrient supply and efficient weed control.

## Grain yield (t/ha)

The highest Grain yield (t/ha) was recorded in treatment with 50% RDF + 50% vermicompost + two hand weedings on 20 and 45 DAT (5.94 t/ha) *fb* treatment with 50% RDF + 50% vermicompost + triafamone + ethoxysulfuron (5.74 t/ha) (Table 1), 50% RDF + 50% vermicompost + cyhalofop butyl + penoxsulam (5.57 t/ha) and 50% RDF + 50% FYM + two hand weedings on 20 and 45 DAT (5.49 t/ha) respectively and lowest Grain yield (t/ha) recorded in treatment with 50% RDF + 50% FYM + Weedy check (3.65 t/ha).

Similar result was also conveyed by Kundu (2012) who stated that the integration of different sources of plant nutrients (e.g. FYM, vermicompost, crop residues etc) has a satisfactory role on all the yield attributes, yield of rice grown either as a single sole crop or as a component crop of a cropping sequence of three or four crops.

## Weed density, dry matter and weed control efficiency

Table no. 2 revealed that in two year pooled data of various treatment combinations had significant effect of total weed density, drymatter and weed control efficiency during the experimental year 2022-23 and 2023-24. Adoption of different weed control treatments exhibited significant variations on the total weed density at all stages of observation. At 30 DAT, the treatment with 50% RDF + 50% vermicompost + two hand weedings on 20 and 45 DAT significantly recorded lowest weed density of 1.06/$m^2$.

It was *fb*treatment with 50% RDF + 50% FYM + two hand weedings on 20 and 45 DAT (1.40/$m^2$), 50% RDF + 50% Vermicompost + Triafamone + ethoxysulfuron also recorded lower weed density of 2.26/$m^2$. Whereas the treatment with 50% RDF + 50% FYM + Weedy check registered significantly a higher total weed density of 3.14/$m^2$. At 60 DAT, treatment with 50% RDF + 50% vermicompost + two hand weedings on 20 and 45 DAT significantly recorded lowest weed density of 1.54/$m^2$. It was *fb* treatment with 50% RDF + 50% FYM + two hand weedings on 20 and 45 DAT (4.0/$m^2$).

Whereas the treatment with 50% RDF + 50% FYM + weedy check registered significantly a higher total weed density of 21.1/$m^2$. The present findings are in conformity with the findings of Deivasigamani (2016).

At 30 DAT, treatment with 50% RDF + 50% vermicompost + two hand weedings on 20 and 45 DAT recorded significantly lower DMP of 2.1 g/$m^2$ and was found to be superior over the rest of the treatments. Next best treatment was treatment with 50% RDF + 50% FYM + two hand weedings on 20 and 45 DAT (3.7 g/$m^2$). Whereas the treatment with 50% RDF + 50% FYM + Weedy check registered significantly a higher total weed DMP of 20.6 g/$m^2$.

At 60 DAT, treatment with 50% RDF + 50% vermicompost + two hand weedings on 20 and 45 DAT recorded significantly lower DMP of 4.0 g/$m^2$. Next best treatment was treatment with 50% RDF + 50% FYM + two hand weedings on 20 and 45 DAT (6.9 g/$m^2$). Whereas the treatment with 50% RDF + 50% FYM + Weedy check registered significantly higher total weed DMP of 38.5 g/$m^2$. The present findings are in conformity with the findings of Rajendra Prasath *et al.,* (2022).

Among the different treatments, treatment with 50% RDF + 50% vermicompost + two hand weedings on 20 and 45 DAT has recorded highest weed control efficiency at all stages of observations (88.9 % at 30 DAT, 89.0% at 60 DAT) *fb* treatment with 50% RDF + 50% FYM + two hand weedings on 20 and 45 DAT recorded a weed control efficiency of (80.1 % at 30 DAT, 81.0 % at 60 DAT respectively).

## Herbicide efficiency index, Crop resistance index and Weed index

Table no. 3 revealed that in two year pooled data of various treatment combinations had significant effect of total Herbicide efficiency index, Crop resistance index and Weed index during the experimental year 2022-23 and 2023-24.

**Table.1** Effect of nutrient and weed management practices on the Dry matter production (kg/ha) of transplanted hybrid rice at 90 DAT

| S. No | Trearments | Number of tillers/m$^2$ | | | Plant height (cm) | | | Dry matter accumulation (kg/ha) | | | Grain yield | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2022 | 2023 | Pooled | 2022 | 2023 | Pooled | 2022 | 2023 | Pooled | 2022 | 2023 | Pooled |
| **1.** | 50% RDF + 50% vermicompost + Bensulfuron methyl + pretilachlor | 300 | 291 | 296 | 81.8 | 79.4 | 80.6 | 8035 | 7795 | 7915 | 4.85 | 4.96 | 4.90 |
| **2.** | 50% RDF + 50% vermicompost + Cyhalofop butyl + penoxsulam | 338 | 356 | 347 | 91.7 | 96.7 | 94.2 | 9065 | 9560 | 9313 | 5.43 | 5.72 | 5.57 |
| **3.** | 50% RDF + 50% Vermicompost + Triafamone + ethoxysulfuron | 361 | 376 | 369 | 97.5 | 101.6 | 99.5 | 9665 | 10070 | 9868 | 5.77 | 5.71 | 5.74 |
| **4.** | 50% RDF + 50% Vermicompost + Chlorimuron-ethyl + metsulfuron-methyl | 253 | 245 | 249 | 69.4 | 67.2 | 68.3 | 6750 | 6535 | 6643 | 4.13 | 4.00 | 4.07 |
| **5.** | 50% RDF + 50% Vermicompost + Two hand weedings | 383 | 359 | 371 | 103.3 | 96.8 | 100.1 | 10270 | 9625 | 9948 | 6.10 | 5.78 | 5.94 |
| **6.** | 50% RDF + 50% Vermicompost + Weedy check | 237 | 227 | 232 | 65.3 | 62.6 | 63.9 | 6320 | 6055 | 6188 | 3.09 | 3.28 | 3.18 |
| **7.** | 50% RDF + 50% FYM + Bensulfuron methyl + pretilachlor | 268 | 276 | 272 | 73.6 | 75.9 | 74.8 | 7175 | 7405 | 7290 | 4.37 | 4.69 | 4.53 |
| **8.** | 50% RDF + 50% FYM + Cyhalofop butyl + penoxsulam | 275 | 278 | 276 | 75.2 | 75.9 | 75.6 | 7350 | 7420 | 7385 | 4.47 | 4.57 | 4.52 |
| **9.** | 50% RDF + 50% FYM + Triafamone + ethoxysulfuron | 310 | 306 | 308 | 84.3 | 83.3 | 83.8 | 8290 | 8195 | 8243 | 5.00 | 5.27 | 5.13 |
| **10.** | 50% RDF + 50% FYM + Chlorimuron-ethyl + metsulfuron-methyl | 243 | 266 | 255 | 67.0 | 73.4 | 70.2 | 6490 | 7110 | 6800 | 3.99 | 3.95 | 3.97 |
| **11.** | 50% RDF + 50% FYM + Two hand weedings | 348 | 389 | 368 | 94.2 | 105.2 | 99.7 | 9325 | 10415 | 9870 | 5.58 | 5.41 | 5.49 |
| **12.** | 50% RDF + 50% FYM + Weedy check | 227 | 249 | 238 | 62.8 | 68.8 | 65.8 | 6060 | 6640 | 6350 | 2.95 | 2.89 | 2.92 |
| **F-Test** | | S | S | S | S | S | S | S | S | S | S | S | S |
| **SEd** | | 12.9 | 13.5 | 13.0 | 3.36 | 3.53 | 3.39 | 348.9 | 365.4 | 352.2 | 1.95 | 1.91 | 1.92 |
| **CD (P=0.05)** | | 26.8 | 28.1 | 27.0 | 6.96 | 7.32 | 7.03 | 723.5 | 757.7 | 730.4 | 4.05 | 3.96 | 3.97 |

**Table.2** Effect of nutrient and weed management practices on the Weed density (no./m²), Weed dry matter production (g/m²), Weed control efficiency (%) at 30 DAT of transplanted hybrid rice

| S. No | Treatments | 2022 | | | 2023 | | | Pooled Data | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | WD (no./m²) | WDMP (g/m²) | WCE (%) | WD (no./m²) | WDMP (g/m²) | WCE (%) | WD (no./m²) | WDMP (g/m²) | WCE (%) |
| **1.** | 50% RDF + 50% vermicompost + Bensulfuron methyl + pretilachlor | 6.32 (2.51) | 12.4 | 36.2 | 6.47 (2.54) | 12.5 | 38.0 | 6.38 (2.52) | 12.5 | 37.9 |
| **2.** | 50% RDF + 50% vermicompost +Cyhalofop butyl + penoxsulam | 5.55 (2.35) | 10.8 | 44.0 | 5.85 (2.41) | 11.4 | 43.9 | 5.65 (2.37) | 11.1 | 45.0 |
| **3.** | 50% RDF + 50% Vermicompost +Triafamone + ethoxysulfuron | 5.12 (2.26) | 10.0 | 48.3 | 5.04 (2.24) | 9.8 | 51.7 | 5.13 (2.26) | 9.9 | 50.0 |
| **4.** | 50% RDF + 50% Vermicompost + Chlorimuron-ethyl+ metsulfuron-methyl | 7.22 (2.68) | 14.1 | 27.1 | 6.93 (2.63) | 13.4 | 33.6 | 7.02 (2.64) | 13.8 | 31.6 |
| **5.** | 50% RDF + 50% Vermicompost + Two hand weedings | 1.25 (1.11) | 2.2 | 87.4 | 1.17 (1.08) | 2.1 | 88.8 | 1.14 (1.06) | 2.1 | 88.9 |
| **6.** | 50% RDF + 50% Vermicompost + Weedy check | 9.91 (3.14) | 19.6 | - | 10.43 (3.22) | 20.6 | - | 10.27 (3.20) | 20.1 | - |
| **7.** | 50% RDF + 50% FYM + Bensulfuron methyl + pretilachlor | 6.87 (2.62) | 13.5 | 32.1 | 7.35 (2.71) | 14.1 | 23.8 | 7.18 (2.67) | 13.8 | 27.3 |
| **8.** | 50% RDF + 50% FYM + Cyhalofop butyl + penoxsulam | 6.79 (2.60) | 13.3 | 32.9 | 6.97 (2.64) | 13.0 | 27.7 | 6.89 (2.62) | 13.1 | 30.2 |
| **9.** | 50% RDF + 50% FYM + Triafamone + ethoxysulfuron | 6.05 (2.45) | 11.9 | 40.2 | 6.47 (2.54) | 11.4 | 32.9 | 6.23 (2.49) | 11.7 | 36.9 |
| **10.** | 50% RDF + 50% FYM + Chlorimuron-ethyl + metsulfuron-methyl | 7.43 (2.72) | 14.5 | 26.6 | 7.33 (2.70) | 13.6 | 24.0 | 7.35 (2.71) | 14.1 | 25.5 |
| **11.** | 50% RDF + 50% FYM + Two hand weedings | 1.92 (1.38) | 3.6 | 81.0 | 1.88 (1.37) | 3.8 | 80.5 | 1.96 (1.40) | 3.7 | 80.1 |
| **12.** | 50% RDF + 50% FYM + Weedy check | 10.12 (3.18) | 20.0 | - | 9.64 (3.10) | 21.2 | - | 9.87 (3.14) | 20.6 | - |
| **F-Test** | | S | S | - | S | S | - | S | S | - |
| **SEd** | | 0.6 | 1.3 | NA | 0.7 | 1.4 | NA | 0.7 | 1.3 | NA |
| **CD (P=0.05)** | | 1.3 | 2.7 | NA | 1.4 | 2.8 | NA | 1.4 | 2.8 | NA |

Square root transformed values are entered in the parenthesis

**Table.3** Effect of nutrient and weed management practices on the Phyto-toxicity rating, Herbicide Efficiency Index (%), Crop Resistance Index (%), and Weed Index of transplanted hybrid rice

| S. No | Treatments | 2022 | | | 2023 | | | Pooled Data | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | HEI (%) | CRI (%) | WI | HEI (%) | CRI (%) | WI | HEI (%) | CRI (%) | WI |
| **1.** | 50% RDF + 50% vermicompost + Bensulfuron methyl + pretilachlor | 0.90 | 2.03 | 20.06 | 0.84 | 2.10 | 14.20 | 0.87 | 2.06 | 17.13 |
| **2.** | 50% RDF + 50% vermicompost + Cyhalofop butyl + penoxsulam | 1.37 | 2.63 | 11.10 | 1.35 | 2.66 | 1.03 | 1.36 | 2.65 | 6.06 |
| **3.** | 50% RDF + 50% Vermicompost + Triafamone + ethoxysulfuron | 1.70 | 3.06 | 5.08 | 1.56 | 3.26 | 1.07 | 1.63 | 3.16 | 3.07 |
| **4.** | 50% RDF + 50% Vermicompost + Chlorimuron-ethyl + metsulfuron-methyl | 0.47 | 1.49 | 32.11 | 0.34 | 1.52 | 30.03 | 0.41 | 1.51 | 31.07 |
| **5.** | 50% RDF + 50% Vermicompost + Two hand weedings | 8.83 | 15.02 | - | 7.54 | 14.58 | - | 8.19 | 14.80 | - |
| **6.** | 50% RDF + 50% Vermicompost + Weedy check | - | 1.00 | 49.04 | - | 1.00 | 46.14 | - | 1.00 | 47.59 |
| **7.** | 50% RDF + 50% FYM + Bensulfuron methyl + pretilachlor | 0.71 | 1.76 | 21.12 | 0.94 | 1.95 | 15.09 | 0.83 | 1.85 | 18.10 |
| **8.** | 50% RDF + 50% FYM + Cyhalofop butyl + penoxsulam | 0.78 | 1.84 | 19.20 | 0.95 | 2.06 | 18.12 | 0.87 | 1.95 | 18.66 |
| **9.** | 50% RDF + 50% FYM + Triafamone + ethoxysulfuron | 1.16 | 2.32 | 10.11 | 1.53 | 2.79 | 5.07 | 1.35 | 2.56 | 7.59 |
| **10.** | 50% RDF + 50% FYM + Chlorimuron-ethyl + metsulfuron-methyl | 0.48 | 1.48 | 28.02 | 0.58 | 1.69 | 29.21 | 0.53 | 1.59 | 28.61 |
| **11.** | 50% RDF + 50% FYM + Two hand weedings | 4.90 | 8.61 | - | 4.89 | 8.57 | - | 4.89 | 8.59 | - |
| **12.** | 50% RDF + 50% FYM + Weedy check | - | 1.00 | 47.11 | - | 1.00 | 48.18 | - | 1.00 | 47.64 |

Not statistically analysed

The maximum performance of Herbicide efficiency index was observed in treatment with 50% RDF + 50% vermicompost + two hand weedings on 20 and 45 DAT (8.19 %) *fb* treatment with 50% RDF + 50% FYM + two hand weedings on 20 and 45 DAT is (4.89 %),

Treatment with 50% RDF + 50% vermicompost + triafamone + ethoxysulfuronis (1.63 %), treatment with 50% RDF + 50% vermicompost + cyhalofop butyl + penoxsulam is (1.36 %) and treatment with 50% RDF + 50% FYM + triafamone + ethoxysulfuron is (1.35 %) respectively and minimum herbicide efficiency index recorded in treatment with 50% RDF + 50% vermicompost + chlorimuron-ethyl + metsulfuron-methyl is (0.41 %).

The maximum performance of crop resistance index was observed in treatment with 50% RDF + 50% vermicompost + two hand weedings on 20 and 45 DAT (14.80 %) *fb* treatment with 50% RDF + 50% FYM + two hand weedings on 20 and 45 DAT is (8.59 %), 50% RDF + 50% vermicompost + triafamone + ethoxysulfuron is (3.16 %), 50% RDF + 50% vermicompost + cyhalofop butyl + penoxsulamis (2.65 %) and 50% RDF + 50% FYM + triafamone + ethoxysulfuron is (2.56 %)

Respectively and minimum crop resistance index recorded in treatment with 50% RDF + 50% vermicompost + weedy check (1.00 %) and treatment with 50% RDF + 50% FYM + weedy check (1.00 %).

## Author Contributions

Ramavath Nagasai Vardhan Naik: Investigation, formal analysis, writing—original draft. Biswarup Mehera: Validation, methodology, writing—reviewing. Joy Dawson:—Formal analysis, writing—review and editing.

## Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethical Approval** Not applicable.

**Consent to Participate** Not applicable.

**Consent to Publish** Not applicable.

**Conflict of Interest** The authors declare no competing interests.

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