



Influence of Nano Fertilizers on Yield of Black Aromatic Rice (*Oryzasativa L. indica*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Present investigation was carried out during the *Kharif* Season of 2024 at Himalayan University farm, Jollang, Itanagar, to determine the response of nano fertilizer on yield of black aromatic rice (*Oryzasativa L. indica*). The experiment was outlined in a Randomized Block Design (RBD) with eight treatments and three replications. The treatments included combination nano nitrogen and nano zinc. The study recorded significance difference among treatments in terms of yield *i.e.*, grain yield, straw yield and harvest index after harvesting of the rice. The result revealed that the treatment T₅ (nano nitrogen at 4ml/L + nano zinc at 2ml/L) was found to be best treatment for obtaining maximum grain yield (1.86kg/ha), straw yield (13 kg/ha) and harvest index (12.85 %) this indicating the combined effect of nano fertilizer on black aromatic rice.

Keywords: Nano fertilizers; nano nitrogen; nano zinc; black aromatic rice.

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1. INTRODUCTION

Oryzasativa 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 porridge, 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; Agrawal, 2021).

"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. 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 (*Oryzasativa* L. *indica*), is a special cultivar of rice which contains remarkably high anthocyanin pigments in the aleurone layer than 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. 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. 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, 2018). "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).

2. MATERIALS AND METHODS

The experiment was carried out at agriculture field, Jollang, College of Agriculture, Himalayan University, Itanagar, Arunachal Pradesh 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 varieties 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 nitrogen 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.

3. YIELD ATTRIBUTES

3.1 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).

3.2 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.

3.3 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.

$$\text{Harvest index (\%)} = \frac{\text{Economic Yield}}{\text{Biological Yield}} \times 100$$

4. RESULTS AND DISCUSSION

4.1 Grain Yield

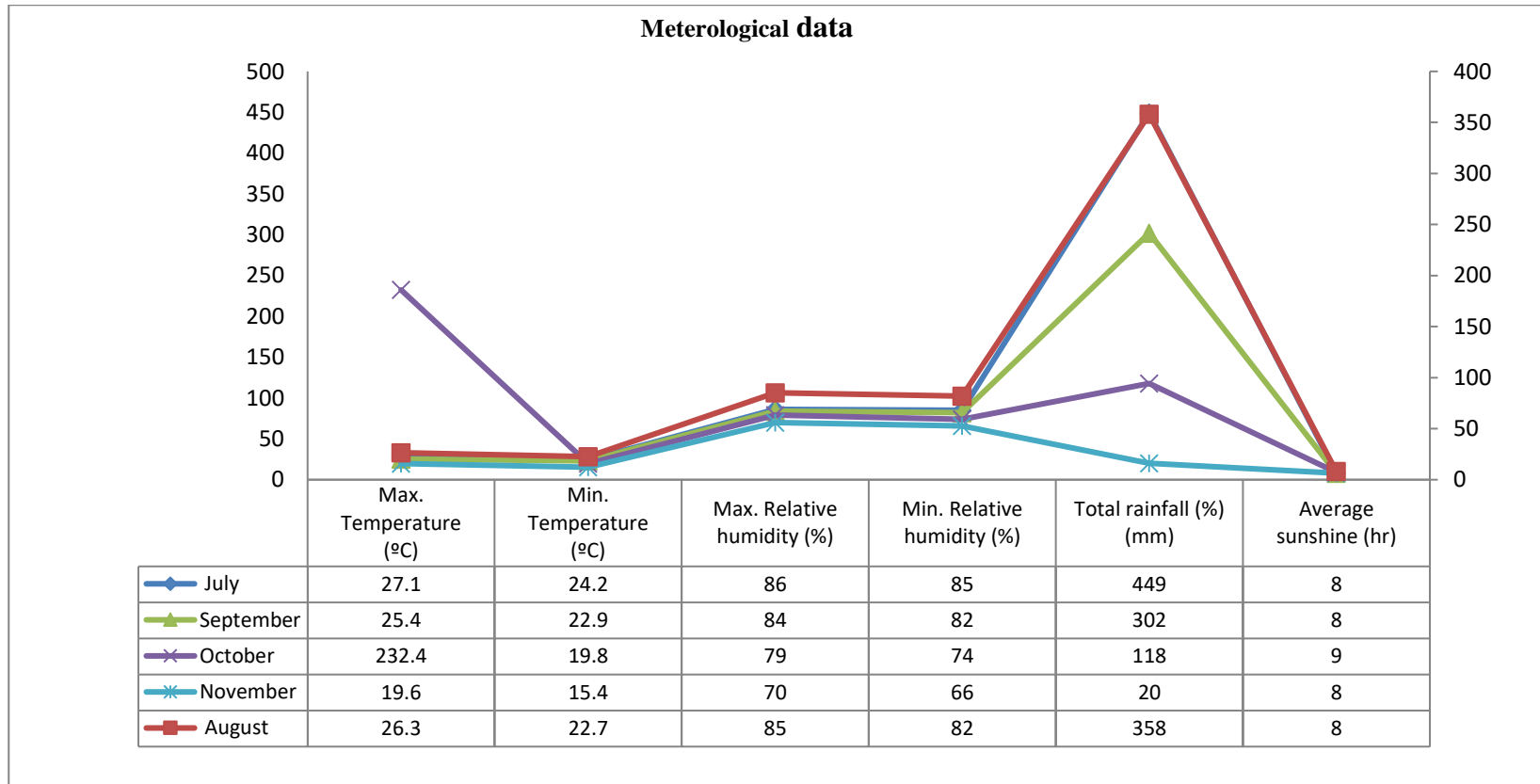
The grain yield (kg/ha), were recorded at harvested and presented in Table 1. The data shows that there is significant effect of different treatment on grain yield and this data are displayed in Table 1.

At harvest maximum grain yield was recorded at 1.86 kg/ha, was found in the treatment T₅, (100% RDF + nano nitrogen @ 4 ml/L + nano zinc @ 2 ml/L), which was statistically significant. This was followed by T₄, (100% RDF + nano nitrogen @ 4 ml/L) with grain yield recorded at 1.86 kg/ha. The lowest grain yield (1.05 kg/ha) was recorded in the control treatment (T₁), which received no additional nutrient supplementation.

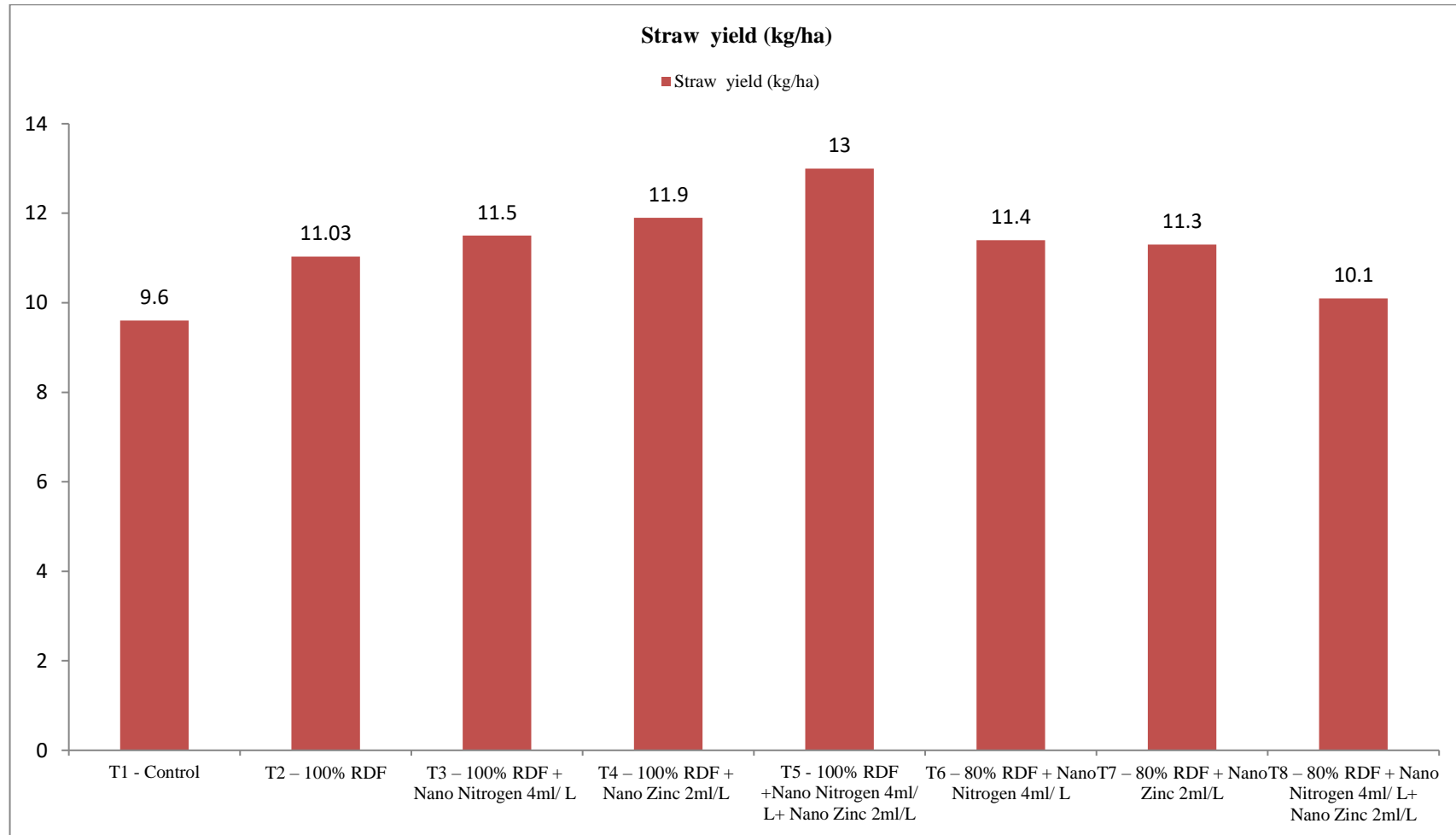
The probable reason for the maximum grain yield in black rice in T₅(100% RDF + Nano Nitrogen @ 4 ml/L + Nano Zinc @ 2 ml/L), could be due to combined application of nano particles of nano N as foliar at tillering and panicle initiation and foliar spray of nano Zn at tillering stage is mainly attributed to higher straw yield components and also stimulation effect of zinc which helps increasing enzymatic activity. (Muthukumaraja and Sriramachandrasekharam, 2012; Kushawa, 2016; Verma et al., 2017).

4.2 Straw Yield

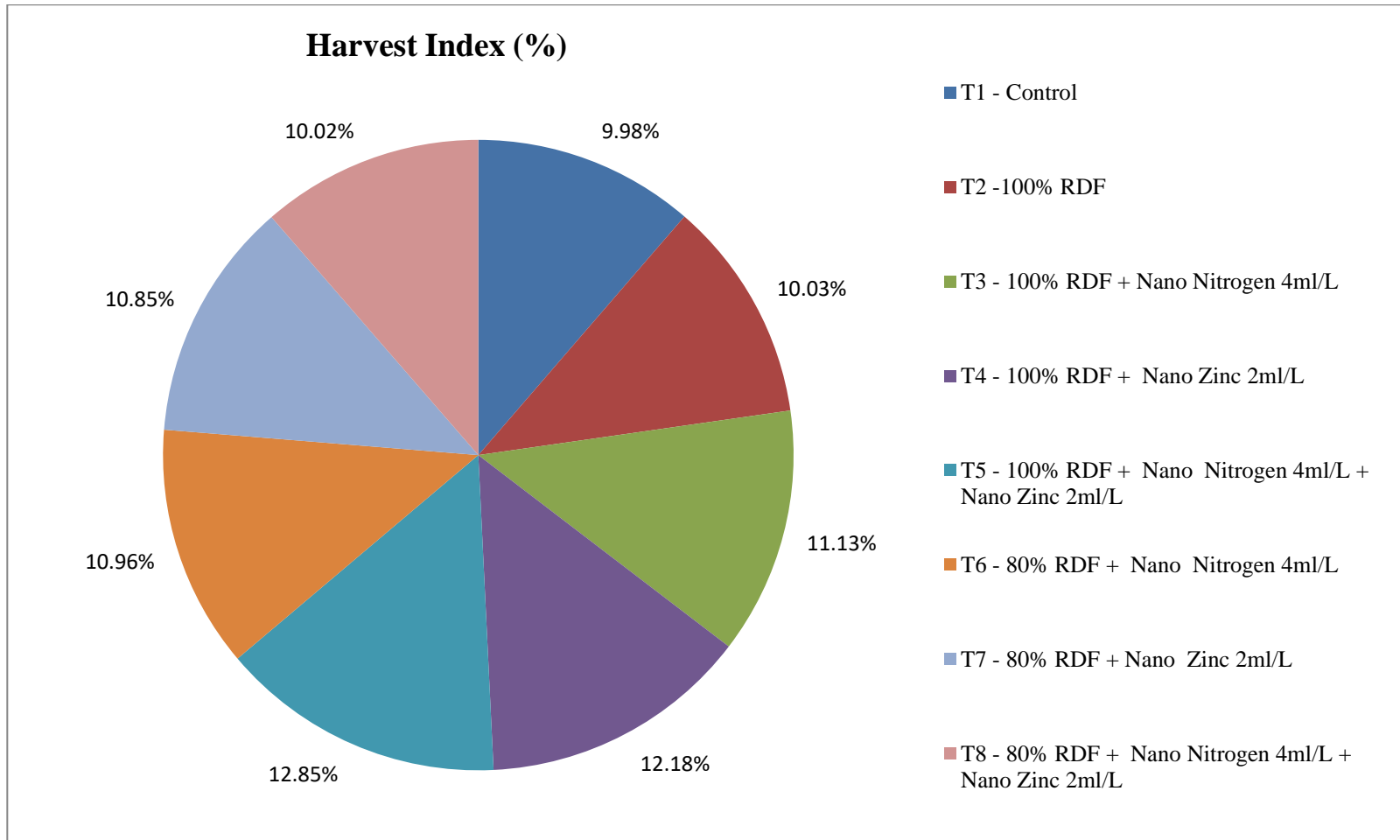
The straw yield (kg/ha), were recorded at harvested and presented in table. The data shows that there is significant effect of different treatment on straw yield and this data are displayed in Table 2.



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



Graph 2. Effect of nano fertilizer on straw yield of Black aromatic rice. Data are mean of 3 replications



Graph 3. Effect of Nano fertilizer on Harvest Index of Black aromatic rice. Data are mean of 3 replications

Table 1. Effect of nano fertilizer on grain yield of Black aromatic rice. Data are mean of 3 replications

Treatment	Grain Yield (Kg/ha)
T ₁ – Control	1.05
T ₂ – 100% RDF	1.13
T ₃ – 100% RDF + Nano Nitrogen 4ml/ L	1.42
T ₄ – 100% RDF + Nano Zinc 2ml/L	1.65
T ₅ - 100% RDF +Nano Nitrogen 4ml/ L+ Nano Zinc 2ml/L	1.86
T ₆ – 80% RDF + Nano Nitrogen 4ml/ L	1.39
T ₇ – 80% RDF + Nano Zinc 2ml/L	1.24
T ₈ – 80% RDF + Nano Nitrogen 4ml/ L+ Nano Zinc 2ml/L	1.12
F test	S
SEd±	0.2200
CD (P=0.05)	0.472014

Table 2. Effect of nano nitrogen and nano zinc on straw yield (kg/ha)

Treatment	Straw yield (kg/ha)
T ₁ - Control	9.6
T ₂ – 100%RDF	11.03
T ₃ – 100%RDF + Nano Nitrogen 4ml/L	11.5
T ₄ – 100%RDF + Nano Zinc 2ml/L	11.9
T ₅ - 100% RDF + Nano Nitrogen 4ml/ L+ Nano Zinc 2ml/L	13
T ₆ – 80%RDF + Nano Nitrogen 4ml/L	11.4
T ₇ -80% RDF + Nano Zinc 2ml/L	11.3
T ₈ -80% RDF + Nano Nitrogen 4ml/L + Nano Zinc 2ml/L	10.1
F test	S
SEd ±	0.8396
CD(P = 0.05)	1.800948

At harvest maximum Straw yield was recorded at 1.86 kg/ha, was found in the treatment T₅, (100% RDF + Nano Nitrogen @ 4 ml/L + Nano Zinc @ 2 ml/L), which was statistically significant. This was followed by T₄, (100% RDF + Nano Nitrogen @ 4 ml/L) with straw yield recorded at 1.65 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 1.05 kg/ha.

The probable reason for the maximum straw yield in black rice in T₅ (100% RDF + Nano Nitrogen @ 4 ml/L + Nano Zinc @ 2 ml/L), could be due to combined application of nano particles of nano N as foliar at tillering and panicle initiation and foliar spray of nano Zn at tillering stage is mainly attributed to higher straw yield components and also stimulation effect of zinc which helps increasing enzymatic activity. (Muthukumaraja and Sriramachandrasekharam, 2012).

4.3 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 12.85%, was found in the treatment T₅, (100% RDF + Nano Nitrogen @ 4 ml/L + Nano Zinc @ 2 ml/L), which was statistically significant. This was followed by T₄, (100% RDF + Nano Nitrogen @ 4 ml/L) with harvest index recorded at 12.18%. The lowest straw yield was recorded in the control treatment (T₁), which received no additional nutrient supplementation, showed the lowest grain yield at 9.98%.

The maximum harvest index recorded at T₅, (100% RDF + Nano Nitrogen @ 4ml/L + Nano Zinc 2ml/L), this might be the foliar application of Nano-fertilizers during critical growth stages, which could provide an adequate supply of nutrients. These nutrients improve the functioning of meristematic cells, nutrient utilization efficiency, cell elongation, and promote grain development (Mehta et al., 2019).

5. CONCLUSION

Based on comprehensive study, it concluded that the utilizing of nano fertilizer on black aromatic rice shows the most favourable outcomes across yield parameters i.e maximum grain yield (1.86kg/ha), maximum straw yield (13 kg/ha) and highest harvest index (12.85 %) after harvesting and moreover, it is seen that under T₅ (Nano Nitrogen + Nano Zinc). The approach use of nanofertilizer not only boosts productivity but also improves soil health, supporting sustainable agriculture in soils. T₅ demonstrated superior performance, showcasing optimal yield parameters proved to be the most effective treatment among all the mentioned treatments.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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 this manuscript.

COMPETING INTEREST

Authors have declared that no competing interests exist.

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