

# **Combined application of inorganic fertilizer and organic manure with Nano urea on growth and yield of scented rice**

## **ABSTRACT**

Rice is a staple cereal grain for millions of the world population. Inorganic, organic and biofertilizer play crucial role in gaining higher production of scented rice. Excessive use of conventional fertilizer lowers the soil health. Therefore, there is a need for such a technology which will be able to achieve higher sustainable production. Nano urea is a nano technology which can provide a way to bring down the minus of conventional fertilizers. Keeping these in view, present investigation entitled the conjoint application of inorganic fertilizer and organic manure with Nano urea on growth and yield of scented rice was carried out at instructional farm unit, Krishi Nagar, JNKVV, Jabalpur during the rainy season of 2022 and 2023. Ten treatments combination was laid out in randomized block design with four replications. The results of present study revealed that application of 75% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at active tillering (AT) and panicle initiation (PI) registered maximum plant height (113.44 and 107.52 cm, respectively), no. of tillers hill<sup>-1</sup> (21.88 and 19.49, respectively) during both the years of experimentation. As regard to yield and yield attributes significantly maximum total no. of grains panicle<sup>-1</sup> (81 and 78, respectively), panicle length (28.23 and 27.19 cm, respectively), grain (4780 and 4418 kg ha<sup>-1</sup> respectively) and straw yield (6652 and 6432 kg ha<sup>-1</sup> respectively) was recorded with the application of 75% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at active tillering and panicle initiation during both the years of experimentation. Thus, the study suggests that trimming down the conventional fertilizer by using Nano urea and *Azospirillum* could help in gaining optimum yield. Also, combination of Nano urea with vermicompost and *Azospirillum* play important role in improving soil quality along and crop health.

*Keywords: Nano urea, inorganic fertilizer and organic manure, vermicompost and Azospirillum*

## **1. INTRODUCTION**

Rice is the staple cereal for millions of the world population. In world, rice occupies 437.80 million hectare (Mha) area in the year 2019 [1] alongside 177.64 million tons (MT) of production. India occupies 43.66 Mha area with the production of 118.87 MT [2]. Inorganic, organic and bio fertilizers are major sources of plant nutrients. These provides all essential major and micronutrients. At present, modern agriculture employs higher doses of fertilizer for higher yield but this declines the soil fertility. Continuous and excessive use of chemical fertilizers leads to soil and water pollution. Organic fertilizers offer a reward to the soil by replenishing mineral nutrient and improving soil health. It also lends a hand towards conservation of water and lowering the pollution. Likewise, biofertilizers are winning interest as they are eco-friendly and non-toxic. They play important role in nitrogen fixation. Nitrogen is one of the most important major plant nutrients of great magnitude to propel the yield of rice. Rice requires higher amount of nitrogen than any other nutrient and hence, a limiting factor that influences the yield of rice [3] so, it cannot be passed over. Inorganic fertilizer, organic manure and biofertilizers enhances the yield and yield attributes of rice [4]. Nitrogen is an integral part of chlorophyll and much of leaf nitrogen is incorporated in the chlorophyll which gives an indirect estimation of nutrient status [5]. Chlorophyll content shows a positive relationship with the grain yield of wheat crop [6]. Moreover, organic and inorganic fertilizer sustains environmental health. Inorganic fertilizers enhance the yield of crop while organic fertilizers improve the quality and aroma of rice [7]. It shows a positive relationship between growth, yield attributes and yield of rice [8]. Increasing

population that brought up poverty, alarms an urgent need for such a technology that can enhance the production to feed the overgrowing population without compromising the environmental health. Nano urea enters into the positive journey that could enhance the crop yield while sustaining the production. Nano urea technology, contains nano scale nitrogen particles which cuts down the load of traditional fertilizer by half or more while improving the crop production, soil health, and nutritional quality. Due to its nano size particles, it enhances nitrogen use efficiency and hence, the yield of crop [9]. Thus, a less expensive technology Nano urea could lower the input cost and benefit to marginal farmers. Keeping these points into consideration the present study was undertaken in order to achieve the objective combined application of inorganic fertilizer and organic manure with Nano urea on growth and yield of scented rice.

## 2. MATERIALS AND METHODS

The experiment was carried at instructional farm unit, Krishi Nagar, JNKVV, Jabalpur during the rainy season of 2022 and 2023. The soil of the experimental field was clay loam in texture, neutral pH, medium in OC (%), available N,  $P_2O_5$  and  $K_2O$  with normal electrical conductivity. Ten treatments comprised of T<sub>1</sub>, Control (0% N + 0% P + 0% K); T<sub>2</sub>, 100% N through urea + 100% P + 100% K (100:60:40 kg ha<sup>-1</sup>); T<sub>3</sub>, 75% N through urea + FS with Nano urea @ 4 ml litre<sup>-1</sup> at active tillering (AT) and panicle initiation (PI) stage; T<sub>4</sub>, 50% N through urea + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage; T<sub>5</sub>, 75% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage; T<sub>6</sub>, 50% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage; T<sub>7</sub>, 75% N through vermicompost + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage; T<sub>8</sub>, 50% N through vermicompost + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI; T<sub>9</sub>, 75% N through vermicompost + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage; T<sub>10</sub>, 50% N through vermicompost + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage was laid out in randomized block design with four replications. The recommended dose of fertilizer was 100:60:40. The fertilizer and manures were applied as basal. Except urea which was applied in split, 50% basal and rest 50 % in again two splits at active tillering and panicle initiation. Sources of phosphorus and potassium were SSP and MOP. Vermicompost and *Azospirillum* was also applied as basal. Nano urea @ 4ml litre<sup>-1</sup> of water was applied at AT and PI stage. Aromatic rice variety PS 4, was transplanted at 20x20 cm<sup>2</sup> with two seedlings hill<sup>-1</sup>. The harvesting of crop was done at 80-90% yellowing of panicles as the crop assessed to maturity. All the package of practices were done as per the recommendation of this area. Data on various growth and yield attributes were collected, tabulated and is presented in the form of table. After harvesting, grains were sun dried to bring optimum moisture percent in the crop. Finally, the grain and straw yield was taken and recorded as kg ha<sup>-1</sup>.

### Statistical procedure

The field data were statistically analyzed using OPSTAT software available online at CCS, HAU, Haryana [10]. The data so obtained was tabulated and statistically analyzed by using analysis of variance (F-test) as suggested by [11].

## 3. RESULTS AND DISCUSSION

### 3.1 Growth parameters

#### 3.1.1 Plant population (m<sup>2</sup>)

The results regarding plant population shows no significant difference among different treatments. This suggests that different nitrogen levels had no significant impact on plant population.

#### 3.1.2 Plant height (cm)

Plant height shows a comparison of different treatments (**Table 1**). It is clear from the table significantly maximum plant height (113.44 and 107.52 cm, respectively) in T<sub>5</sub>, 75% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI which was at par with T<sub>3</sub>, 75% N through urea + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI and T<sub>2</sub>, 100% N through urea + 100% P + 100% K (100:60:40 kg ha<sup>-1</sup>) during both the years of experimentation. This might be because of combination of different fertilizer that availed mineral nutrients. It is anticipated that foliar application of Nano urea with conventional fertilizers provided nutrients on demand at the critical stages, by better absorption and easy transportation of nitrogen during the critical period of crop growth. [12],[13] and [14] noted enhanced plant height with the application of Nano-nitrogen fertilizer.

[15] also observed more plant height with the application of 75% RDN + Nano urea (2 foliar spray) + P + K. Among the treatment combination with organic manure, T<sub>9</sub>, 75% N through Vermicompost + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage. *Azospirillum* showed supremacy of the combination with vermicompost, which readily availed essential nutrient. Moreover, vermicompost acted as a source of carbon for the growth of microbes. Thus, it makes out a complimentary effect than combined with urea [16].

### 3.1.3 Number of tillers hill<sup>-1</sup>

Number of tillers hill<sup>-1</sup> gives an estimate of plant growth and provides a basis for comparison of treatments (Table 1). Among the various treatments, significantly maximum no. of tillers hill<sup>-1</sup> (21.88 and 19.49, respectively) was observed with the application of T<sub>5</sub>, 75% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage which was at par with T<sub>3</sub>, 75% N through urea + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage over the other treatments. It is anticipated that more nitrogen provided by the treatment combination might have favored the vegetative growth. Foliar spray of Nano urea along with conventional fertilizer might have made available nitrogen at critical stages. Moreover, the Nano urea which was not used remain in the plant vacuole and slowly released so the efficient utilization of nitrogen for proper growth and development of the crop. Reduced particle size provides more surface area and hence, more number of particles unit<sup>-1</sup> of fertilizer thereby, surpass its absorption and nutrient uptake. [17] observed more no. of tillers with the combined application of urea and Nano urea. [18] also observed a greater number of tillers with 100% nano fertilizer. Among the treatment combination with organic manure T<sub>9</sub>, 75% N through vermicompost + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage found to be superior this may be because of vermicompost that availed nutrients with some plant growth hormones which favored the crop growth. Furthermore, *Azospirillum* when combined with vermicompost proved a worthy combination by providing nutrient in simpler form. [16] and [19] also found that inoculation of *Azospirillum* significantly increased the plant growth characters.

## 3.2 Yield attributes

### 3.2.1 Panicle length (cm)

Panicle length was significantly influenced by different treatments (Table 1). The longest panicle length (28.23 and 27.19 cm, respectively) was noted under T<sub>5</sub>, 75% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI which was followed by T<sub>3</sub>, 75% N through urea + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage. This might be because of nitrogen supply at critical growth stage by urea and Nano urea. Nano urea gets easily absorbed by the epidermis of the leaves and translocated to the site of action as the particles of Nano urea are small in size and large surface area than the stomata. Also, nitrogen promotes panicle growth by stimulating cell division at reproductive stage, elongates the cell, and increases meristematic activity. Moreover, higher absorption of fertilizer favored length of panicle. The results are corroborated with the findings of [20] also observed the increase in panicle length with the foliar application of nano super micro plus fertilizer, di-combination of nano N, P and K fertilizer and commercial fertilizer. [21] and [22] also noted that Nano urea along with urea significantly increased the panicle length.

### 3.2.2 Total no. of grains panicle<sup>-1</sup>

Total number of grains panicle<sup>-1</sup> significantly influenced by different treatments (Table 2). Significantly a greater number of grains per panicle (81 and 78, respectively) noted under T<sub>5</sub>, 75% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage which was significantly at par with T<sub>3</sub>, 75% N through urea + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage, T<sub>2</sub>, 100% N through urea + 100% P + 100% K (100:60:40 kg ha<sup>-1</sup>) and T<sub>9</sub>, 75% N through vermicompost + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage. This might be because of sufficient availability of nitrogen at panicle initiation stage at which nitrogen is essential for more number of flowers. It also helps in cytokinin biosynthesis essential to enhance cell division. [17] also observed a greater number of grains per panicle with the application of urea along with Nano urea. [22] also observed more no of grains per panicle with application of basal dose alongwith Nano urea. Moreover, vermicompost treated with *Azospirillum* worked out synergistically by providing essential plant nutrient and growth hormones. Also, fixation of nitrogen by *Azospirillum* and breakdown from complex form to simpler form that make their easy absorption thus, improved fertility status of soil. [19] also observed inoculation of *Azospirillum* significantly increased the plant growth characters. [16] improved plant growth parameters with the application of vermicompost carrier-based inoculants.

### 3.2.3 Test weight (g)

Test weight (g) was found not significantly influenced by different treatments (**Table 2**). This is due to the fact that test weight being a genetic character was significantly influenced by the application of Nano urea in conjunction with different fertilizers. The results are in agreement with [23], [24] and [22].

UNDER PEER REVIEW

**Table 1 Effect of combined application of inorganic fertilizer and organic manure with Nano urea on growth parameters of scented rice**

Treatment		Plant population (m <sup>2</sup> )		Plant height (cm)		No. of tillers Hill <sup>-1</sup>	
		2022	2023	2022	2023	2022	2023
T <sub>1</sub>	Control (0% N + 0% P + 0% K)	23.25	22.75	84.43	76.49	8.65	8.26
T <sub>2</sub>	100% N through urea + 100% P + 100% K (100:60:40 kg ha <sup>-1</sup> )	24.75	24.50	110.64	103.65	19.93	17.29
T <sub>3</sub>	75% N through urea + FS with Nano urea*	24.50	24.00	111.70	105.45	20.58	18.54
T <sub>4</sub>	50% N through urea + FS with Nano urea*	23.75	23.25	93.94	88.83	12.46	11.18
T <sub>5</sub>	75% N through urea + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	24.75	24.50	113.44	107.52	21.88	19.49
T <sub>6</sub>	50% N through urea + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	24.00	23.75	95.38	90.10	13.64	12.14
T <sub>7</sub>	75% N through Vermicompost + FS with Nano urea*	24.00	25.50	101.47	95.38	16.11	14.08
T <sub>8</sub>	50% N through Vermicompost + FS with Nano urea*	23.50	23.00	91.60	84.95	10.94	9.40
T <sub>9</sub>	75% N through Vermicompost + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	24.25	23.25	105.88	99.10	17.91	15.81
T <sub>10</sub>	50% N through Vermicompost + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	23.50	23.00	97.21	91.10	14.17	12.31
<b>SE m±</b>		<b>0.36</b>	<b>1.02</b>	<b>3.13</b>	<b>3.83</b>	<b>0.74</b>	<b>0.92</b>
<b>CD (P=0.05)</b>		<b>NS</b>	<b>NS</b>	<b>2.15</b>	<b>2.81</b>	<b>2.15</b>	<b>2.67</b>

FS – Foliar spray, \*@ 4ml litre<sup>-1</sup> of water at AT and PI, AT - Active tillering, PI - Panicle initiation, 100% P & K through SSP and MOP, respectively

**Table2 Effect of combined application of inorganic fertilizer and organic manure with Nano urea on yield attributes parameters of scented rice**

Treatment		Panicle length (cm)		Total no. of grains panicle <sup>-1</sup>		Test weight (g)	
		2022	2023	2022	2023	2022	2023
T <sub>1</sub>	Control (0% N + 0% P + 0% K)	16.17	15.89	60	53	32.04	30.72
T <sub>2</sub>	100% N through urea + 100% P + 100% K (100:60:40 kg ha <sup>-1</sup> )	26.92	25.86	79	74	34.84	33.52
T <sub>3</sub>	75% N through urea + FS with Nano urea*	27.92	26.76	80	76	37.73	33.79
T <sub>4</sub>	50% N through urea + FS with Nano urea*	20.78	20.28	72	68	33.71	32.22
T <sub>5</sub>	75% N through urea + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	28.23	27.19	81	78	38.43	34.35
T <sub>6</sub>	50% N through urea + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	21.42	21.46	74	70	34.29	32.33
T <sub>7</sub>	75% N through Vermicompost + FS with Nano urea*	23.93	23.58	75	72	34.78	32.78

T <sub>8</sub>	50% N through Vermicompost + FS with Nano urea*	18.06	17.80	69	65	33.65	31.64
T <sub>9</sub>	75% N through Vermicompost + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	25.73	25.17	78	75	36.38	33.58
T <sub>10</sub>	50% N through Vermicompost + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	22.26	22.35	74	70	34.61	32.37
<b>SE m±</b>		<b>0.76</b>	<b>0.86</b>	<b>1.41</b>	<b>1.20</b>	<b>1.70</b>	<b>0.75</b>
<b>CD (P=0.05)</b>		<b>2.19</b>	<b>2.48</b>	<b>4.07</b>	<b>3.46</b>	<b>NS</b>	<b>NS</b>

\* FS – Foliar spray, \*@ 4ml litre<sup>-1</sup> of water at AT and PI, AT - Active tillering, PI - Panicle initiation, 100% P & K through SSP and MOP, respectively

**Table3 Effect of combined application of inorganic fertilizer and organic manure with Nano urea on grain and straw yield of scented rice**

Treatment		Grain yield (kg ha <sup>-1</sup> )		Straw yield (kg ha <sup>-1</sup> )	
		2022	2023	2022	2023
T <sub>1</sub>	Control (0% N + 0% P + 0% K)	2491	2125	3938	3418
T <sub>2</sub>	100% N through urea + 100% P + 100% K (100:60:40 kg ha <sup>-1</sup> )	4388	4044	6275	5987
T <sub>3</sub>	75% N through urea + FS with Nano urea*	4598	4223	6393	6177
T <sub>4</sub>	50% N through urea + FS with Nano urea*	3605	3202	5314	5058
T <sub>5</sub>	75% N through urea + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	4780	4418	6652	6432
T <sub>6</sub>	50% N through urea + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	3663	3267	5380	5118
T <sub>7</sub>	75% N through Vermicompost + FS with Nano urea*	3868	3571	5578	5422
T <sub>8</sub>	50% N through Vermicompost + FS with Nano urea*	3363	3018	5115	4925
T <sub>9</sub>	75% N through Vermicompost + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	4253	3965	6074	5916
T <sub>10</sub>	50% N through Vermicompost + <i>Azospirillum</i> @ 5 kg ha <sup>-1</sup> + FS with Nano urea*	3748	3434	5468	5201
<b>SE m±</b>		<b>111.60</b>	<b>133.07</b>	<b>137.24</b>	<b>165.39</b>
<b>CD (P=0.05)</b>		<b>322.88</b>	<b>385.02</b>	<b>397.09</b>	<b>478.52</b>

FS – Foliar spray, \*@ 4ml litre<sup>-1</sup> of water at AT and PI, AT - Active tillering, PI - Panicle initiation, 100% P & K through SSP and MOP, respectively

### 3.3 Grain and straw yield (kg ha<sup>-1</sup>)

The data on grain yield and straw yield of rice (Table 3) showed that application of T<sub>5</sub>, 75% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI registered significantly higher grain (4780 and 4418 kg ha<sup>-1</sup>, respectively) and straw yield (6652 and 6432 kg ha<sup>-1</sup>, respectively) during both the years of experimentations which was at par with T<sub>3</sub>, 75% N through urea + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage. However, it is closely followed by T<sub>2</sub>, 100% N through urea + 100% P + 100% K (100:60:40 kg ha<sup>-1</sup>). This is due to sufficient nitrogen availability of Nano urea by plant cell that resulted in improved growth. Further, easy absorption of by the plant cells tune up the nitrogen availability required for the metabolic process like photosynthesis and translocation of photosynthates to the sink gave higher grain and straw yield. The results are supported by the findings of [15]. Who also observed more grain and straw yield with the application of 75% RDN + Nano urea (2 foliar spray) + P + K. [18], [17] and [26] also observed significant increase in yield with the application of urea and Nano urea. Among the treatment combination of Nano urea along with organic manure T<sub>9</sub>, 75% N through Vermicompost + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage proved to be best. *Azospirillum* might have supported in nitrogen fixation and availing nutrient to the plants. With regard to the yield achieved by the combination of vermicompost, *Azospirillum* and Nano urea suggests that organic fertilizers might enriched the soil with macro and micro- nutrients, enzymes and a carbon source for soil microbes that may perhaps positively influenced the growth and yield attributes so the yield. Moreover, more yield attributes favored higher yield of rice. All the factors like better absorption and transportation positively influenced the grain and straw yield. The results are in agreement with [16], 2010 and [19].

## 4. CONCLUSION

The results of present findings concludes that application of 75% N through urea + *Azospirillum* @ 5 kg ha<sup>-1</sup> + FS with Nano urea @ 4 ml litre<sup>-1</sup> at AT and PI stage was the better proffer to gain higher growth, yield and yield attributes of rice and could be an option for sustainable production of rice. Vermicompost synergistically outperformed in gaining higher yield which was closed to best treatment. Hence, the treatment, vermicompost with *Azospirillum* in combination with Nano urea can also be recommended to maintain soil fertility with optimum yield.

## REFERENCES

1. [FAO 2022 fao.org./faostat/en/#data](https://faostat.fao.org/en/#data)
2. Agricultural statistics at a glance; 2020. Available: <https://eands.dacnet.nic.in>
3. Siddiqui MH, Khan MN, Mohammad F and Khan MMA. Role of nitrogen and gibberellin in regulation of enzyme activities and in Osmoprotectant accumulation in *Brassica juncea*L. under salt stress. Journal of Agronomy and crop science.2008;194:214-224.
4. Kumar N, Tiwari BK, Tiwari RK and GajbhiyeM. Effect of integrated nutrient management on growth, yield attributes, productivity of direct seeded rice under rainfed conditions. International Journal of Environment and climate change. 2023a;13(11):4297-4304.
5. Moran JA, Mitchell AK, Goodmanson G and KA Stockburger. Differentiation among effects of nitrogen fertilization treatments on conifer seedlings by foliar reflectance: a comparison of methods. Tree physiology. 2000;20(16):1113-1120.

6. Gajbhiye M, Bhan M, Agrawal KK and Kumar N. Influence of irrigation scheduling on physiological growth parameters and yield of wheat under different sowing dates. *International Journal of plant & soil Science*. 2023;35(22):18-27.
7. Kumpawat BS. Integrated nutrient management in blackgram (*Vigna mungo*) and its residual effect on succeeding mustard (*Brassica juncea*) crop. *Indian Journal of agricultural Sciences*. 2010;80(1):76-79.
8. Kumar N, Tiwari BK, Tiwari RK, Gajbhiye M and Kushawah. Response of inorganic fertilizers in conjunction with organic sources on performance of Drought tolerant Direct seeded rice (*Oryza sativa* L.) in central India. *Biological forum- An international journal*.2023b. 15 (11):06-12.
9. Kumar YO, Tiwari KN, Singh T and Raliya R. Nano fertilizers and their role in sustainable agriculture. *Annals of plant and soil research*. 2021;23(3):238-255.
10. OPSTAT software available online at CCS, Haryana Agriculture university. Available: [www.hau.ernet.in](http://www.hau.ernet.in)
11. Gomez KA and Gomez AA. Statistical procedure for agriculture research. 2<sup>nd</sup> Edition. pp. 241-71. John Wiley & Sons, New York. 1984
12. Rathnayaka RMNN, Mahendran S, Iqbal YB and Rifnaf LM. Studied the influence of urea and nano nitrogen fertilizers on growth and yield of rice (*Oryza sativa* L.) cultivar Bg250. *International journal of research publications*. 2018;5(2):1-7.
13. Velmurugan A, Subramanil T, Bommayasamy N, Ramakrishna, Kumar M and Swarnam TP. *Journal of the andaman science association*. 2021;26(2):76-81.
14. Anushka AS, Kumar GS, Sriharan N, Radhamani S, Maragatham S. Studies on the effect of Nano urea on growth yield and nutrient use efficiency in transplanted rice. *International journal of environment and climate change*. 2023;13(10):1547-1554.
15. Bhargavi G and Sungari A. Effect of Nano urea on the growth and yield of rice (*Oryza sativa*) under SRI in the Cauvery delta zone of Tamilnadu. *Crop research* 2023;58(1&2):12-17.
16. Gandhi A and Sivakumar K. Impact of vermicompost carrier based bio inoculents on the growth, yield and quality of rice (*Oryza sativa* L.) CVNLR145. *Ecscan*. 2010;4(1):83-88.
17. Midde SK, Perumal MS, Murugan G, Sudhagar, Mattepally VS, and Bada MR. Evaluation of Nano Urea on Growth and Yield Attributes of Rice (*Oryza sativa* L.). *Chemical science Review and letters*. 2022;11(42):211-214.
18. Rathnayaka RMNN, Mahendran S, Iqbal YB and Rifnaf LM. Studied the influence of urea and nano nitrogen fertilizers on growth and yield of rice (*Oryza sativa* L.) cultivar Bg250. *International journal of research publications*. 2018;5 (2):1-6
19. Yasuda M, Dastogeer, Addo ES, Tokiwa, Ishawa, Shinozali and Okazaki. Impact of *Azospirillum* sp. B510 on the rhizosphere microbiome of rice under field conditions. *Agronomy*. 2022;12:1367.
20. Al-juthery HWA, Habeeb KH, Altaee FJK, Al-taey DKA and Al-tawaha ARM. Effect of foliar application of different sources of nano fertilizers on growth and yield of wheat. *Bioscience research*. 2018;15(4):3988-3997.
21. Sahu KB, Sharma G, Dinesh P, Keshry PK and Chaure NK. Effect of nitrogen management through nano-fertilizer in rice (*Oryza sativa* L.). *International Journal of Chemical Research and Development*. 2022; 4(1):25-27.
22. Dhawne MN, Shamkuwar GR, SHamkuwar SG, Landge NH, Sable AD and Tinpayle AD. Influence of foliar applications of Nano urea on morpho-physiological and yield parameters in rice (*Oryza sativa* L.). *Biological forum and international journal*. 2023;15(11):548-553.
23. Gewaily E, Ghoneim A and Khattab E. Nano-silicon and nitrogen foliar spray affects the growth, yield and Nutrients content of rice. *World Journal of Agriculture Science*. 2019;15 (6):367-375.

24. Dhamankar C. Nitrogen management in drilled paddy through nano urea. MSc. (Agri). Thesis (Unpub.). 2022 Punjabrao Deshmukh Krishi Vidyapeeth, Akola.
25. Kumar S, Rajendra L, Mirhja PR, Yadav S and Uraon P. Effect of levels of and numbers of nano urea application with different dose on productivity of rice (*Oryza sativa* L.) in Vertisols of Chattisgarh. *The Pharma Innovation Journal*. 2023;12(7):2759-2762.
26. Namasharma S, Pahari A, Banik A, Pal S, Sana M, Pal S and Banerjee H. Impact of foliar applied Nano urea on growth, productivity and profitability of hybrid rice (*Oryza sativa* L.). *Oryza*. 2023;60(3): 464-472.

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