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Influence of Foliar Application of Nano-Urea on Morpho-Physiological and Yield Parameters in Rice (*Oryza sativa* L.)

M.N. Dhawne[1*], G.R. Shamkuwar[2], S.G. Shamkuwar[3], Nikita H. Landge[1], Anjali D. Sable[1] and A.D. Tinpayale[1]

[1]P.G. Scholar, Department of Agricultural Botany (Plant Physiology), Dr. PDKV Akola, College of Agriculture Nagpur 440010, Maharashtra, India.
[2]Professor of Botany (CAS), Zonal Agriculture Research Station, Sindewahi 441222 Dist. Chandrapur Maharashtra, India.
[3]Ph.D. Scholar, Department of Genetics and Plant Breeding, Banaras Hindu University, Varanasi 221005, Uttar Pradesh, India.

(Corresponding author: M.N. Dhawne)*

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ABSTRACT: An experiment was carried in field of Agriculture Research Station, Sakoli, district Bhandara, Maharashtra, India during *Kharif 2022-23* season in RBD with PDKV-Sadhana variety, three replication and eleven treatments were taken. The treatment T_6 (50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20 and 40 DAT) was found most effective for increasing the morpho-physiological parameters like plant height, number of tillers per plant, total dry matter production, leaf area per plant, leaf area index and length of flag leaf, while yield and yield attributing characters like total number of grains, length of panicle, number of filled grains, number of unfilled grains, weight of grains $panicle^{-1}$, number of panicle m^{-2}, grain yield $plant^{-1}$, grain yield ha^{-1} over rest of the treatments. NPK consumption ratio has widened from 4:3.2:1 in 2009-10 to 7:2.8:1 in 2019-20, combination of nano urea with basal dose helps in enhancing the productivity of rice without negative influence on plant and the environment.

Keywords: Nano-urea, Rice, PDKV-Sadhana, foliar application, moprho-physiological.

INTRODUCTION

Rice (*Oryza sativa* L.) is semi-aquatic annual grass plant also known as paddy which belongs to family Gramineae. It is C3, self-pollinated, monocotyledonous, short day plant with chromosome number 2n=24. The sativa rice varieties of the world are commonly divided into three sub-species Indica, Javanica and Japonica. Japonica also known as called as sinica. Inflorescence of rice is known as panicle wile fruit type is caryopsis. ‘Rice is Life’ for more than half of humanity, considering its importance the United Nations designated the year 2004 as the “International Year of Rice”.

Agriculture worldwide is facing wide spectrum of challenges, such as stagnation in crop yields, low nutrient use efficiency (NUE), declining soil organic matter, multi-nutrient deficiencies, shrinking arable land and water availability. Fertilizers do provide nutrients needed by the plants for their optimal productivity. However, presently the farmers typically apply fertilizers through the soil by surface broadcasting, subsurface placement or mixing with irrigation water. It is worrisome that in this process, a large portion of bulk conventional fertilizers like urea is lost to the atmosphere or surface water bodies, thereby polluting the ecosystem. It is disheartening that fertilizer consumption in India is imbalanced, and Urea accounts for more than 82% of the nitrogenous fertilizers applied to majority of the crops. Furthermore, the Nitrogen, Phosphorus and Potassium (NPK) consumption ratio has widened from 4:3.2:1 in 2009-10 to 7:2.8:1 in 2019-20 (Anonymous, 2023).

MATERIALS

Researchers have tended to study several modern techniques in the agricultural field, particularly the possibility of using nanotechnology to improve the fertilizer use efficiency towards the design and development of so-called nano fertilizers. Nano fertilizers are important in increasing the efficiency of nutrients, having a higher yield, better quality and safer environment. It reduces soil contamination as well as potential adverse effects when conventional mineral fertilizers are applied. Nano fertilizers (NF) are more efficient and effective than conventional fertilizers because of their positive effects on the quality of food crops, reduce stresses that occur to the plant, small applied quantities and costs, their fast absorption by plant cells and penetration of cells and the fats of transport and representation within plant tissue. Foliar nutrition means the application of the nutrients needed by the plant by spraying their solutions on the vegetative part within certain concentrations and in time so that the plant can absorb it through the stomata of the leaf or through the cell walls and membranes to participate in the vital plant processes. This increases the vegetative and qualitative qualities to avoid conditions that reduce the availability of plant nutrients in the soil (Hayyawi *et al*., 2020).

METHODS

A field experiment was carried out at research farm of Agriculture Research Station, Sakoli, Bhandara district, Maharashtra, India. The design for the experiment was RBD with PDKV-Sadhana Variety, three replications and eleven treatments of different doses of nano-urea. The treatments were, T_1: No fertilizer (Control), T_2: 100:50:50 NPK Kg ha^{-1} (RDF), T_3: 50:50:50 NPK Kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 2ml l^{-1} of water at 20 and 40 DAT, T_4: 50:50:50 NPK Kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40 and 60 DAT, T_5: 50:50:50 NPK Kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40, 60 and 80 DAT, T_6: 50:50:50 NPK Kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20 and 40 DAT, T_7: 50:50:50 NPK Kg ha^{-1} as basal dose + 3 Foliar Sprays of nano urea @ 3 ml l^{-1} of water at 20, 40 and 60 DAT, T_8: 50:50:50 NPK Kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20, 40, 60 and 80 DAT, T_9: 50:50:50 NPK Kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20 and 40 DAT, T_{10}: 50:50:50 NPK Kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40 and 60 DAT, T_{11}: 50:50:50 NPK Kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40, 60 and 80 DAT. The nano-urea used was IFFCO nano-urea (4%). Sowing was done on June 29, 2022 while transplanting was done on July 29, 2022 at spacing of 20 cm × 15 cm on plot with gross plot size 4.0 m × 2.0 m and net plot size 3.40 m × 1.60 m. Five plants from each plot were selected randomly and data for morpho-physiological parameters *viz.* plant height, number of tillers plant^{-1}, days to maturity, days to flowering, total dry matter production plant^{-1}, leaf area plant^{-1}, leaf area index plant^{-1}, length of flag leaf were collected at 25, 45, 65, 85 DAT and at harvest, while for yield and yield contributing character *viz,* total number of grains, length of panicle, number of filled grains, number of unfilled grains, weight of grains panicle^{-1}, number of panicle m^{-2}, 1000 grain weight, grain yield plant^{-1}, grain yield ha^{-1}, harvest index were collected at harvest. The data were analysed statistically as per the method suggested by Panse and Sukhathme (1954).

RESULTS AND DISCUSSION

Morpho-physiological characters. All the morpho-physiological characters were significantly influenced by the foliar application of nano-urea, except days to 50% flowering, days to maturity and at 25 DAT. Morpho-physiological character *viz.,* plant height, number of tillers plant^{-1}, days to maturity, days to flowering, total dry matter production plant^{-1}, leaf area plant^{-1}, leaf area index plant^{-1} and length of flag leaf in various stages of rice growth was enhanced due to application of nano-urea. The significantly maximum morpho-physiological characters were recorded in T_6. (50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3ml l^{-1} of water at 20 and 40 DAT) *viz.*, plant height of 79.11, 96.90 and 118.85 cm at 45, 65 DAT and at harvest respectively. Number of tillers plant^{-1} of 11.56 and 12.67 at 45 and 65 DAT respectively, while number of effective tillers plant^{-1} of 7.44 at harvest. Total dry matter production of 10.87, 20.12, 29.63 and 29.90 g at 45, 65, 85 DAT and at harvest respectively. Leaf area of 8.78, 12.37 and 5.49 at 45, 65 and 85 DAT respectively. Leaf area index of 2.93, 4.2 and 1.83 at 45, 65 and 85 DAT respectively. Length of flag leaf of 38.40 and 39.50 cm at 65 and 85 DAT. While lowest number of days to 50% flowering 89.3 and days to maturity 119.0 was recorded in T_1 (control).

Taller plants may result from enhanced food absorption and transport, which may have boosted cell division and protein content in the cells. Rathnayaka *et al*. (2018), Rostaman *et al*. (2021), Midde *et al* (2022), Lahari *et al*. (2021) and Dhamankar *et al*. (2023) discovered similar results.

One possible explanation for this beneficial effect on the number of tillers plant^{-1} increase could be the easily accessible nitrogen source provided by nano urea. The foundation of the foliar application of nanotechnology is nano nitrogen, which provides more nutrients than RDF by itself. Due to its small size (20-50 nm), it is more than 80% more available to the crop, increasing the number of tillers per plant while lesser number of effective tillers plant^{-1} might be due late tillers could not get converted into effective tillers and get mortality. These outcomes agreed with those of Rathnayaka *et al*. (2018), who discovered that the number of tillers in rice rose with the use of nano fertilisers. As there is no fertilizer application in control, it attends reproductive stage quickly by completing vegetative growth, resulting early 50% flowering and maturity than other, while increased strength when nano urea is sprayed during the panicle initiation period, which results in early flowering and maturity than RDF. Similar result was reported by Midde *et al*. (2022). These outcomes agreed with those of Yadav *et al.* (2023), who discovered that the number of days to maturity in wheat decrease with the use of nano fertilisers. Similar finding was also observed by Swati *et al*. (2017).

The dry matter build up was greatly enhanced by the foliar application of fertilisers containing nano-urea. The explanation could be that nano-urea fertilisers exhibit greater activity because of their larger surface area. This increased activity may have improved the plants' ability to absorb nutrients, which in turn caused a cumulative increase in plant height, leaf area and number of tillers per plant. Greater utilisation of solar radiation and available nutrients, which are necessary for greater photosynthetic surface area, are facilitated by larger leaf areas. This may have led to an increase in the accumulation and translocation of photosynthates, which in turn increased the production of biomass. Present findings are in line with those found by Rahman *et al*. (2014) in wheat.

In the current study, foliar spray of nano-urea in conjunction of basal fertilizer dose, enhanced leaf area. This could be because there is an enough supply of nitrogen, which results in increased leaf area. According to Raheem *et al*. (2019), the application of nano-fertilizer during the various stage of paddy improved the leaf area, which is similar with the current findings. Comparable results were also noted in maize by Navya *et al*. (2022) and in mustard by Reddy *et al*. (2022).

It has been demonstrated that using nano-urea spray has a major impact on the rice leaf area index (LAI). Higher LAI is the outcome of enhanced nutrient uptake and utilisation brought on by nano-urea spray, as per studies by Sharma *et al*. (2022). The nanoscale formulation ensures better nutrient absorption and penetration via leaves, promoting overall canopy development and leaf growth. Similar results were recorded by Gewaily *et al*. (2019), Midde *et al*. (2022), Bhargavi and Sundari (2023).

In the current study, foliar spray of nano-urea in conjunction with basal fertilizer dose increased length of flag leaf; this. This could be because there is an enough supply of nitrogen, which results in increased length of flag leaf. Similar results were recorded by Bahmaniar *et al*. (2007); Morteza *et al*. (2011).

Yield and yield contributing characters. All the yield and yield contributing characters *viz.*, total number of total number of grains, length of panicle, number of filled grains, number of unfilled grains, weight of grains panicle^{-1}, number of panicle m^{-2}, grain yield plant^{-1} and grain yield ha^{-1} except 1000 seed weight and harvest index, was enhanced due to application of nano-urea. Among the imposed treatments $T_{6.}$ (50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3ml l^{-1} of water at 20 and 40 DAT) recorded a significantly highest number of 130.57 filled grains panicle^{-1}, length of 27.90 cm of panicle, number of 98.60 filled grains panicle^{-1}, weight of 2.31 g of grains panicle^{-1}, number of 234.67 panicle m^{-2}, grain yield of 13.78 g plant^{-1}, grain yield of, 4593 kg ha^{-1}, and harvest index of 47.46%. While maximum number of 1000 grains weight of 25.50 g.

In the current study, the total number of grains panicle^{-1} was raised by applying nano-urea typically. This, together with the dose of basal fertiliser, produced an equal total number of grains panicle^{-1}. This may be because timely nitrogen delivery encourages the commencement of grain production, which helps to increase the number of grains panicle^{-1}. Additionally, the foliar spray of nano urea may boost photosynthate assimilation and translocation of photosynthates from the source to the sink. Similar results were recorded by Raheem *et al.* (2019).

In present study the length of panicle is increased with foliar application of nano urea. This may be due the foliar application of nano urea at their critical stage (tillering and panicle initiation), this may lead to supply sufficient amount of nitrogen. Nitrogen enhances the cell elongation, activity of merismatic cells and also increase grain formation.

The highest number of filled grains panicle^{-1}. It might be attributed due to the enhancement in enzymatic activity that may leads to formation and transportation photosynthates that may results trigger the number of grains per panicle. Similar result was found by Midde *et al*. (2022).

Weight of grains panicle^{-1} was significantly increased as compared to control treatment (No fertilizer). Foliar application of nano fertilizers which enhanced the photosynthetic activity, dry matter production and translocation of photosynthates from source to sink as a result of easy penetration through the stomata and timely nutrient supply leading to the increased panicle weight.

The foliar application of nano fertilisers improved the plant's ability to absorb and translocate nutrients and created a hospitable environment for the crop. This increased cell division, meristematic activity and stimulation of cell elongation in plants ultimately led to a higher number of panicles per m^{-2}.

Test weight being a genetical character, it was not significantly influenced by the foliar application of nano fertilizers. Similar results were recorded by Gewaily *et al.* (2019), Dhamankar *et al.* (2023).

Increased nutrient uptake by the plant, which results in optimal growth of plant parts and metabolic processes like photosynthesis, which maximises the accumulation and translocation of photosynthates to the plant's economic parts, may be the cause of higher grain yield, which may also be attributed to stronger sources (leaves) and sinks (economic parts). Increased source (leaves) and sink (economic part) strength may be responsible for higher grain yield. Improved nutrient uptake by the plant may lead to the ideal growth of plant parts and metabolic processes like photosynthesis may result in maximum accumulation and translocation of photosynthates to the economic parts of the plant. These findings were in agreement with the findings of Taiz and Zeiger (2006); Dhamankar *et al.* (2023).

The foliar application of nano urea on harvest index of rice was found significant. Indicating the importance of providing a substantial amount of fertilizer. The results obtained in the present study are supported by the works of Valojai *et al*. (2021).

Table 1: Plant height, number of tillers and effective tillers at harvest influenced by treatments in rice.

Treatments		Plant height (cm)				Number of tillers plant^{-1}			Effective tillers plant^{-1} at harvest
		25 DAT	45 DAT	65 DAT	at harvest	25 DAT	45 DAT	65 DAT	
T_1	Control	48.17	60.75	73.37	93.00	6.89	8.33	8.89	5.44
T_2	RDF (100:50:50 NPK kg ha^{-1})	61.99	76.33	94.67	115.91	9.89	11.22	12.00	7.22
T_3	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20 and 40 DAT	58.29	71.90	89.41	107.42	9.44	10.44	11.55	7.00
T_4	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40 and 60 DAT	57.25	70.33	87.31	105.79	9.00	10.33	11.11	6.67
T_5	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40, 60 and 80 DAT	56.25	68.66	85.07	102.78	8.51	10.29	10.67	6.66
T_6	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20 and 40 DAT	63.56	79.11	96.90	118.85	9.79	11.56	12.67	7.44
T_7	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20, 40 and 60 DAT	60.60	76.39	94.07	116.26	9.00	10.32	11.45	7.00
T_8	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20, 40, 60 and 80 DAT	59.93	75.69	92.34	114.16	8.56	10.17	10.89	6.67
T_9	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20 and 40 DAT	62.83	77.96	95.99	117.53	9.78	11.33	12.11	7.33
T_{10}	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40 and 60 DAT	59.77	76.39	93.91	115.26	9.22	10.78	11.44	7.11
T_{11}	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40, 60 and 80 DAT	58.20	72.89	90.48	113.57	9.11	10.11	10.78	7.00
Mean		58.80	73.31	90.32	110.96	9.02	10.44	11.23	6.87
SE (m) ±		2.75	3.45	4.24	5.14	0.56	0.54	0.59	0.32
CD at 5%		NS	10.17	12.50	15.16	NS	1.61	1.75	0.95

Table 2: Days to flowering, days to maturity and total dry matter production influenced by treatments in rice.

Treatments		Days to 50% flowering	Days to maturity	Total dry matter production (g) plant^{-1}				
				25 DAT	45 DAT	65 DAT	85 DAT	at harvest
T_1	Control	89.3	119.0	2.49	7.60	12.17	15.47	15.57
T_2	RDF (100:50:50 NPK kg ha^{-1})	93.0	122.7	2.54	10.76	19.45	28.56	28.80
T_3	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20 and 40 DAT	90.3	120.0	2.53	10.61	19.41	27.77	27.98
T_4	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40 and 60 DAT	90.7	120.3	2.51	10.49	19.16	27.43	27.62
T_5	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40, 60 and 80 DAT	91.0	120.7	2.51	10.32	18.74	26.15	26.32
T_6	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20 and 40 DAT	91.0	120.7	2.55	10.87	20.12	29.63	29.90
T_7	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20, 40 and 60 DAT	91.3	121.0	2.54	10.71	19.57	28.04	28.29
T_8	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20, 40, 60 and 80 DAT	91.7	121.3	2.53	10.65	19.34	27.72	27.94
T_9	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20 and 40 DAT	91.7	121.3	2.52	10.80	19.84	29.03	29.28
T_{10}	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40 and 60 DAT	91.7	121.3	2.52	10.68	19.39	27.96	28.18
T_{11}	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40, 60 and 80 DAT	92.0	121.7	2.50	10.45	18.84	27.04	27.23
Mean		91.2	120.9	2.52	10.36	18.73	26.80	27.01
SE (m) ±		1.58	1.86	0.18	0.50	1.08	1.50	1.50
CD at 5%		NS	NS	NS	1.48	3.20	4.43	4.44

Table 3: Leaf area, leaf area index and length of flag leaf influenced by treatments in rice.

Treatments		Leaf area (dm^2)				Leaf area index				Length of flag leaf (cm)	
		25 DAT	45 DAT	65 DAT	85 DAT	25 DAT	45 DAT	65 DAT	85 DAT	65 DAT	85 DAT
T_1	Control	3.32	6.43	9.04	3.86	1.11	2.14	3.01	1.29	29.82	30.58
T_2	RDF (100:50:50 NPK kg ha^{-1})	4.10	8.63	11.97	5.43	1.37	2.88	3.99	1.81	37.53	38.66
T_3	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20 and 40 DAT	3.99	8.56	11.54	5.22	1.33	2.85	3.85	1.74	35.68	36.80
T_4	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40 and 60 DAT	3.98	8.56	11.36	5.21	1.33	2.85	3.79	1.74	33.82	34.82
T_5	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40, 60 and 80 DAT	3.83	8.41	10.91	4.95	1.28	2.80	3.64	1.65	32.96	33.86
T_6	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20 and 40 DAT	4.19	8.78	12.37	5.49	1.40	2.93	4.12	1.83	38.40	39.50
T_7	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20, 40 and 60 DAT	4.15	8.60	11.96	5.21	1.38	2.87	3.99	1.74	37.21	38.21
T_8	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20, 40, 60 and 80 DAT	4.11	8.56	11.54	5.21	1.37	2.85	3.85	1.74	35.98	36.88
T_9	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20 and 40 DAT	4.18	8.69	11.95	5.43	1.39	2.90	3.98	1.81	37.58	38.68
T_{10}	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40 and 60 DAT	4.13	8.58	11.25	5.26	1.38	2.86	3.75	1.75	35.98	36.95
T_{11}	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40, 60 and 80 DAT	3.97	8.51	10.70	5.10	1.32	2.84	3.57	1.70	33.78	34.68
Mean		4.00	8.39	11.33	5.12	1.33	2.80	3.78	1.71	35.34	36.33
SE (m) ±		0.20	0.39	0.58	0.28	0.07	0.13	0.19	0.09	1.63	1.72
CD at 5%		NS	1.15	1.72	0.83	NS	0.38	0.57	0.28	4.81	5.08

Table 4: Yield and yield contributing characters influenced by treatments in rice.

Treatments		Total number of grains $panicle^{-1}$	Length of panicle (cm)	Number of filled grains $panicle^{-1}$	Weight of grains $panicle^{-1}$ (g)	Number of panicles m^{-2}	1000 grain weight (g)	Grain yield $plant^{-1}$ (g)	Grain yield ha^{-1} (kg)	Harvest index (%)
T_1	Control	103.92	20.99	69.05	1.74	182.00	24.97	10.28	3426	36.16
T_2	RDF (100:50:50 NPK kg ha^{-1})	126.63	27.70	88.43	2.28	228.33	25.35	13.09	4362	46.86
T_3	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20 and 40 DAT	118.53	26.67	80.00	2.23	219.00	25.13	12.67	4223	43.84
T_4	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40 and 60 DAT	113.50	26.40	73.67	2.22	209.00	25.03	12.61	4203	42.47
T_5	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 2 ml l^{-1} of water at 20, 40, 60 and 80 DAT	110.03	26.10	69.93	2.16	200.67	25.00	12.46	4152	41.51
T_6	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20 and 40 DAT	130.57	27.90	98.60	2.31	234.67	25.50	13.78	4593	47.46
T_7	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20, 40 and 60 DAT	128.04	27.33	85.87	2.26	227.00	25.22	13.24	4415	44.96
T_8	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20, 40, 60 and 80 DAT	126.53	26.83	84.00	2.24	220.67	25.10	12.91	4303	43.88
T_9	50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20 and 40 DAT	126.33	27.83	89.00	2.25	231.67	25.28	13.23	4411	47.11
T_{10}	50:50:50 NPK kg ha^{-1} as basal dose + 3 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40 and 60 DAT	119.96	26.93	79.53	2.20	221.67	25.18	13.18	4395	44.87
T_{11}	50:50:50 NPK kg ha^{-1} as basal dose + 4 foliar sprays of nano urea @ 4 ml l^{-1} of water at 20, 40, 60 and 80 DAT	115.64	26.10	72.87	2.16	210.33	25.14	13.05	4351	43.24
Mean		119.97	26.44	81.00	2.19	216.82	25.17	12.77	4258	43.85
SE (m) ±		5.55	1.24	4.36	0.10	10.11	0.59	0.59	196.62	2.08
CD at 5%		16.36	3.66	12.86	0.30	29.83	NS	1.74	580.02	6.13

CONCLUSIONS

Based on results, application of 50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20 and 40 DAT recorded higher morpho-physiological, yield and yield contributing characters. From the enlightment of the study, it can be concluded and recommended that application of 50:50:50 NPK kg ha^{-1} as basal dose + 2 foliar sprays of nano urea @ 3 ml l^{-1} of water at 20 and 40 DAT could be a viable option for enhancing the productivity of rice without negative influence on plant and the environment.

FUTURE SCOPE

The present findings are based on one year research and needs further 1 to 2 years experimentation for validation of influence of nano urea on rice crop.

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