**Effect of Integrated Nutrient Management on Yield 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 2024-25 with treatments 8 replicated three in Randomized Block Design, to determine the effect of Integrated Nutrient Management on Yield of Black Aromatic Rice. The study recorded significance difference among treatments in terms of Grain yield, Straw yield and Harvest index of plant. The result revealed that the treatment T4 (100% RDF + Vermicompost @ 3tha-1) was found to be best Treatment for obtaining maximum Grain yield, Straw yield and Harvest index.

**Keywords:** Black Aromatic Rice, FYM, Integrated Nutrient Management, Rhizobium, Randomized Block Design (RBD) and Vermicompost.

**Introduction**

Black rice refers to a variety of rice from the species *Oryza sativa* L. Subspecies indica. It has high levels of nutrients, high antioxidant property and is glutinous in nature. It is also known as purple rice, heaven rice, imperial rice, king’s rice, prize rice and forbidden rice. Recently it was referred as “Super Food”(Saha, 2016). It is cultivated in South - East Asian countries (Kong *et al*., 2008).

“It is the staple food for more than 65% of the country’s population and also the most important source for meeting the calorie and dietary protein needs of the people. Mostly, white or brown rice is consumed in the world whereas black rice is consumed by a very small portion of people in Asia during the special occasions. It is a medium-grain, no glutinous heirloom rice with a deep purple hue and a nutty, slightly sweet flavour. The dark colour of the grain is due to anthocyanin, a powerful antioxidant. Black rice has a deep black colour and usually turns deep purple when cooked. It is suitable for creating porridge, dessert, cake, bread, kheer, noodles and many other dishes. The Japanese researchers analysed the genome of 21 black rice varieties and found that the specific gene that triggers the plant to produce large amounts of anthocyanin” (Oikawa *et al*., 2015).

“The dark purple colour of Black rice is due to the high anthocyanin content, located in the pericarp layers. Anthocyanin pigment which is present in black rice has been documented as health promoting food ingredients because of antioxidant activity” (Takashi *et al*., 2001). “Due to growing demand, there has been increased interest in the alternative sources of anthocyanin, which is inexpensive sources of natural and stable pigments” (Hu *et al*., 2003). “The Black rice was also reported as good source of fiber, minerals, and several important amino acids” (Zhang *et al.*, 2005). “Black rice also contains higher levels of proteins, vitamins and also relatively richer in the mineral contents such as Fe, Zn, Mn and P as compared to common white rice” (Suzuki *et al*., 2004).

“Integrated use of inorganic fertilizers, organic manures, green manures and crop residue are the only alternatives which may help in improving soil health and sustained productivity. Use of organic manures, green manures, crop residues along with inorganic fertilizers not only reduces the demand of inorganic fertilizers but also increases the efficiency of applied nutrients due to their favourable effect on physical, chemical and biological properties of soil” (Pandey *et al.,* 2007).

FYM being store-house of both macro and micro nutrients which might have enhanced the metabolic process vis-à-vis enlarged source and sink capacity, which ultimately enhanced the grain and straw yields. The results agree with finding of Sowmya *et al.,* (2011). “The growing interest in black rice(*Oryza sativa* L.) stems from its potential health benefits attributed to its unique starch and phytochemical compositions” (Tiranusornkij *et al.*,2019). “The inherent pigments of black rice, distinguished for their abundance in phytochemicals, notably anthocyanins, manifest a spectrum of pharmacological activities such as anti-diabetic” (Bhuyan *et al*., 2022). “Additionally, black rice is recognised to offer several health advantages such as boosting eye and heart health, protection against certain forms of cancer as it is highly antioxidant. The yield of black is substantially lower than other rice varieties. In northeast India, black rice is commonly cultivated in Manipur and indigenously called “chakhao”. As the yield is very poor and chakhao is grown in very limited acreage by farmers in Manipur only for ceremonial and cultural purposes” (Sultana and Ningthoujam, 2023).

Black rice is a rainfed crop and is adopted in several states of northeast India. The introduction of black rice in the region will improve returns of the farmers, income of farmers, per capita income of farmers, the standard of living, and would promote doubling of farmers income. The high output of Black rice varieties would possibly improve the storage capacity, cropping system, and companion crops of the region. It would mitigate the shortage of rice grains and undernourishment by maintaining food security, industrial establishment and livelihood. Lingaiah *et al*. (2014)

**MATERIALS AND METHODS**

The Experiment was carried out at Agriculture field, Jullang, 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 analyse the different rice verities and to assess their performance in Kharif season.

The Treatment includes, 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)**

**YIELD ATTRIBUTES**

**Grain yield:**

The Rice plants collected from each plot were manually threshed to remove the grains. After threshing, the grains were cleaned and dried under the sun until they reached a standard moisture content to ensure accurate and uniform weight measurements. The dried grain from each plot was weighed and recorded in kilograms. To allow for comparison between different treatments, the grain yield was then converted into kilograms per hectare (kg/ha).

**Straw yield:**

After harvesting, rice plants from each plot were threshed to separate the grains, leaving behind the remaining plant parts such as stems, leaves, and unfilled spikelet and these referred as **straw**. This straw was then dried properly, and the total amount from each plot was measured using a digital weighing scale. The straw weight was recorded in **kilograms per plot.**

**Harvest Index:**

It was calculated by diving economic yield by total biological yield (Donald ,1962) the following formula was used.

Harvest index (HI) = $\frac{Economic Yield }{Biological Yield}×100$

**RESULTS AND DISCUSSIONS**

The yield 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 grain yield, straw yield and harvest index. The data were statistically analyzed to compute the general mean, standard error (SEd), and critical difference (CD) for each trait.

**Grain Yield:**

The grain yield (kg/ha), were recorded at harvested and presented in table 1. The data shows that there is significant effect of different treatment on grain yield and this data are displayed in table 1. and graphically depicted.

At harvest maximum grain yield was recorded at 2.06 kg/ha, was found in the treatment T4, (100% RDF + Vermicompost @ 3 t/ha), which was statistically significant. This was followed by **T5**, (75% + Vermicompost @ 3 t/ha) with grain yield recorded at 1.72 kg/ha. The lowest grain yield was recorded in the control treatment (**T1**), which received no additional nutrient supplementation, showed the lowest grain yield at 1.05 kg/ha.

The probable reason for the maximum grain yield in black rice in **T4** (100% RDF + Vermicompost @ 3 t/ha), could be due to the application of Vermicompost (VC) as an organic input for attaining sustainable agricultural production is a potential source of beneficial microorganisms, prime (NPK) and micro nutrients, enzymes and metabolites (Sinha *et al*., 2009).

Table 1 Effect of Integrated Nutrient Management of Grain yield of Black Aromatic Rice

|  |  |
| --- | --- |
| **Treatment** | **Grain Yield (Kg/ha)** |
| **T1 – Control** | 1.05 |
| **T2 – 100% RDF + FYM @ 5t/ha** | 1.46 |
| **T3 – 75% RDF + FYM @ 5t/ha**  | 1.29 |
| **T4 – 100% RDF + Vermicompost @ 3t/ha**  | 2.06 |
| **T5 - 75% RDF +Vermicompost @ 3t/ha** | 1.72 |
| **T6 – 100% RDF + Rhizobium + PSB** | 1.45 |
| **T7 – 75% + RDF + Rhizobium + PSB** | 1.32 |
| **T8 – 100% RDF + Rhizobium + PSB + Vermicompost @ 3t/ha** | 1.10 |
| **F test** | S |
| **SE(d±)** | 0.146622 |
| **CD (P=0.05)** | 0.314473 |

**Straw yield:**

The straw yield (kg/ha), were recorded at harvested and presented in table. The data shows that there is significant effect of different treatment on straw yield and this data are displayed in table 2

At harvest maximum Straw yield was recorded at 12.71 kg/ha, was found in the treatment T4, (100% RDF + Vermicompost @ 3t/ha), which was statistically significant. This was followed by **T5**, (75% RDF + Vermicompost @ 3 t/ha) with straw yield recorded at 12.09 kg/ha. The lowest straw yield was recorded in the control treatment (**T1**), which received no additional nutrient supplementation, showed the lowest grain yield at 9.05 kg/ha.

The probable reason for the maximum straw yield in black rice in **T4** (100% RDF + Vermicompost @ 3t/ha), could be due to application of vermicompost. Carried out a study to identify the effect of vermicompost on yield characteristics of paddy. The yield of paddy with the amendment of vermicompost showed notable increase in 12.71 kg plot-1 vermicompost amendment with regular farmers practice. Jayakumar *et al*. (2011).

Table 2 Effect of Integrated Nutrient Management of Straw yield of Black Aromatic Rice

|  |  |
| --- | --- |
| **Treatment** | **Straw yield (kg/ha)** |
| **T1 – Control** | 9.05 |
| **T2 – 100% RDF + FYM @ 5t/ha** | 11.37 |
| **T3 –75% RDF + FYM @ 5t/ha**  | 11.30 |
| **T4 –100% RDF + Vermicompost @ 3t/ha**  | 12.71 |
| **T5 - 75% RDF +Vermicompost @ 3t/ha** | 12.09 |
| **T6 – 100% RDF + Rhizobium + PSB** | 11.37 |
| **T7 – 75% + RDF + Rhizobium + PSB** | 11.36 |
| **T8 – 100% RDF + Rhizobium + PSB + Vermicompost @ 3t/ha** | 10.12 |
| **F test** | S |
| **SE(d±)** | 0.527373 |
| **CD (P=0.05)** | 1.131103 |

**Harvest Index:**

The harvest index (%), were recorded at harvested and presented. The data shows that there is significant effect of different treatment on harvest index and this data are displayed in graph 1.

At harvest maximum harvest index was recorded at 14.30%, was found in the treatment **T4**, (100% RDF + Vermicompost @ 3t/ha), which was statistically significant. This was followed by **T5**, (75% RDF + Vermicompost @ 3t/ha) with harvest index recorded at 14.6%. The lowest straw yield was recorded in the control treatment (**T1**), which received no additional nutrient supplementation, showed the lowest grain yield at 8.84%.

The maximum harvest index recorded at T4, (100% RDF + Vermicompost @ 3t/ha), this might be the application of vermicompost during critical growth. Vermicompost significantly increased the water holding capacity, porosity, drainage as well as microbial activity in soil (Albanell *et al*., 1988).

Graph 1 Effect of Integrated Nutrient Management on Harvest Index 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 yield parameters *i.e* maximum grain yield (2.06 kg/ha), maximum straw yield (12.71 kg/ha) and highest harvest index (14.30%) after harvestingand moreover, it is seen that under T4 (100% RDF + Vermicompost @ 3t/ha). The approach 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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**REFERENCES**

Albanell, E., Plaixats, J., Cabrero, T., 1988. Chemical changes during vermicomposting (*Eisenia fetida*) of sheep manure mixed with cotton industrial wastes. Biology and Fertility of Soils 6, 266-269.

Hu C, Zawistowski J, Ling WH and Kitts DD. 2003. Black rice (Oryza sativa L. indica) pigmented fraction suppresses both reactive oxygenspecies and nitric oxide in chemical and biological model systems. *Journal Agriculture Food Chemistry*, 51: 5271–5277.

Jayakumar, M., Sivakami, T., Ambika, D. and Karmegam, N. (2011). Effect of turkey litter (*Meleagris gallopavo* L.) vermicompost on growth and yield characteristics of paddy, *Oryza sativa* (ADT-37). *African Journal of Biotechnology*. **10**(68): 15295-15304.

Kong L, Wang Y and Cao Y. 2008. Determination of Myo-inositol and D-chiro-inositol in black rice bran by capillary electrophoresis with electrochemical detection. *Journal of Food Composition and Analysis*, 21 (6):501-504.

Lingaiah, N., Venkanna, V. and Cheralu, C. (2014). Genetic variability analysis in rice (*Oryza sativa* L.). *Int. J. Pure App. Biosci*. **2** : 203- 04.

Oikawa, T., Maeda, M., Oguchi, T., Yamaguchi, T., Tanabe, N., Ebana, K., Yano, M., Ebitani, T., Izawaa, T., 2015. The Birth of a Black Rice Gene and Its Local Spread by Introgression. The Plant Cell 27, 2401–2414. DOI: https://doi.org/10.1105/ tpc.15.00310

Pandey, N., Verma A.K., Anurag and Tripathi, R.S. (2007). Integrated nutrient management in transplanted hybrid rice (*Oryza sativa* L.)*. Journal of Agronomy* 52(1):40-42.

Saha S. 2016. Black rice: the new age super food (an extensive review). American International Journal of research in formal, applied & natural sciences, 16(1):16-322.

Sinha RK, Heart S, Valani D, Chauhan K. Vermiculture and sustainable agriculture. Am.-Eurasian. J agric. environ. Sci. 2009;5(S):1-55.

Sowmya, C., Ramana, M.V. and Kumar, M. (2011). Effect of systems of rice cultivation and nutrient management options on yield, nutrient uptake and economics of rice. *Crop Research (Hisar)*42 (½): 3,69.

Sultana, S. and D. S. Ningthoujam, 2023. Evaluation of plant growth promoting potential and biocontrol activities of *Bacillus sp. Strain CA2*, a rhizobacteria from *chakhao amubi,* J. Soils and Crops, **33**(1): 78-84.

Suzuki M, KimurT, Yamagishi K, Shinmoto H and Yamak K. 2004.Comparison of mineral contents in 8 cultivars of pigmented brown rice. Nippon Shokuhin Kagaku Kogaku Kaishi, 51(58):424-427.

Takashi I, Bing X, Yoichi Y, Masaharu N and Tetsuya K. 2001. Antioxidant activity of anthocyanin extract from purple black rice. Journal of Medicinal Food, 4:211-218.

Zhang M W, Guo BJ and Peng Z M. 2005. Genetic effects on grain characteristics of indica black rice and their uses on indirect selections for some mineral element contents in grains. Genetic Resource. Crop Evolution.52:1121–1128.