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Combined Application of Inorganic Fertilizer and Organic Manure with Nano Urea on Growth and Yield of Scented Rice

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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

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 heath. 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 combined 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

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design with four replications. The results of present study revealed that application of 75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at active tillering (AT) and panicle initiation (PI) stage registered maximum plant height (113.44 and 107.52 cm, respectively), no. of tillers hill^{-1} (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^{-1} (81 and 78, respectively), panicle length (28.23 and 27.19 cm, respectively), grain (4780 and 4418 kg ha^{-1}, respectively) and straw yield (6652 and 6432 kg ha^{-1}, respectively) was recorded with the application of 75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage 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 alongwith crop health.

Keywords: Nano urea; inorganic fertilizer and organic manure; vermicompost; Azospirillum.

1. INTRODUCTION

Rice is the staple cereal for millions of the world population. In world, rice occupies 437.80 million hectares (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 biofertilizers 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 along with loss of nutrients. Efficient nutrient management by supplying nitrogen on plant demand can minimize the N loss [3]. Organic fertilizers offer a reward to the soil by replenishing mineral nutrient and improving soil health. Organic manures are very well source to improve soil property and fertility for sustaining the soil by excluding or minimizing the dependency on chemical fertilizer [4]. 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 [5] so, it cannot be passed over. Yield and yield attributes are critically dependent on the amount of N fertilizer used [6]. Inorganic fertilizer, organic manure and biofertilizers enhances the yield and yield attributes of rice [7]. 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 [8]. Its deficiency reduces leaf chlorophyll content resulting in low light absorption [9]. Chlorophyll content shows a positive relationship with the grain yield of wheat crop [10]. 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 [11]. It shows a positive relationship between growth, yield attributes and yield of rice [12]. 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 [13]. 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_1, Control (0% N + 0% P + 0% K); T_2, 100% N through urea + 100% P + 100% K (100:60:40 kg ha^{-1}); T_3, 75% N through

urea + FS with Nano urea @ 4 ml litre^{-1} at active tillering (AT) and panicle initiation (PI) stage; T_4, 50% N through urea + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage; T_5, 75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage; T_6, 50% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage; T_7, 75% N through vermicompost + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage; T_8, 50% N through vermicompost + FS with Nano urea @ 4 ml litre^{-1} at AT and PI; T_9, 75% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage; T_{10}, 50% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage was laid out in randomized block design with four replications. The recommended dose of fertilizer was 100:60:40 NPK kg ha^{-1}. The fertilizer and manures were applied as basal except urea which was applied in split, 50% as basal and rest 50 % in again two splits, at active tillering (AT) and panicle initiation (PI) stage. Sources of phosphorus and potassium were SSP and MOP. Vermicompost and *Azospirillum* was also applied as basal. Nano urea @ 4ml litre^{-1} of water was applied at AT and PI stage. Scented rice variety PS 4, was transplanted at 20×20 cm^2 with two seedlings hill^{-1}. 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. Finally, the grain and straw yield was taken and recorded as kg ha^{-1}.

2.1 Statistical procedure

The field data were statistically analyzed using OPSTAT software available online at CCS, HAU, Haryana [14]. The data so obtained was tabulated and statistically analyzed by using analysis of variance (F-test) as suggested by Gomez and Gomez [15].

3. RESULTS AND DISCUSSION

3.1 Growth parameters

3.1.1 Plant population (m^{-2})

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_5, 75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage which was at par with T_3, 75% N through urea + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage and T_2, 100% N through urea + 100% P + 100% K (100:60:40 kg ha^{-1}) 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. Rathnayaka et al. [16], [17], [18] noted enhanced plant height with the application of Nano-nitrogen fertilizer. Bhargavi and Sundari [19] 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_9, 75% N through Vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage was superior. *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 [20].

3.1.3 Number of tillers hill^{-1}

Number of tillers hill^{-1} 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^{-1} (21.88 and 19.49, respectively) was observed with the application of T_5, 75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage which was at par with T_3, 75% N through urea + FS with Nano urea @ 4 ml litre^{-1} 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^{-1} of fertilizer thereby, surpass its absorption and nutrient uptake. Midde et al. [21] observed more no. of tillers with the combined application of urea and Nano urea. Rathnayaka et al. [22] also observed a greater number of tillers with 100% Nano fertilizer. Among the treatment combination with organic manure, T_9, 75% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage was 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. [20] and [23] 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 2). The longest panicle length (28.23 and 27.19 cm, respectively) was noted under T_5, 75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage which was followed by T_3, 75% N through urea + FS with Nano urea @ 4 ml litre^{-1} 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

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^{-2})		Plant height (cm)		No. of tillers hill^{-1}	
		2022	2023	2022	2023	2022	2023
T_1	Control (0% N + 0% P + 0% K)	23.25	22.75	84.43	76.49	8.65	8.26
T_2	100% N through urea + 100% P + 100% K (100:60:40 kg ha^{-1})	24.75	24.50	110.64	103.65	19.93	17.29
T_3	75% N through urea + FS with Nano urea*	24.50	24.00	111.70	105.45	20.58	18.54
T_4	50% N through urea + FS with Nano urea*	23.75	23.25	93.94	88.83	12.46	11.18
T_5	75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	24.75	24.50	113.44	107.52	21.88	19.49
T_6	50% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	24.00	23.75	95.38	90.10	13.64	12.14
T_7	75% N through vermicompost + FS with Nano urea*	24.00	25.50	101.47	95.38	16.11	14.08
T_8	50% N through vermicompost + FS with Nano urea*	23.50	23.00	91.60	84.95	10.94	9.40
T_9	75% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	24.25	23.25	105.88	99.10	17.91	15.81
T_{10}	50% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	23.50	23.00	97.21	91.10	14.17	12.31
SE m±		0.36	1.02	3.13	3.83	0.74	0.92
CD (P=0.05)		NS	NS	2.15	2.81	2.15	2.67

*FS – Foliar spray, *@ 4ml litre^{-1} of water at AT and PI, AT - Active tillering, PI - Panicle initiation, 100% P & K through SSP and MOP, respectively*

Table 2. 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^{-1}		Test weight (g)	
		2022	2023	2022	2023	2022	2023
T_1	Control (0% N + 0% P + 0% K)	16.17	15.89	60	53	32.04	30.72
T_2	100% N through urea + 100% P + 100% K (100:60:40 kg ha^{-1})	26.92	25.86	79	74	34.84	33.52
T_3	75% N through urea + FS with Nano urea*	27.92	26.76	80	76	37.73	33.79
T_4	50% N through urea + FS with Nano urea*	20.78	20.28	72	68	33.71	32.22
T_5	75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	28.23	27.19	81	78	38.43	34.35
T_6	50% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	21.42	21.46	74	70	34.29	32.33
T_7	75% N through vermicompost + FS with Nano urea*	23.93	23.58	75	72	34.78	32.78
T_8	50% N through vermicompost + FS with Nano urea*	18.06	17.80	69	65	33.65	31.64
T_9	75% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	25.73	25.17	78	75	36.38	33.58
T_{10}	50% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	22.26	22.35	74	70	34.61	32.37
SE m±		0.76	0.86	1.41	1.20	1.70	0.75
CD (P=0.05)		2.19	2.48	4.07	3.46	NS	NS

** FS – Foliar spray, *@ 4ml litre^{-1} of water at AT and PI, AT - Active tillering, PI - Panicle initiation, 100% P & K through SSP and MOP, respectively*

findings of [24] who 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. Sahu et al. [25], [26] also noted that Nano urea along with urea significantly increased the panicle length.

3.2.2 Total no. of grains panicle^{-1}

Total number of grains panicle^{-1} significantly influenced by different treatments (Table 2). Significantly a greater number of grains panicle^{-1} (81 and 78, respectively) noted under T_5, 75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage which was significantly at par with T_3, 75% N through urea + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage, T_2, 100% N through urea + 100% P + 100% K (100:60:40 kg ha^{-1}) and T_9, 75% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} 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. Midde et al. [21] also observed a greater number of grains panicle^{-1} with the application of urea along with Nano urea. Dhawne et al. [26] also observed more no. of grains panicle^{-1} with application of basal dose along with 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. Yasuda et al. [23] also observed inoculation of *Azospirillum* significantly increased the plant growth characters. Gandhi and Sivakumar [20] 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 not significantly influenced by the application of Nano urea in conjunction with different fertilizers. The results are in agreement with Gewaily et al. [27], [28], [26], [29].

3.3 Grain and Straw Yield (kg ha^{-1})

The data on grain yield and straw yield of rice (Table 3) showed that application of T_5, 75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage registered significantly higher grain (4780 and 4418 kg ha^{-1}, respectively) and straw yield (6652 and 6432 kg ha^{-1}, respectively) during both the years of experimentation which was at par with T_3, 75% N through urea + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage. However, it was closely followed by T_2, 100% N through urea + 100% P + 100% K (100:60:40 kg ha^{-1}). This is due to sufficient nitrogen availability by Nano urea to the 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 that gave higher grain and straw yield. The results are supported by the findings of Bhargavi and Sundari [19] who also observed more grain and straw yield with the application of 75% RDN + Nano urea (2 foliar spray) + P + K. Rathnayaka [22], [21], [30] 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_9, 75% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml litre^{-1} at AT and PI stage proved to be the 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 being 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. Gajbhiye et al. [31] also observed that yield attributes increase the grain yield of wheat. Also, all the factors like better absorption and transportation positively influenced the grain and straw yield. The results are in agreement with Gandhi and Sivakumar [20] and Midde et al. [21].

Table 3. 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^{-1})		Straw yield (kg ha^{-1})	
		2022	**2023**	**2022**	**2023**
T_1	Control (0% N + 0% P + 0% K)	2491	2125	3938	3418
T_2	100% N through urea + 100% P + 100% K (100:60:40 kg ha^{-1})	4388	4044	6275	5987
T_3	75% N through urea + FS with Nano urea*	4598	4223	6393	6177
T_4	50% N through urea + FS with Nano urea*	3605	3202	5314	5058
T_5	75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	4780	4418	6652	6432
T_6	50% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	3663	3267	5380	5118
T_7	75% N through vermicompost + FS with Nano urea*	3868	3571	5578	5422
T_8	50% N through vermicompost + FS with Nano urea*	3363	3018	5115	4925
T_9	75% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	4253	3965	6074	5916
T_{10}	50% N through vermicompost + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea*	3748	3434	5468	5201
SE m±		111.60	133.07	137.24	165.39
CD (P=0.05)		322.88	385.02	397.09	478.52

*FS – Foliar spray, *@ 4ml litre^{-1} of water at AT and PI, AT - Active tillering, PI - Panicle initiation, 100% P & K through SSP and MOP, respectively*

4. CONCLUSION

The results of present findings concludes that application of 75% N through urea + *Azospirillum* @ 5 kg ha^{-1} + FS with Nano urea @ 4 ml $litre^{-1}$ 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 close to best treatment. Hence, the treatment, vermicompost with *Azospirllium* in combination with Nano urea can also be recommended to maintain soil fertility with optimum yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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