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Kiran Reddy
Department of Agronomy, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Ramesha YM
Associate Professor, Department of Agronomy, Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur, Karnataka, India

Krishnamurthy D
Associate Professor, Department of Agronomy, College of Agriculture, Hagari, University of Agricultural Sciences, Raichur, Karnataka, India

Kamble Anand Shankar
Associate Professor, Department of Agronomy, Organic Farming Research Institute, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Mahadeva Swamy
Professor and Head, Department of Microbiology, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author:
Kiran Reddy
Department of Agronomy, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Effect of nano urea and nano DAP on growth, yield and economics of transplanted rice

Kiran Reddy, Ramesha YM, Krishnamurthy D, Kamble Anand Shankar and Mahadeva Swamy

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Abstract
A field experiment was conducted to study the effect of nano urea and nano DAP on growth and yield of transplanted rice at Agricultural Research Station, Dhadesugur, UAS, Raichur during *kharif*, 2023 in *vertisol*. The experiment was laid out in a randomized complete block design with three replications and eight treatments comprising of different doses of nano urea and nano DAP along with soil application of conventional fertilizers. The results revealed that, treatment receiving 50% Rec. N with soil application + 50% Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application recorded significantly higher growth and yield attributes resulted in higher grain yield (5578kg ha^{-1}), gross returns (Rs. 1,84,933 ha^{-1}), net returns (Rs. 122,725ha^{-1}) and BC ratio (2.97). The experimental results concluded that, treatment receiving 50% Rec. N with soil application + 50% Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application was best to get higher grain yield.

Keywords: Nano urea, Nano DAP, Transplanted rice, Grain yield

1. Introduction
Rice (*Oryza sativa* L.) is an important cereal crop and a staple food for one third of the world population. It is necessary to increase its production and productivity in order to meet the growing demand of rice by increasing population. In the world, rice is being grown in an area of 165.03 m ha with a production of 777.46 m t with the productivity of 4704 kg ha^{-1}**.** The total area under rice in India is 47.83 m ha with a production of 135.75 m t and productivity of 2.83 t ha^{-1} (Anon., 2023) [1].
Since the green revolution, chemical fertilizers have been deemed indispensable in modern crop production systems. In order to increase crop output and nutritional quality, fertilizers have become increasingly important, especially with the emergence of fertilizer-responsive crop types. Conventional fertilizers offer nutrients in chemical forms that are not often fully accessible to plants (Akshay Kumar Kurdekar, 2021) [2]. Additionally, the inversion of these chemical fertilizers to sparingly soluble forms in the soil is the main reason for the low utilization of most of the added macronutrients. The unscientific fertilizer management has affected the soil health and resulted in avert yield responses to applied fertilizer.
To address these challenges, we should think of an alternate technology such as nanotechnology to precisely detect and deliver correct quantity of nutrients and other inputs required by crops in suitable proportion that promote productivity while ensuring environmental safety. Farmers are using urea and DAP fertilizers for soil as well as foliar application to crops. However, the efficacy is lower. In view of the above facts, the present investigation was carried out to study the "Effect of nano urea and nano DAP on growth and yield of transplanted rice".

2. Materials and Methods
The experiment was carried out at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur, Karnataka. The research centre is located in agroclimatic zone III (Northern Dry Zone) of Karnataka and it is situated at latitude of 15° 69' N and 76° 89' E longitude with an altitude of 358 meters above the mean sea level. The soil of the experimental

site was medium black clay in texture classified under the order *vertisols* having pH 8.07 and EC 0.43 dS m^{-1}. The soil was medium in available P_2O_5 (31.05 kg ha^{-1}), low in organic carbon 0.46% and available N (273.5 kg ha^{-1}) with higher available K_2O (374.8 kg ha^{-1}).

The experiment was laid out in randomized complete block design (RCBD) with three replications. There were eight treatments consisting of different doses of RDF with different doses of nano urea and nano DAP. The treatment combinations are T_1: RDF with soil application, T_2: Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application, T_3: Rec. P through nano DAP with two applications (at tillering and panicle initiation stage) + Rec. N & K with soil application, T_4: Rec. N & P through nano urea and nano DAP, respectively with two applications (at tillering and panicle initiation stage) + Rec. K with soil application, T_5: 50 % Rec. N with soil application + 50 % Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application, T_6: 50 % Rec. P with soil application + 50 % Rec. P through nano DAP with two applications (at tillering and panicle initiation stage) + Rec. N & K with soil application, T_7: 50 % Rec. N & P with soil application + 50 % Rec. N & P through nano urea and nano DAP, respectively + Rec. K with soil application and T_8: Control. RDF - 150:75:75 kg $N:P_2O_5:K_2O$ ha^{-1} and 50 % of N, entire P and K were applied as basal and remaining 50 % of N was top dressed at tillering and panicle initiation stage.

From randomly tagged five plants, plant height was measured on the five tagged plants individually from ground level to the base of fully opened top leaf. Biometric observations were recorded at 30 days interval. The observation on grain and straw yield was recorded at harvest. The economics was worked out based on the prevailing market price for the existing year. Data analysis and interpretation was done using Fisher's method of analysis and variance technique as given by Panse and Sukhatme (1967) [3].

3. Results and Discussion

3.1 Effect of nano fertilizers on growth attributes

3.1.1 Plant height

Plant height of transplanted rice was significantly influenced by the application of different levels of conventional and nano fertilizers (Table 1). Application of 50 % Rec. N with soil application + 50 % Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application recorded significantly taller plant height. Significantly shorter plants were recorded in control. Significant increase in plant height might be due to the fact that basal application of conventional fertilizers along with foliar spray of nano fertilizers increased activity of enzymes and auxin metabolism in the plant, which in turn enlarge the cell and cell elongation might resulted in taller plants. This is in conformity with the works of Arya *et al.* (2022) [4] and Gaikwad *et al.* (2023) [5].

3.1.2 Dry matter production

Dry matter production and its accumulation at various growth stages was significantly affected by the application of different levels of conventional and nano fertilizers (Table 1). Significantly higher total dry matter accumulation at harvest was noticed in 50 % Rec. N with soil application + 50 % Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application (70.03 g $plant^{-1}$) and it was followed by RDF with soil application (65.28 g $plant^{-1}$). Whereas lower total dry matter production was recorded in control (38.51 g $plant^{-1}$). Basal application of conventional fertilizers on soil and then foliar spray of nano fertilizers significantly increased the total dry matter production at all stages of crop growth due to cumulative vigorous growth which in turn put forth more photosynthetic surface, chlorophyll formation, biomass and more nutrient uptake. Increased crop growth rate is attributed to luxuriant growth, taller plants, a greater number of green leaves and higher leaf area which intern improved dry matter accumulation at periodic intervals. Tiny size of nano fertilizers results in better absorption of nano nutrients which affects plant growth mechanisms. Plant metabolic activities such as chlorophyll synthesis and photosynthetic activity both of which enhance vegetative growth increased due to proper supply of nutrients and accumulation of dry matter in leaves helped, the photosynthetic area to remain active for, longer period and was responsible for overall growth of plant in terms of dry matter. Production. Similar observations were recorded by Asha Kiran (2022) [6] and Sunil *et al.* (2023) [7].

3.2 Effect of nano fertilizers on yield

3.2.1. Grain yield

Significantly higher grain yield was recorded in treatment receiving 50 % Rec. N with soil application + 50 % Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application (5578 kg ha^{-1}) and followed by RDF with soil application (5342 kg ha^{-1}). Significantly lower grain yield was noticed in control (2681 kg ha^{-1}). Among nano DAP treatments, application of 50 % Rec. P with soil application and 50 % nano DAP with two applications (at tillering and panicle initiation stage) + Rec. N & K with soil application recorded significantly higher grain yield (5126 kg ha^{-1}) and found on par with 50 % Rec. N & P with soil application + 50 % Rec. N & P through nano urea and nano DAP, respectively (at tillering and panicle initiation stage) + Rec. K with soil application (5072 kg ha^{-1}). Higher grain yield might be attributed to higher yield components *viz.*, panicle length, maximum number of grains per panicle, grain weight and test weight. In addition to combined application of conventional and nano fertilizers (nano urea and DAP) ensured optimum and balanced nutrient availability throughout the crop period especially during the critical stages of crop. This is due to smaller size and larger effective surface area of nano particles which can easily penetrate into the plant and lead to better uptake of nutrients. The higher uptake of nutrients results in optimal growth of plant parts and metabolic processes like photosynthesis that increase photosynthates accumulation and translocation to the economically productive parts of the plant which results in increased biomass, yield attributing characters and finally yield by amplifying the translocation of assimilates to seeds. Similar results were also reported by Midde *et al.* (2022) [8] and Dhamankar *et al.* (2023) [9].

3.2.2 Stover yield

Among all the treatments, 50 % Rec. N with soil application + 50 % Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application was recorded significantly higher straw yield (6437 kg ha^{-1}) and followed by RDF with soil application (6104 kg ha^{-}

^{1}). Significantly lower straw yield was produced in control (3268 kg ha^{-1}) as compared to all other treatments.

Among nano DAP treatments, significantly higher straw yield was recorded in treatment receiving 50 % Rec. P with soil application and 50 % nano DAP with two applications (at tillering and panicle initiation stage) + Rec. N & K with soil application (5774 kg ha^{-1}) and found on par with 50 % Rec. N & P with soil application + 50 % Rec. N & P through nano urea and nano DAP, respectively (at tillering and panicle initiation stage) + Rec. K with soil application (5650 kg ha^{-1}).

Likewise, the increase in straw production with the foliar spray of nano fertilizers might be credited to nano fertilizers because of the rapid uptake of nano fertilizers by the plant and ease of translocation which assisted in a quicker rate of photosynthesis and more dry matter accumulation, resulting in a higher stover yield. This is in conformity with the results of Reddy *et al.* (2022) [10] and Anushka *et al.* (2023) [11].

3.3 Effect of nano fertilizers on economics

Among different treatments, RDF with soil application has incurred greater cost of cultivation of transplanted rice (Rs. 62,506 ha^{-1}) and followed by 50 % Rec. N with soil application + 50 % Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application (Rs. 62,439 ha^{-1}) and Rec. N through nano urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application (Rs.62,373 ha^{-1}). Lower cost of cultivation was noticed in control (Rs. 45,636 ha^{-1}) as compared to all other treatments (Table 2).

Significantly higher gross returns, net returns and B C ratio were recorded in 50 % Rec. N with soil application + 50 % Rec. N through nano-urea with two applications (at tillering and panicle initiation stage) + Rec. P & K with soil application (Rs. 1,84,933 ha^{-1}, Rs. 1,22,494 ha^{-1} and 2.96). Among nano DAP treatments, 50 % Rec. P with soil application and 50 % nano DAP with two applications (at tillering and panicle initiation stage) + Rec. N & K with soil application recorded significantly higher gross returns, net returns and BC ratio (Rs. 1,69,806 ha^{-1}, Rs. 1,09,471 ha^{-1} and 2.81) and found on par with 50 % Rec. N & P with soil application + 50 % Rec. N & P through nano urea and nano DAP, respectively (at tillering and panicle initiation stage) + Rec. K with soil application (Rs. 1,67,954 ha^{-1}, Rs. 1,07,652 ha^{-1} and 2.79). Whereas lower gross returns, net returns and BC ratio were noticed in control (Rs. 89,060 ha^{-1}, Rs. 43,424 ha^{-1} and 1.95).

The gross returns, net returns and BC ratio were lowest in control because the nutrient requirement of plant was not met, as a result of this the plant produced lower yields and fetched lower returns. Whereas, basal application of conventional and foliar application of nano fertilizers supplied the required amount of nutrients adequately and resulted in producing higher yields fetching higher returns. Similar results were also obtained by Rajesh (2021) [12] and Nandhakumar *et al.* (2023) [13].

Table 1: Growth and yield parameters of transplanted rice as influenced by the application different levels of conventional and nano fertilizers

Treatment	Plant height (cm)	Total dry matter production (g plant^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	113.2	65.28	5342	6104
T_2	96.9	55.77	4821	5418
T_3	93.1	51.73	4603	5063
T_4	87.9	47.79	4310	4779
T_5	119.7	70.03	5578	6437
T_6	106.4	61.74	5126	5774
T_7	103.5	59.69	5072	5650
T_8	78.4	38.51	2681	3268
S.Em.±	2.0	1.13	69	104
C.D. (P=0.05)	6.2	3.42	211	315

Table 2: Economics of transplanted rice as influenced by the application of different levels of conventional and nano fertilizers

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BC ratio
T_1	62506	177048	114542	2.83
T_2	62373	159690	97317	2.56
T_3	58648	152359	93711	2.60
T_4	58548	142699	84151	2.44
T_5	62439	184933	122494	2.96
T_6	60335	169806	109471	2.81
T_7	60302	167954	107652	2.79
T_8	45636	89060	43424	1.95
S.Em.±	-	2142	2142	0.04
C.D. (P=0.05)	-	6497	6497	0.13

4. Conclusion

It was concluded that, soil application of 50 % of Rec. N and full dose of Rec. P and K through conventional fertilizers as basal application and foliar spray of 50 % Rec. N through nano urea with two applications, one at tillering (1.87 ml l^{-1}) and another at panicle initiation stage (1.87 ml l^{-1}) recorded higher growth attributes *viz.*, plant height and dry matter production and also best to get higher grain, straw yield, net returns and benefit cost ratio as compared to other treatments. Similarly, among nano DAP treatments, 50 % Rec. P with soil application and 50 % nano DAP with two applications, one at tillering (0.23 ml l^{-1}) and another at panicle initiation stage (0.23 ml l^{-1}) + Rec. N & K with soil application is best to get higher grain, straw yield, net returns and benefit cost ratio.

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