**Response of Nano Fertilizers on Growth attributes of Black Aromatic Rice (*Oryza sativa* L. indica)**

**Abstract**

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. A present investigation was carried out during the *Kharif s*eason of 2024 at Himalayan University farm, Jollang, Itanagar, to determine the response of nano fertilizer on growth of black aromatic rice (*Oryza sativa* L. *indica*). The experiment was outlined in a Randomized Block Design (RBD) with eight treatment and three replications. The treatment included combination Nano Nitrogen and Nano Zinc. The study recorded significance difference among treatments in terms of plant height, leaf length, number of tillers, dry weight and width of leaves of plant at 30, 60 and 90 DAT. The result revealed that the treatment T5 (Nitrogen at 4ml/L + Nano Zinc at 2ml/L) was found to be best treatment for obtaining maximum plant height, leaf length, number of tillers, dry weight and width of leaves, this indicating the combined effect of nano fertilizer on black aromatic rice.

**Keywords:** Nano fertilizers, Nano nitrogen, Nano zinc, Black aromatic rice, Days after transplanting

**Introduction**

“Oryza sativa L., the rice species from which black rice is derived, is a very advantageous rice species” (Agarwal, 2021). “Rice has been a staple food worldwide. As a result, more than half of the population consumes it regularly. According to the look of rice bran, there are several sorts of rice, such as black, brown, red and white rice” (Prasad *et al*.,2019). “In some cultures, forbidden rice is also known as black rice. It is also known as king, heaven, royal and valued” ( Thanuja*et al*., 2018). “This shows different colours due to pigments in rice varieties. Black rice production has a long history in nations like India, Thailand, China and Indonesia. Black rice is produced mainly in India and China” ( Prasad*et al*., 2019)). “Asian countries make over 90% of black rice**.** Black rice has a deep black colour and usually turns deep purple when cooked. It is suitable for creating pooridge, dessert, cake, bread, kheer, noodles and many other dishes. The Japanese researchers analyzed 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). “Rice has white, red, purple, and black colours based on its pigment. Pigmented rice contains anthocyanins, which have the potential to be used as a source of antioxidants apart from being a source of starch” (Hosoda*et al*., 2018)

“The term ‘black rice’ actually refers to a variety of rice types from the species Oryza sativa, and is descriptive of the colour of grain, rather than other properties. Black rice also comes in a number of short grain, long grain and glutinous varieties similar to brown rice. The dark purple colour of Black rice is due to the high anthocyanin content, located in the pericarp layers” (Takashi *et al*., 2001). “The uniqueness of the black aromatic rice of Manipur is its pleasant aroma and color coupled with stickiness which is not common in other black rice grown in other parts of the world. The local name of this black rice is Chak-hao. Black rice owes its color to powerful natural black coloring pigments called anthocyanins which boost an impressive antioxidant activity adding to health benefits of this rice variety. It also -oryzanol,γconsists of pharmacological compounds such as phenolic and flavonoid compounds” (Balasubramaniam*et al*., 2019). “Aromatic rice are special group of rice with nutty or popcorn like aroma. They possess scent in their plant parts and grain” (Ahuja*et al*., 2008). “In most countries aromatic rices commands higher prices in the market” (Singh *et al*., 2000). “The colored rice varieties are considered to have numerous health benefits. Black rice (*Oryza sativa* L. *indica*), is a special cultivar of rice which contains remarkably high anthocyanin pigments in the aleurone layer thanBlack 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” (Kushwaha, 2016) “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 Srilanka (8.6%), Indonesia (7.2%), India (5.1%), Bangladesh (4.1%) and few in Malaysia” (Chaudhary, 2003). So far they have developed 200 varieties including 52 high yielding varieties (Biswas, 2018)

In the world of agriculture, foliar application of nano fertilizers has emerged as a promising technique that offers prospective solutions to improve crop yield, lower environmental impact and increase nutrient uptake efficiency. Rice plant require large amounts of mineral nutrients, including nitrogen for their growth, development and grain production (Ma, 2004). Nitrogen is a major nutrient for plant that primarily influences vegetative growth and crop yield (Gnaratnam*et al*., 2019). Nano nitrogen enhances plant uptake while simultaneously reducing environmental losses. For a steady and controlled release of nutrients into the soil, nano nitrogen is a suitable substitute for traditional fertilizers. Without sacrificing soil productivity, nano urea improves crop production, soil health and nutritional quality while reducing the requirement for conventional urea by half or more. (Quijano-Guerta*et al*., 2002).During the early and midtillering, panicle initiation, booting, and grain development phases of ripening, Nitrogen is the most typically required nutrient element. (Bai, 2019). N has an important role in the creation of rice quality. Increasing Nitrogen fertilization can help improve the nutritional quality and processing quality of rice, but excessive Nitrogen fertilization can increase rice chalkiness and worsen the rice appearance quality, cooking and eating quality. (Li *et al*., 2019). Among the major nutrient elements, nitrogen (N) is the most important and limiting nutrient for rice crop growth and yield which is required in higher amounts compared to other nutrients.(Djaman, 2019). Zinc is an essential trace element required in small but critical amounts by both plants and animals (including humans). Many microorganisms exist in the range of hundreds of nanometers to tens of micrometers. ZnO-NPs have a higher specific surface area and better surface reactivity because of their smaller particle size, which contributes to their appealing antibacterial qualities (Seil, 2012)

**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, T3 – 100% RDF + Nano Nitrogen at 4ml/L, T4 - 100% RDF + Nano Zinc at 2ml/L, T5 – 100% RDF +Nano Nitroegn at 4ml/L + Nano Zinc at 2ml/L, T6 – 80% RDF + Nano Nitrogen at 4ml/L, T7 – 80% RDF + Nano Zinc at 2ml/L, T8 - 80% RDF + Nano Nitrogen at 4ml + Nano Zinc at 2ml/L. The experiment was carried out in Randomized Block Design (RBD) in the year 2024 – 2025.

The climate condition of Itanagar is humid subtropical 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.Meterological 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 DISCUSSION**

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 T5, which included 100% recommended dose of fertilizers (RDF) along with Nano Nitrogen at 4 ml/L and Nano Zinc at 2 ml/L, resulting in an average height of 65.9 cm. Treatment T4, consisting of 100% RDF and Nano Zinc at 2 ml/L, produced a height of 64 cm, with no significant difference compared to T5. The shortest plants, measuring 59.8 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 T5 which included 100% recommended dose of fertilizers (RDF) along with Nano Nitrogen at 4 ml/L and Nano Zinc at 2 ml/L, resulting in average height of 111.5 cm. and T4 consisting of 100% RDF and Nano Zinc at 2 ml/L, giving an average height of 109.3 cm. The shortest plants, measuring 92.8cm, were recorded in the control treatment (T1), which did not receive any additional inputs. At 90 DAT, the greatest plant height was observed intrreatment T5, which included 100% recommended doseof fertilizer (RDF) along with Nano Nitrogen at 4 ml/L and Nano Zinc at 2 ml/L, resulting in an average height of 150.9 cm. Treatment T4, consisting of 100% RDF and Nano Zinc at 2 ml/L, produced a plant height of 148.6 cm, with no significant difference compared to T5. The shortest plants, measuring 123.6 cm, were recorded in the control treatment (T1), which did not receive any additional inputs

“Taller plants recorded with the application of higher dose of fertilizer application might be due to increased availability of nutrients, especially nitrogen during initial growth stages which might have resulted in better root and shoot growth. Further, nano-sprays of nitrogen and zinc due to their unique properties of nano size particles and higher surface area helps in easier and efficient uptake of nutrients inside plant parts. Zinc in addition, has an important and crucial role in various physiological and biochemical processes resulting in improved metabolism of growing plants, cell and internodal elongation and increased availability of zinc also resulted in improving photosynthetic activity and ultimately increased plant height. Moreover, nitrogen and zinc application were reported to have positive interaction in combination and have resulted in higher plant height. Significantly, shorter plants were recorded at 50% N treatment without any spray, which could be attributed to inadequate supply of nutrients, mainly nitrogen to rice crop, particularly during initial stages of plant growth which resulted in poor crop growth. The results of increased plant height with higher nitrogen fertilization have also been reported by” (Verma*et al*., 2017)

Table 1. Effect of Nano fertilizers on plant height of Black aromatic rice

|  |  |
| --- | --- |
| **Treatment**  | **Plant height (cm)** |
| **30 DAS** | **60 DAS** | **90 DAS** |
| **T1 - Control** | 59.8 | 92.8 | 123.6 |
| **T2 – 100% RDF** | 61.7 | 103.2 | 128.4 |
| **T3 – 100% + Nano Nitrogen 4ml/ L** | 63.5 | 106.1 | 142.8 |
| **T4 – 100% RDF + Nano Zinc 2ml/L** | 64 | 109.3 | 148.6 |
| **T5 - 100% RDF +Nano Nitrogen 4ml/ L+ Nano Zinc 2ml/L** | 65.9 | 111.5 | 150.9 |
| **T6 – 80% RDF + Nano Nitrogen 4ml/ L** | 63 | 105.06 | 140.4 |
| **T7 – 80% RDF + Nano Zinc 2ml/L** | 62.1 | 104.1 | 130.4 |
| **T8 – 80% RDF + Nano Nitrogen 4ml/ L+ Nano Zinc 2ml/L** | 60.7 | 101.6 | 127.4 |
| **F test** | S | S | S |
| **S.Ed±** | 0.8419 | 2.9825 | 1.5931 |
| **CD (P=0.05)** | 1.805865 | 6.396845 | 3.416865 |

**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 T5, which included 100% recommended dose of fertilizers (RDF) along with Nano Nitrogen at 4 ml/L and Nano Zinc at 2 ml/L, resulting in an average length of 46.7 cm. Treatment T4, consisting of 100% RDF and Nano Zinc at 2 ml/L, produced a leave length of 45.5 cm, with no significant difference compared to T5. The shortest plants, measuring 41.7 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 T5 which included 100% recommended dose of fertilizers (RDF) along with Nano Nitrogen at 4 ml/L and Nano Zinc at 2 ml/L, resulting in average height of 83.1 cm. and T4 consisting of 100% RDF and Nano Zinc at 2 ml/L, 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.

The greater leaf length observed in treatment T5 (100% RDF + Nano Nitrogen @ 4 ml/L + Nano Zinc @ 2 ml/L) compared to the shortest leaf length in treatment T1 (Control) can likely be attributed to the positive effects of nano nitrogen and nano zinc on black rice growth. Nano urea enhances nitrogen uptake by releasing nutrients in a controlled manner, ensuring a steady supply of nitrogen to the plants. Its nano-sized particles allow for more efficient absorption through the roots, leading to better nutrient utilization. These findings align with those reported by Sahu*et al*. (2022).

Table 2. Effect of Nano fertilizers on leaf length of Black aromatic rice

|  |  |
| --- | --- |
| **Treatments** | **Leaf length (cm)** |
| **30 DAS** | **60 DAS** | **90 DAS** |
| **T1 - Control** | 41.7 | 74.2 | 84.9 |
| **T2 – 100% RDF** | 43.2 | 76.5 | 85.7 |
| **T3 – 100% RDF + Nano Nitrogen 4ml/ L**  | 44.8 | 79.6 | 91.1 |
| **T4 – 100% RDF + Nano Zinc 2ml/L**  | 45.5 | 81.1 | 92.7 |
| **T5 - 100% RDF +Nano Nitrogen 4ml/ L+ Nano Zinc 2ml/L** | 46.7 | 83.1 | 93.8 |
| **T6 – 80% RDF + Nano Nitrogen 4ml/ L** | 44.4 | 79.5 | 89.9 |
| **T7 – 80% RDF + Nano Zinc 2ml/L** | 44.1 | 79.2 | 88.9 |
| **T8 – 80% RDF + Nano Nitrogen 4ml/ L+ Nano Zinc 2ml/L** | 42.6 | 75.9 | 85.1 |
| **F test** | S | S | S |
| **S.Ed±** | 1.0496 | 1.9238 | 1.3489 |
| **CD (P=0.05)** | 2.059025 | 4.126221 | 2.970275 |

**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 T5, which received 100% of the recommended dose of fertilizers (RDF) along with Nano Nitrogen (4 ml/L) and Nano Zinc (2 ml/L), recorded the highest number of tillers (15.7), and this difference was statistically significant. This was followed by treatment T4, which received 100% RDF and Nano Zinc (2 ml/L), with an average tiller count of (15.3). The lowest number of tillers (11.4) was observed in the control treatment (T1), which did not receive any additional nutrient inputs. At 60 DAT, treatment T5, which received 100% of the recommended dose of fertilizers (RDF) along with Nano Nitrogen (4 ml/L) and Nano Zinc (2 ml/L), recorded the highest number of tillers (21.4), and this difference was statistically significant. This was followed by treatment T4, which received 100% RDF and Nano Zinc (2 ml/L), with an average tiller count of (19.5). The lowest number of tillers (14.4) was observed in the control treatment (T1), which did not receive any additional nutrient inputs. At 90 DAT, treatment T5, which received 100% of the recommended dose of fertilizers (RDF) along with Nano Nitrogen (4 ml/L) and Nano Zinc (2 ml/L), recorded the highest number of tillers (23.1), and this difference was statistically significant. This was followed by treatment T4, which received 100% RDF and Nano Zinc (2 ml/L), with an average tiller count of (22.5). The lowest number of tillers (17.7) 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 increase of supply of nitrogen and zinc to plants, which accelerated the activity of enzyme involved in photosynthesis, carbohydrats metabolism cell division and cell elongation (Beersa , 2018 and Uma, 2019)

Table 3. Effect of Nano fertilizers on total number of tillers of Black aromatic rice

|  |  |
| --- | --- |
| **Treatments** | **Total number of tillers** |
| **30 DAS** | **60 DAS** | **90 DAS** |
| **T1 - Control** | 11.4 | 14.4 | 17.7 |
| **T2 – 100% RDF** | 12.9 | 18.2 | 21.3 |
| **T3 – 100% RDF + Nano Nitrogen 4ml/ L**  | 14.7 | 19.4 | 21.9 |
| **T4 – 100% RDF + Nano Zinc 2ml/L**  | 15.3 | 19.5 | 22.5 |
| **T5 - 100% RDF +Nano Nitrogen 4ml/ L+ Nano Zinc 2ml/L** | 15.7 | 21.4 | 23.1 |
| **T6 – 80% RDF + Nano Nitrogen 4ml/ L** | 13.8 | 18.8 | 21.7 |
| **T7 – 80% RDF + Nano Zinc 2ml/L** | 13.4 | 18.3 | 21.5 |
| **T8 – 80% RDF + Nano Nitrogen 4ml/ L+ Nano Zinc 2ml/L** | 12.5 | 17.3 | 19.6 |
| **F test** | S | S | S |
| **S.Ed±** | 0.8048 | 1.4247 | 0.9788 |
| **CD (P=0.05)** | 1.726171 | 3.055701 | 2.099324 |

**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 T5, which received (100%RDF + Nano Nitrogen @ 4ml/L + Nano Zinc @ 2ml/L), exhibited the highest dry weight of 1.93kg, a statistically significant result. This was closely followed by Treatment T4, ( 100% RDF + Nano Nitrogen @ 4ml/L), recording an average dry weight of 1.87kg. The lowestfry weight was obsereved 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 T5, which received (100%RDF + Nano Nitrogen @ 4ml/L + Nano Zinc @ 2ml/L), exhibited the highest dry weight of 3.7kg, a statistically significant result. This was closely followed by Treatment T4, ( 100% RDF + Nano Nitrogen @ 4ml/L), recording an average dry weight of 3.42kg. The lowest dry weight was observed in control group (T1), which received no additional nutrient supplementation, showed the lowest dry weight at 2.91kg. At 90 days after transplanting (DAT), Treatment T5, which received (100%RDF + Nano Nitrogen @ 4ml/L + Nano Zinc @ 2ml/L), exhibited the highest dry weight of 8.72g, a statistically significant result. This was closely followed by Treatment T4, ( 100% RDF + Nano Nitrogen @ 4ml/L), recording an average dry weight of 7.93g. The lowest dry weight was observed in control group (T1), which received no additional nutrient supplementation, showed the lowest dry weight at 5.87g.

 The likely reason for the observed increase in dry matter production can be attributed to the elevated levels of nitrogen application, which tend to stimulate vegetative growth by enhancing plant height and promoting the development of a greater number of tillers per square meter. This cumulative effect of increased structural biomass and tillering capacity consequently leads to a substantial rise in the overall accumulation of dry matter within the plant system (Wani*et al*., 2016)

Figure 2. Effect of Nano Fertilizers on dry weight of Black aromatic rice

**CONCLUSION**

Based on comprehensive study, it concluded that the utilizing of nano fertilizer on black aromatic rice shows the most favourable outcomes across growth parameters*i.e* highest plant height (150 cm), highest leaf length (93.8 cm), highest number of tillers (23.1) and highest dry weight (8.72) at 90 DAS and moreover, it is seen that under T5 ( Nano Nitrogen + Nsno Zinc) . The approachthe use of nanofertilizer not only boosts productivity but also improves soil health, supporting sustainable agriculture in soils. T5 demonstrated superior performance, showcasing optimal growth parameters proved to be the most effective treatment among all the mentioned treatments.

**DISCLAIMER**

I Basu Hali, hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of the manuscript.

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