**Effect of Integrated Nutrient Management on Yield Attributes 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 yield of black aromatic rice. The study recorded significance difference among treatments in terms of grain yield, straw yield and harvest index 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 grain yield, straw yield and harvest index.

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

**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)**

**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 spikelets 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:**

The ratio of economic yield (seed yield) to biological yield was worked out to estimate harvest index as per formula given by Singh and Stoskopf, 1971.

Harvest index (%) =

**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 1.

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 (Probodhini, 1994; Sinha *et al*., 2009).

Table 1 Effect of integrated nutrient management on 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 |
| **SEd±** | 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. Vermicompost provides required plant elements notably nitrate, phosphate and exchangeable calcium and soluble potassium (Das, 1996).

Table 2 Effect of integrated nutrient management on 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 |
| **SEd±** | 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.

**REFERENCES**

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

Bajpai, R.K., Chitale, S., Upadhyay, S.K. and Urkurkar ,J.S.(2006). Longterm studies on soil physico-chemical properties and productivity of rice-wheat system as influenced by integrated nutrient management in Inceptisols of Chhattisgarh. *Journal of the Indian Society of Soil Science* ;54(1):24-29.

Biswas, J.K. (2018). A few words on black rice. *Malaysian Journal of Halal Research*, 1 (1); 1-2.

Das, P.K. (1996). Inorganic Farming and Sustainable Agriculture. National Seminar. Puat, G.B. (Ed), Pantnagar, India, p. 45.

Doan, T. T., Henry-des-Tureaux, T., Rumpel, C., Janeau, J. L. and Jouquet, P. (2015). Impact of compost, vermicompost and biochar on soil fertility, maize yield and soil erosion in Northern Vietnam: a three year mesocosm experiment. *Sci. Total Environ*. **514**: 147-154.

Jha, P., Das, A.J. and Deka, S.C. (2017). Optimization of saccharification conditions of black rice (cv. Po ire ton) using microbial strains through response surface methodology. *Journal of the Institute of Brewing*, 123: 423-431.

Kangwan, N.,Komsak,P.,Watcharaporn,P.,Payungsak,T.,Orada,C. and Maitree,S.(2015). Learning and Memory Enhancing Effects of Anthocyanin in Black Rice Extract on Cerebral Ischaemia in Mice.” *Science Asia* 41:315-321.

Probodhini, J. (1994). Recycle kitchen waste into vermicompost. *Indian Farming.*, 43(12): 34.

Sinha, R., Sunil, H., Dalsukhbhai,V. and Chauhan,K.A. (2009). Earthworms Vermicompost: A powerful crop nutrient over the conventional compost & protective soil conditioner against the destructive chemical fertilizers for food safety and security*. Amer.-Eurasian J. Agric. Environ. Sci.*, 5(S): 01-55.

Thomas, R., Wan-Nadiah, W.A. and Bhat, R. (2013). Physiochemical properties, proximate composition, and cooking qualities of locally grown and imported rice varieties marketed in Penang, Malaysia. *International Food Research Journal*, 20(3):1345-1351.

Togas, R., Yadav, L. R., Choudhary, S. L. and Shisuvinahalli, G. V. (2017). Effect of Integrated use of Fertilizer and Manures on Growth, Yield and Quality of Pearl Millet. *International Journal of Current Microbiology and Applied Sciences, 6*(8): 2510-2516.

Upadhyay, V.B., Jain. V., Vishwakarma, S.K. and Kumhar, A.K. (2011). Production potential, soil health, water productivity and economics of rice (*Oryza sativa*)–based cropping systems under different nutrient sources. *Indian Journal of Agronomy*. 56(4): 311–16.

Welch, R. M. (2005). Biotechnology, biofortification, and global health. *Food and Nutrition Bulletin*, *26*(4), 419421.

Yuniarti, A., Machfud, Y., Damayani, M. and Solihin, E. (2019). The application of various types of organic fertilizer and N, P, K combination on soil fertility, growth and yield of black rice. In IOP Conference Series: *Earth and Environmental Science*; 393(1), p. 012019).