**Effect of Integrated Nutrient Management on Growth of Black Aromatic Rice (*Oryza sativa* L. *indica*)**

**Abstract**

A field experiment was conduct at Himalayan University farm, Jollang, Itanagar, Arunachal Pradesh, during the kharif season of 2024 with 8 treatments replicated thrice in Randomized Block Design, to determine the effect of integrated nutrient management on growth of black aromatic rice. The study recorded significance difference among treatments in terms of plant height, leaf length, number of tillers, dry weight and leaf width of plant at 30, 60 and 90 DAT. The result revealed that the treatment T4 (100% RDF + Vermicompost @ 3tha-1) was found to be best treatment for obtaining maximum plant height, leaf length, number of tillers, dry weight and leaf width

**Keywords:** Integrated nutrient management, FYM, Vermicompost, Rhizobium and PSB, Black aromatic rice, Days after transplanting (DAT)

**Introduction**

Black rice is a variety of *Oryza sativa* L., commonly known as glutinous rice, that is cultivated primarily in the Asian continent (Kong *et al*., 2008). It is distinguished by its higher nutrient content compared to other rice species. Consumer preference has significantly increased regarding foods that contain beneficial compounds and essential nutrients necessary for the human body. Approximately 3 billion individuals worldwide experience malnutrition as a prevailing issue, primarily attributed to the inadequate intake of vitamins, minerals, and essential amino acids in their daily dietary practises (Welch, 2005).

Black rice has been consumed for centuries in Asian countries such as China, Korea and Japan. It has been reported that black rice has greater antioxidant activity than white rice. In Asian countries, China and Indonesia common people were not allowed to store/ cultivate/ consume black rice during imperial period without permission of the authorities and was solely consumed by royals and elite personalities and used as a tribute food. In ancient times it was believed that black rice would increase the life span and good health of king and was considered very superior and rare. Black rice is known by many names such as forbidden rice, imperial rice, king’s rice, purple rice, heaven rice and prized rice and is packed with high level of antioxidants and micronutrients. Now, black rice is consumed and grown in many countries. In India, black rice is grown in Manipur on small scale by traditional farmers. China is the richest country in the black rice resources (62%) followed by Sri Lanka (8.6%), Indonesia (7.2%), India (5.1%), Bangladesh (4.1%) and few in Malaysia. So far they have developed 200 varieties including 52 high yielding varieties (Biswas, 2018).

Black rice is locally known as ‘Chakhao’, means delicious rice in Manipuri language is cultivated mainly by Meitei farmers of Manipur. There are four landraces of black rice in Manipur which includes *Chakhao amubi*, *Chakhao angouba*, *Chakhao poireiton* and *Chakhao* *pungdol amubi*. Black rice is almost six times richer in antioxidant activities, have high protein content (8.16%) and low fat content (0.07%) (Thomas *et al*., 2013) as compared with other rice varieties, is gluten free, gut friendly and a natural cleaner with many medicinal values (Jha *et al*., 2017).

Black rice is more nutritious than common rice. It contains higher content of protein, vitamins and minerals compared to other rice varieties; although, nutrient content varies with cultivar and production location. Mineral contents in rice were highly influenced not only by difference among cultivar, but also difference in cultivating area. (Suzuki 424) Anthocyanin pigments have been reported to be highly effective in reducing cholesterol levels in the human body. Anthocyanins play an important role in neuroprotection by reducing oxidative stress, pre-serving cognitive performance as well as limiting or reversing the deleterious effects of brain ageing. (Kangwan, 2017).

The use of integrated nutrient management, which makes the most of both organic and inorganic fertilizers, appears to be a promising strategy for preserving soil sustainability, crop productivity, and soil health (Yuniarti *et al.*, 2019). Integrated nutrient management of fertilizers and organic manures is thus one of the potential strategies for supporting soil health in relation to crop productivity (Bajpai *et al.,* 2006).

The integrated nutrient supply system is the most logical concept for managing long term soil fertility and productivity (Ramesh *et al.,* 2009). Use of chemical fertilizers and organic manures has been found promising in arresting the decline trend in soil-health and productivity through the correction of marginal deficiencies of some secondary and micro-nutrients, micro-flora and fauna and their beneficial influence on physical and biological properties of soil. Integrated nutrient management system can bring about equilibrium between degenerative and restorative activities in the soil eco-system (Upadhyay *et al.,* 2011).

Vermicompost is composted organic waste substrates in the presence of earthworms with a good physical structure, abundant labile resources, and high microbial activities (Doan *et al*., 2015). In recent years, numerous studies have shown that vermicompost amendments can promote soil quality and productivity by improving the structure and chemical properties of the soil, increasing the amount of plant-available nutrients, promoting soil biological activities, and enhancing crop yield and/or quality (Doan *et al.,* 2015).

Black rice contains many vitamins and minerals, including iron, vitamin A and vitamin B, fibre, protein, essential amino acids, etc. Black rice is high in nutritional value. It contains 18 amino acids, iron, copper, carotene, zinc, and several important vitamins. Thus black rice is a universal remedy to many diseases. Minerals such as calcium (Ca) and iron (Fe) are high in black rice (21.38 mg/100g) sodium (Na), is low in all samples except for the black rice (10.19 mg/100g). Magnesium and potassium content is high in it (Potassium 186.54 mg/100g and Magnesium 107.21 mg/100g). “Among all the rice varieties investigated, the total saturated fatty acid and unsaturated fatty acid content was highest in black rice (5.89%).” (Thomas *et al.,*2013).

Balanced nutrition due to release of macro and micro nutrients due to application of Vermicompost and Farm Yard Manure under favourable environment might have helped in higher uptake of nutrients. This accelerated the growth of new tissues and development of new shoots that have ultimately increased the plant height, dry matter accumulation, chlorophyll content and total tillers per meter row length (Togas *et al*., 2017)

**MATERIALS AND METHODS**

The experiment was carried out at agriculture field, Jollang, college of agriculture, Himalayan University, during the period of Kharif season of 29 June 2024. The experimental farm is situated at 27.074684, N latitude and 93.652878 E longitude with an average elevation of 320 meters. It was undertaken with the objective to analyze the different rice verities and to assess their performance in Kharif season.

The treatment include, T1 –Control, T2 – 100% RDF + FYM @ 5tha-1, T3 – 75% RDF + FYM @ 5tha-1, T4 - 100% RDF + Vermicompost @ 3 tha-1, T5 – 75% RDF + Vermicompost @ 3tha-1, T6 – 100% RDF + Rhizobium + PSB, T7 – 75% RDF + Rhizobium + PSB, T8 – 100% RDF + Rhizobium + PSB + Vermicompost @ 3tha-1. The experiment was carried out in Randomized Block Design (RBD) in the year 2024 – 2025.

The climate condition of Itanagar is humid sub-tropical climate with distinct season. the rainy season usually starts from May and it extends up to September and from October onwards. The meteorological data of weather parameter. temperature, rainfall, relative humidity and sunshine hours recorded during the period of experimentation from July to November during the year 2024-2025 were obtained from meteorological observatory, for the period of the experimentation have been presented in the table. The mean minimum and maximum temperature recorded during the cropping season was 22.3 °C and 27.6 "C, respectively. The average relative humidity

 **Figure 1. Meteorological data of weather parameters and total rainfall during the cropping season (*Kharif* 2024-2025)**

**CROP GROWTH ATTRIBUTES**

Plant height was measured in centimeters from the base to the tip of the plant for 5 randomly selected plants in each plot. These plants were tagged so the same ones could be observed again later. Measurements were taken three times—at 30, 60, and 90 days after sowing (DAS). The average height of the plants in each treatment was calculated for each observation time. Leaf length was measured from the base to the tip of the leaf on 5 randomly selected plants in each plot. These plants were tagged and measured again later. Observations were taken at 30, 60, and 90 days after sowing (DAS), and the average leaf length for each treatment was calculated at each time point. The number of tillers was recorded by counting all tillers on 5 randomly selected plants from each plot. These observations were made at 30, 60, and 90 days after sowing (DAS), and the average number of tillers per treatment was calculated for each time point. The dry weight of a plant is the weight remaining after all the water has been eliminated. This is usually achieved by heating the plant material at a temperature above normal room temperature until all the moisture has been dried out.

**RESULTS AND DISCUSSIONS**

The growth and development parameters of black aromatic rice were recorded under a Randomized Block Design (RBD) with three replications. Observations were taken for various traits such as plant height (cm), leaf length, number of tillers, and leaf width. The data were statistically analyzed to compute the general mean, standard error (SEd), and critical difference (CD) for each trait.

**Plant height:**

Plant height of black aromatic rice recorded at 30, 60, and 90 DAT was statistically analyzed and presented in tables 1.

At 30 days after sowing (DAS), the greatest plant height was observed in treatment T4, which included 100% recommended dose of fertilizers (RDF) along with Vermicompost @ 3tha-1, resulting in an average height of 75.9 cm. Treatment T5, consisting of 75% RDF and Vermicompost @ 3tha-1, produced a height of 69.8 cm, with no significant difference compared to T4. The shortest plants, measuring 59.9 cm, were recorded in the control treatment (T1), which did not receive any additional inputs.

 At 60 DAS, the greatest plant height was observed to be statistically significant in treatment T4 which included 100% recommended dose of fertilizers (RDF) along with Vermicompost @ 3tha-1, resulting in an average height of 146.1 cm. and T5 consisting of 75% RDF and Vermicompost @ 3tha-1, giving an average height of 141 cm. The shortest plants, measuring 108.8 cm, were recorded in the control treatment (T1), which did not receive any additional inputs.

 At 90 DAT, the greatest plant height was observed in treatment T4, which included 100% recommended dose of fertilizer (RDF) along with Vermicompost @ 3tha-1, resulting in an average height of 181.2 cm. Treatment T5, consisting of 100% RDF and Vermicompost @ 3tha-1, produced a plant height of 168.2 cm, with no significant difference compared to T4. The shortest plants, measuring 145.9 cm, were recorded in the control treatment (T1), which did not receive any additional inputs

The higher plant height recorded in **T4** (100% RDF + Vermicompost @3tha-1) may be attributed to the beneficial effects of Vermicompost on soil structure and water retention. Vermicompost is a nutrient-rich, microbiologically- active organic amendment that result from the interactions between earthworms and microorganisms during the breakdown of organic matter. It is a stabilized, finely divided hums-like material with low C: N ratio, high porosity and high water holding capacity, in which most nutrients are present in forms that are readily taken up by plants. The shortest plants were recorded in the control treatment (T1), which did not receive any additional inputs (Dominguez, 2004).

Table 1. Effect of Integrated nutrient management on plant height of Black aromatic rice

|  |  |
| --- | --- |
| **Treatment**  | **Plant height (cm)** |
| **30 DAS** | **60 DAS** | **90 DAS** |
| **T1 – Control** | 59.9 | 108.8 | 145.9 |
| **T2 – 100% RDF + FYM @5tha-1** | 68.5 | 133.2 | 164.4 |
| **T3 – 75% RDF + FYM @5tha-1** | 65.9 | 106.1 | 150 |
| **T4 – 100% RDF + Vermicompost @ 3tha-1** | 75.9 | 146.13 | 181.2 |
| **T5 - 75%RDF + Vermicompost @ 3tha-1** | 69.8 | 141 | 168.2 |
| **T6 – 100%RDF + Rhizobium + PSB** | 68.13 | 130 | 162 |
| **T7 – 75% RDF + Rhizobium + PSB** | 67.0 | 129..4 | 159.7 |
| **T8 – 100%RDF + Rhizobium + PSB + Vermicompost @3tha-1** | 64.0 | 116.3 | 147.9 |
| **F test** | NS | S | S |
| **S.Ed±** | 2.241217 | 1.89062 | 0.249125 |
| **CD (P=0.05)** | 4.806933 | 4.054977 | 0.534321 |

**Leave length:**

Leaf length of black aromatic rice recorded at 30, 60, and 90 DAT was statistically analyzed and presented in tables 2.

At 30 days after transplanting (DAT), the greatest leave length was observed in treatment T4, which included 100% recommended dose of fertilizers (RDF) along with Vermicompost @ 3tha-1 resulting in an average length of 46.6 cm. Treatment T5, consisting of 75% RDF and Vermicompost @ 3tha-1 produced a leave length of 45.5 cm, with no significant difference compared to T4. The shortest plants, measuring 42.4 cm, were recorded in the control treatment (T1), which did not receive any additional inputs.

At 60 DAT, the greatest leave length was observed to be statistically significant in treatment T4 which included 100% recommended dose of fertilizers (RDF) along with Vermicompost @ 3tha-1 resulting in average height of 81.8 cm. and T5 consisting of 75% RDF and Vermicompost @ 3tha-1, giving an average length of 81.1 cm. The shortest leave, measuring 74.2 cm, were recorded in the control treatment (T1), which did not receive any additional inputs.

At 90 DAT, the greatest leave length was observed to be statistically significant in treatment T4 which included 100% recommended dose of fertilizers (RDF) along with Vermicompost @ 3tha-1 resulting in average height of 92.76 cm. and T5 consisting of 75% RDF and Vermicompost @ 3tha-1, giving an average length of 92.73 cm. The shortest leave, measuring 84.9 cm, were recorded in the control treatment (T1), which did not receive any additional inputs.

The greater leaf length observed in treatment T4 (100% RDF +Vermicompost @ 3tha-1) compared to the shortest leaf length in treatment T1 (Control) can likely be attributed to the positive effects of Vermicompost. Vermicompost is also enriched with vitamins, enzymes, antibodies and growth hormones. Unlike compost, vermicompost exhibit different physical and chemical characteristics that affect soil properties and plant growth in diverse ways. Compared with raw manure materials and its traditional compost, vermicompost possesses a greater capacity for cation exchange and a larger surface area (Meier *et al*., 2017).

Table 2. Effect of Integrated nutrient management on leaf length of Black aromatic rice

|  |  |
| --- | --- |
| **Treatments** | **Leaf length (cm)** |
| **30 DAS** | **60 DAS** | **90 DAS** |
| **T1 – Control** | 42.4 | 74.2 | 84.9 |
| **T2 – 100% RDF + FYM @5tha-1** | 44.8 | 79.6 | 91 |
| **T3 –75% RDF + FYM @5tha-1**  | 43.2 | 76.4 | 85.7 |
| **T4 –100%RDF + Vermicompost @ 3tha-1**  | 46.6 | 81.8 | 92.76 |
| **T5 - 75%RDF + Vermicompost @ 3tha-1** | 45.5 | 81.1 | 92.73 |
| **T6 – 100%RDF + Rhizobium + PSB** | 44.36 | 79.5 | 89.9 |
| **T7 – 75% RDF + Rhizobium + PSB** | 44.06 | 79.2 | 88.8 |
| **T8 – 100%RDF + Rhizobium + PSB + Vermicompost @3tha-1** | 42.56 | 75.9 | 85.0 |
| **F test** | NS | S | S |
| **S.Ed±** | 1.049641 | 1.923838 | 1.335014 |
| **CD (P=0.05)** | 2.251256 | 4.126221 | 2.86332 |

**Total number of tillers:**

The number of tillers in black aromatic rice, recorded at 30, 60, and 90 days after sowing (DAT), was statistically analyzed and the results were displayed in table 3.

At 30 DAT, treatment T4, which received 100% of the recommended dose of fertilizers (RDF) along with Vermicompost @ 3tha-1, recorded the highest number of tillers (16.6), and this difference was statistically significant. This was followed by treatment T5, which received 75% RDF and Vermicompost @ 3tha-1, with an average tiller count of (16.5). The lowest number of tillers (12.9) was observed in the control treatment (T1), which did not receive any additional nutrient inputs.

 At 60 DAT, treatment T4, which received 100% of the recommended dose of fertilizers (RDF) along with Vermicompost @ 3tha-1, recorded the highest number of tillers (18.8), and this difference was statistically significant. This was followed by treatment T5, which received 75% RDF and Vermicompost @ 3tha-1, with an average tiller count of (18.6). The lowest number of tillers (15.8) was observed in the control treatment (T1), which did not receive any additional nutrient inputs.

At 90 DAT, treatment T4, which received 100% of the recommended dose of fertilizers (RDF) along with Vermicompost @ 3tha-1, recorded the highest number of tillers (23.2), and this difference was statistically significant. This was followed by treatment T5, which received 75% RDF and Vermicompost @ 3tha-1, with an average tiller count of (22.6). The lowest number of tillers (16.6) was observed in the control treatment (T1), which did not receive any additional nutrient inputs. The probable reason for maximum tillers in black rice plant might be the positive effect of vermicompost. Vermicompost is more effective in its use compared to other organic fertilizers because it has a faster effect and a lower application rate, so that the use of inorganic fertilizers can be saved. This has been proven by (Regista *et al*., 2017).

Table 3. Effect of Integrated nutrient management on total number of tillers of Black aromatic rice

|  |  |
| --- | --- |
| **Treatments** | **Total number of tillers** |
| **30 DAS** | **60 DAS** | **90 DAS** |
| **T1 - Control** | 12.9 | 15.8 | 16.6 |
| **T2 – 100% RDF + FYM @5tha-1** | 16.4 | 18.5 | 22.0 |
| **T3 –75% RDF + FYM @5tha-1**  | 15.2 | 17.4 | 18.8 |
| **T4 –100%RDF + Vermicompost @ 3tha-1**  | 16.6 | 18.8 | 23.2 |
| **T5 - 75%RDF + Vermicompost @ 3tha-1** | 16.5 | 18.6 | 22.6 |
| **T6 – 100%RDF + Rhizobium + PSB** | 16.2 | 18.2 | 19.6 |
| **T7 – 75% RDF + Rhizobium + PSB** | 16.0 | 17.46 | 19.0 |
| **T8 – 100%RDF + Rhizobium + PSB + Vermicompost @3tha-1** | 14.8 | 17.2 | 18.7 |
| **F test** | S | S | S |
| **S.Ed±** | 0.22599 | 0.515321 | 0.413848 |
| **CD (P=0.05)** | 0.4847 | 1.105253 | 0.887615 |

**Dry weight:**

Dry weight of black aromatic rice recorded after 90 DAT and this was statistically analyzed and presented in graphical form.

At 30 days after transplanting (DAT), Treatment T4, which received (100%RDF + Vermicompost @ 3tha-1), exhibited the highest dry weight of 1.94kg, a statistically significant result. This was closely followed by Treatment T4, (75% RDF + Vermicompost @ 3tha-1), recording an average dry weight of 189kg. The lowest dry weight was observed in control group (T1), which received no additional nutrient supplementation, showed the lowest dry weight at 0.91kg.

At 60 days after transplanting (DAT), Treatment T4, which received (100%RDF + Vermicompost @ 3tha-1), exhibited the highest dry weight of 3.38kg, a statistically significant result. This was closely followed by Treatment T5, (75% + Vermicompost @ 3tha-1), recording an average dry weight of 3.52kg. The lowest dry weight was observed in control group (T1), which received no additional nutrient supplementation, showed the lowest dry weight at 3.03kg.

At 90 days after transplanting (DAT), Treatment T4, which received (100%RDF + Vermicompost @ 3tha-1)exhibited the highest dry weight of 7.10kg, a statistically significant result. This was closely followed by Treatment T5, (75% RDF + Vermicompost @ 3tha-1), recording an average dry weight of 7.03kg. The lowest dry weight was observed in control group (T1), which received no additional nutrient supplementation, showed the lowest dry weight at 4.17kg.

The likely reason for the observed increase in dry matter production this might be attributed due to the fact that higher doses of nutrients resulted in higher availability of nutrients in the soil for plant nourishment and further, organic source release slow and continuous availability of nutrients enhanced cell division, elongation as well as various metabolic processes which increased plant growth attributes which ultimately attained the highest source capacity and dry matter accumulation. The results have got close conformity with the findings of (Krishna *et al.,* 2008).

Figure 2. Effect of Integrated nutrient management on dry weight of Black aromatic rice

**CONCLUSION**

In conclusion, this study demonstrates that the utilizing of integrated nutrient management on black aromatic rice shows the most favourable outcomes across growth parameters *i.e* highest plant height (181.2cm), highest leaf length (92.6 cm), highest number of tillers (23.2) and highest dry weight (7.10kg) at 90 DAS and moreover, it is seen that under T4 (100% RDF + Vermicompost). The approach the use of Vermicompost not only boosts productivity but also improves soil health, supporting sustainable agriculture in soils. T4 demonstrated superior performance, showcasing optimal growth parameters proved to be the most effective treatment among all the mentioned treatments.

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