Bangladesh J. Bot. **52**(4): 1025-1031, 2023 (December) DOI: https://doi.org/10.3329/bjb.v52i4.70589

EFFECTS OF SEEDLING DIPPING AND FOLIAR APPLICATION OF NANO DAP ON GROWTH, YIELD AND ECONOMICS OF FINE RICE

MEENAKSHI ATTRI*, NEETU SHARMA, SWATI MEHTA AND JOY SAMUEL MECARTY

Division of Agronomy, FOA, SKUAST-J, Chatha-180009, India

Keywords: Seedling dipping, Foliar application, Growth, Yield, Rice (*Oryza sativa*)

Abstract

A field experiment was conducted to assess the effect of seedling dipping and foliar application of phosphorus on growth, yield and economics of fine rice. The experimental results revealed that 75% recommended nitrogen, phosphorus and 100% recommended potassium + seedling dipping with nano di-ammonium phosphate @ 5 ml/litre + foliar spray with nano di-ammonium phosphate @ 4 ml/litre application recorded significantly higher growth, yield and yield attributes, which was statistically at par with, 50% recommended nitrogen, phosphorus +100% recommended potassium + seedling treatment with nano di-ammonium phosphate @ 5 ml/litre+ 2 foliar spray with nano di-ammonium phosphate each @ 4 ml/litre and @ 2 ml/litre and 100% recommended nitrogen, phosphorus and potassium. However, 50% recommended nitrogen, phosphorus +100% recommended potassium + seedling treatment with nano di-ammonium phosphate @ 5 ml/litre+ 2 foliar spray with nano nano di-ammonium phosphate each @ 4 ml/litre recorded significantly highest agro physiological efficiency. However, in terms of economics 75% recommended nitrogen, phosphorus and 100% recommended potassium + seedling dipping with nano di-ammonium phosphate @ 5 ml/litre + foliar spray with nano nano di-ammonium phosphate @ 4 ml/litre recorded highest net returns and benefit cost ratio .

Introduction

Rice (*Oryza sativa* L.) is a major staple food for more than the world's half population. Rice productivity in India is mainly dependent on judicious input use of fertilizers and accounts for about 35 to 40 per cent of the crop productivity. Indiscriminate and imbalanced use of inorganic fertilizers adversely affects the soil health and thereby reduces the soil productivity. The application of inorganic fertilizers *viz* Urea, Di-ammonium phosphate and Muriate of potash have been found to have lower fertilizer use efficiency in rice crop which ranges from 20 to 50 per cent for nitrogen, 10 to 25 per cent for phosphorus and 70 to 80 per cent for potassium (Chinnamuthu and Boopathi 2017) owing to leaching, volatilization and denitrification losses which contribute to greenhouse gases emission. To overcome these drawbacks, nanotechnology holds promise and nano-fertilizers provide a way in ensuring sustainable soil health and higher crop production. Nano-fertilizers provides nutrients in a slow and steady way to the crop as per the requirement in order to increase crop yield, improve quality and to improve the overall sustainability of agricultural systems (Tarafdar *et al.* 2014).

The eco-friendly fertilizer Nano Di-ammonium phosphate in liquid formulations are manufactured by Nano Biotechnology Research Center in association with Indian Farmers Fertilizers Cooperative Limited to avoid the imbalanced and excessive use of Di-ammonium phosphate. Nano Di-ammonium phosphate contains 8 per cent nitrogen and 16 per cent phosphorus by weight in its nano form. Seedling treatment and foliar application with Nano Di-ammonium phosphate effectively fulfils crop nitrogen and phosphorus requirement. Seedling dipping with nano Di-ammonium phosphate enhances seedling vigor, promotes root growth which

*Author for correspondence: <meenakshiattri418@gmail.com>.

leads to higher biomass production. Seedling dipping with nano Di-ammonium phosphate also results in 10 to 50%higher grain yield of rice with 40 to 60% reduction in applied phosphorus through Di-ammonium phosphate (Swetha *et al*. 2017). However, foliar application of nano Di-ammonium phosphate enters the leaf through stomatal and cuticular pores which increase in phosphorus concentration not only in shoots but also in roots, which ultimately increases the rapid uptake of phosphorus by rice crop (Talboys *et al.* 2020). Consequently, the importance of promoting the efficiency of phosphorus uptake and use in agricultural crops like rice becomes evident, while supplying nano fertilizers with phosphorus represents an alternative. The present study was carried out aiming at evaluating the effect of seedling dipping and foliar application of nano Di-ammonium phosphate on growth, yield, uptake, economics and nutrient use efficiency of rice plants.

Materials and Methods

A field experiment was conducted during *Kharif* season 2021 and 2022 at research farm of Division of Agronomy, SKUAST-Jammu (32°40' Latitude and 74°58' Longitude and an altitude of 332 m above mean sea level). The experimental soil was sandy clay loam in texture, slightly alkaline in reaction (pH 7.32), low in organic carbon (3.4 g/kg) and available nitrogen (252.30 kg/ha) but medium in available phosphorus (14.02 kg/ha) and potassium (146.50 kg/ha). The experiment was conducted in randomized block design with three replications. The experiment consisted of 10 treatments *viz*. T_1: Recommended potassium (0:0:15 kg/ha), T_2: 100% recommended nitrogen, phosphorus and potassium (50:25:15 kg/ha), T_3: 75% recommended nitrogen, phosphorus and 100% recommended potassium (37.5:18.75:15 kg/ha), T_4: 50% recommended nitrogen, phosphorus and 100% recommended potassium (25:12.5:15 kg/ha), T_5: 75% recommended nitrogen, phosphorus and 100% recommended potassium (37.5:18.75:15 kg/ha)+ seedling dipping with nano di-ammonium phosphate @ 5 ml/litre + foliar spray with nano di-ammonium phosphate @ 2 ml/l, T_6: 75% recommended nitrogen, phosphorus and 100% recommended potassium `(37.5:18.75:15 kg/ha) + seedling dipping with nano di-ammonium phosphate @ 5ml/litre + foliar spray with nano di-ammonium phosphate @ 4 ml/litre, T_7: 50% recommended nitrogen, phosphorus and 100% recommended potassium (25:12.5:15 kg/ha) + seedling dipping with nano di-ammonium phosphate @ 5 ml/l + foliar spray with nano di-ammonium phosphate @ 2 ml/l, T_8: 50% recommended nitrogen, phosphorus and 100% recommended potassium (25:12.5:15 kg/ha) + seedling dipping with nano di-ammonium phosphate @ 5 ml/l + foliar spray with nano di-ammonium phosphate @4 ml/l, T_9: 50% recommended nitrogen, phosphorus and 100% recommended potassium (25:12.5:15 kg/ha) + seedling dipping with nano di-ammonium phosphate @ 5 ml/l + 2 foliar spray with nano di-ammonium phosphate each@ 2 ml/l, T_{10}: 50% recommended nitrogen, phosphorus and 100% recommended potassium (25:12.5:15 kg/ha) + seedling dipping with nano di-ammonium phosphate @ 5 ml/l + 2 foliar spray with nano di-ammonium phosphate each @ 4 ml/l, arranged in randomized block design with three replications. Seedlings of Pusa Basmati-1121 were transplanted at a spacing of 20 cm x 10 cm during second fortnight of July. The crop was fertilized with 50: 25: 15 kg of N: P_2O_5: K_2O/ha. Full doses of phosphorus and potassium along with one-third of nitrogen were applied as basal dose at the time of puddling. Apart from this 25% additional nitrogen over recommended dose of nitrogen was applied in all the treatments. The remaining 2/3rd of nitrogen was applied in two equal splits *i.e.*, at 30 and 60 days after transplanting. Bispyribac sodium 10% SC through commercial product Nominee Gold @ 250 ml/ha was sprayed manually with the help of knap sack sprayer using 500 litres of water. Recording of several important agronomic parameters, observations on plant height, dry matter production, leaf area index, no. of effective tillers/m^2, no. of grains/panicle, test weight, grain and

straw yield were taken at maturity by randomly selecting ten hills that were analyzed. Economics was calculated via prevailing prices of inputs and outputs. Nitrogen use efficiency, Agronomic efficiency (AE), Apparent nitrogen recovery (RE) and Agro-physiological efficiency were estimated to evaluate the effectiveness of nitrogen application.

Different nitrogen use efficiency indices were calculated by using the formula given below.

$$\text{Nitrogen use efficiency} = \frac{\text{Grain yield in treated plot (kg/ha) - grain yield in control plot (kg/ha)}}{\text{Amount of nitrogen applied (kg/ha)}}$$

$$\text{Apparent recovery (\%)} = \frac{\text{N uptake in treated plot (kg/ha) –N uptake in control plot (kg/ha)}}{\text{Amount of nitrogen applied (kg/ha)}}$$

$$\text{Agro-physiological efficiency} = \frac{\text{Grain yield produced (kg/ha)}}{\text{N uptake in above dry matter at harvest (kg/ha)}}$$

Among economic parameters, net return per ha was calculated by deducting cultivation cost from gross returns. Benefit cost ratio was calculated by dividing net returns with total cost of cultivation to evaluate the economic viability of treatments. The observations recorded during the course of investigation were tabulated and subjected to analysis of variance techniques as described by Gomez and Gomez (1984). The key for degree of freedom used in analysis of variance is given below:

Source of variations	Degree of freedom
Replications (r)	3-1= 2
Treatments(t)	10-1= 9
Error (r-1) (t-1)	(3-1) (10-1)= 18
Total (rt-1)	**30-1= 29**

Results and Discussion

The data on growth parameters (Table 1) revealed that the growth characters of rice were significantly influenced by different treatments of nano di-ammonium phosphate. 75% recommended nitrogen +100% recommended potassium+ seedling treatment with nano di-ammonium phosphate @ 5 ml/l + foliar spray with nano di-ammonium phosphate @4 ml/l recorded significantly higher plant height, dry matter accumulation and leaf area index which was at par with 75% recommended nitrogen, phosphorus +100% recommended potassium +seedling treatment with nano di-ammonium phosphate @ 5 ml/l + foliar spray with nano di-ammonium phosphate @ 2 ml/l, 50% recommended nitrogen, phosphorus +100% recommended potassium + seedling treatment with nano di-ammonium phosphate @ 5 ml/l + 2 foliar spray with nano di-ammonium phosphate each @ 4 ml/l, 50% recommended nitrogen, phosphorus + 100% recommended potassium +seedling treatment with nano di-ammonium phosphate @5 ml/l + 2 foliar spray with nano di-ammonium phosphate each @ 2 ml/l and 100% recommended nitrogen, phosphorus and potassium. Significant increases in growth parameters may be attributed to the

beneficial effects of nanoparticles which have high reactivity because of more specific surface area, more density of reactive areas or increased reactivity of these areas on the particle surfaces. Moreover, nano di-ammonium phosphate meets immediate requirement of nitrogen and phosphorus, triggers the enzymatic activity and protein assimilation pathways that led to significant enhancement in biomass production as well as crop growth rate. These findings were in corroboration with the findings of Singh *et al*. (2021).

Seedling dipping and foliar application of nano-di-ammonium phosphate recorded significantly higher yield attributes, grain yield and straw yield with 75% recommended nitrogen +100% recommended potassium + seedling dipping with nano di-ammonium phosphate @ 5 ml/litre + foliar spray with nano di-ammonium phosphate @ 4 ml/l. This might be due to the fact that nano di-ammonium phosphate enhances the direct availability of nitrogen and phosphorous which resulted in the increase in leaf area and higher dry matter accumulation. Foliar application of nano di-ammonium phosphate improves plant metabolic processes and photosynthesis, as a result it increases number of panicles and grain development, thus led to significant improvement in yield attributes and yield. Foliar application of nano di-ammonium phosphate at 30 days after transplanting and one week before flowering is directly involved in the metalloprotease and enzymatic activities in plant, which are more important for increased grain and straw yield and provide targeted delivery of nutrients throughout crop growth period. Experimental results are concomitant with the findings of Poudel *et al*. (2023), Saraiva *et al*. (2022).

Efficiencies in terms of nitrogen use efficiency, apparent recovery of nitrogen and physiological efficiency presented in Table 2, revealed that 50% recommended nitrogen and phosphorous +100% recommended potassium +seedling treatment with nano di-ammonium phosphate @ 5 ml /l + 2 foliar spray with nano di-ammonium phosphate each @ 4 ml/l recorded significantly highest nitrogen use efficiency which was followed by 50% recommended nitrogen and phosphorous +100% recommended potassium +seedling treatment with nano di-ammonium phosphate @ 5 ml/l +2 foliar spray with nano di-ammonium phosphate each @ 2 ml/l, respectively. However, 50% recommended nitrogen and phosphorous + 100% recommended potassium recorded highest physiological efficiency followed by 75% recommended nitrogen and phosphorous +100% recommended potassium. Similar findings were also reported by Attri *et al.* (2022) and Bhat *et al.* (2015) who suggested that synchronizing crop nitrogen demand with fertilizer nitrogen supply using nano di-ammonium phosphate lead to apparent recovery of nitrogen and agro physiological efficiency.

However, maximum net returns and benefit cost ratio was recorded in 75% recommended nitrogen and phosphorous +100% recommended potassium + seedling treatment with nano di-ammonium phosphate @ 5 ml/l + foliar spray with nano di-ammonium phosphate @ 4 ml/l which was closely followed by 75% recommended nitrogen and phosphorous and 100% recommended potassium +seedling dipping with nano di-ammonium phosphate @ 5 ml/l + foliar spray with nano di-ammonium phosphate @ 2 ml/l. This might be due to variation in cost of cultivation and net returns. These results are in conformity with the findings of Kumar *et al*. (2014).

From the above findings, it may be concluded that 75% recommended nitrogen and phosphorous and 100% recommended potassium + seedling dipping with nano di-ammonium phosphate @ 5 ml/l + foliar spray with nano di-ammonium phosphate @ 4ml/l application recorded significantly higher growth parameters, yield attributes, grain yield, straw yield, net returns and benefit cost ratio and was found suitable for yield maximization and higher net returns. Thus, 75% recommended nitrogen and phosphorous and 100% recommended potassium + seedling dipping with nano di-ammonium phosphate @5 ml/l + foliar spray with nano di-ammonium phosphate @ 4 ml/l helping farmer community to utilize the nitrogenous and phosphorus fertilizers efficiently and optimally.

Table1.Effect of seedling dipping and foliar application of phosphorus through nano nano di-ammonium phosphate on growth, yield attributes and yield of fine rice (Pooled data of two years).

Sl. no.	Treatment	Growth			Yield attributes			Yield	
		Plant height (cm)	Dry matter accumulation (g/m^2)	Leaf area index	Effective tillers	No. of grains/ panicle	1000 grain weight	Grain yield (kg/ha)	Straw yield (kg/ ha)
T_1	N_0 :P_0+Recommended K (0:0:15kg/ha)	81.79	485.36	1.87	207.92	51.75	20.09	1930	2942
T_2	100% recommended N:P:K (50:25:15kg/ha)	103.75	884.34	2.52	252.25	65.91	24.44	3862	4917
T_3	75% recommendedN:P+100% recommended K(37.5:18.75:15 kg/ha)	91.47	693.48	2.32	230.25	60.29	23.11	3030	3897
T_4	50% recommended N:P +100% recommended K (25:12.5:15 kg/ha)	86.22	617.32	2.15	219.61	57.62	22.88	2664	3447
T_5	75%recommendedN:P+100% recommended K (37.5:18.75:15 kg/ha)+ seedling treatment with nano DAP @5 ml/litre + FS with nano DAP @2 ml/litre	105.72	932.35	2.66	257.83	67.90	24.87	4150	5218
T_6	75% recommended N:P+100% recommended K (37.5:18.75:15 kg/ha) + seedling treatment with nano DAP @5 ml/litre + FS with nano DAP @4 ml/litre	107.34	949.35	2.71	258.97	68.40	25.06	4223	5301
T_7	50% recommended N: P+ 100% recommended K (25:12.5:15kg/ha) + seedling treatment with nano DAP @5 ml/litre + FS with nano DAP @2 ml/litre	96.48	782.87	2.45	241.50	63.05	23.61	3401	4355
T_8	50% recommended N:P +100% recommended K (25:12.5:15kg/ha) + seedling treatment with nano DAP @5 ml/litre +FS with nano DAP @4 ml/litre	98.54	803.65	2.50	242.77	63.19	24.15	3494	4451
T_9	50% recommended N:P+100% recommended K (25:12.5:15kg/ha) + seedling treatment with nano DAP @5 ml/litre+2 FS with nano DAP each @2 ml/litre	104.32	915.26	2.59	255.06	66.47	24.57	4003	5091
T_{10}	50% recommended N:P+100% recommended K(25:12.5:15 kg/ha)+ seedling treatment with nano DAP @5 ml/litre+2 FS with nano DAP each@4 ml/litre	105.45	923.54	2.62	257.69	67.42	24.63	4078	5144
SEm ±		1.58	27.69	0.04	3.44	0.92	1.05	123.37	131.86
CD (5%)		4.52	83.08	0.11	10.32	2.75	NS	370.12	395.59

Table 2. Effect of seedling dipping and foliar application of nano di-ammonium phosphate on various nitrogen efficiency indices and relative economics of fine rice (pooled data of two years).

Sl. no.	Treatments	Agronomic nitrogen use efficiency (kg/kg)	Apparent recovery efficiency (%)	Agro physiological efficiency (kg/kg)	Net return (Rs./ha)	B:C ratio (Re. /Re.)
T_1	N0 :P0+Recommended K (0:0:15kg/ha)				29722	0.67
T_2	100% recommended N:P:K (50:25:15kg/ha)	19.33	43.30	44.63	98916	2.13
T_3	75% recommendedN:P+100%recommended K(37.5:18.75:15kg/ha)	14.67	29.29	50.07	68390	1.49
T_4	50% recommended N:P +100%recommended K (25:12.5:15kg/ha)	14.68	25.02	58.65	55214	1.21
T_5	75%recommendedN:P+100% recommended K (37.5:18.75:15kg/ha)+ seedling treatment with nano DAP @5ml/litre+FS with nano DAP @2ml/litre	29.60	65.96	44.89	106680	2.16
T_6	75% recommended N:P+100% recommended K (37.5:18.75:15kg/ha)+seedling treatment with nano DAP @5ml/litre+FS with nano DAP @4ml/litre	30.58	68.36	44.76	108549	2.16
T_7	50% recommended N: P+ 100% recommended K (25:12.5:15kg/ha)+seedling treatment with nano DAP @5ml/litre+FS with nano DAP @2ml/litre	29.42	63.07	46.64	79345	1.62
T_8	50% recommended N:P +100% recommended K (25:12.5:15kg/ha)+seedling treatment with nano DAP @5ml/litre +FS with nano DAP @4ml/litre	31.29	67.08	46.65	82175	1.66
T_9	50% recommended N:P+100% recommended K (25:12.5:15kg/ha)+seedling treatment with nano DAP @5ml/litre+2 FS with nano DAP each @2ml/litre	41.48	92.52	44.83	100057	1.98
T_{10}	50%recommendedN:P+100%recommendedK(25:12.5:15kg/ha)+seedlin g treatment with nano DAP @5ml/litre+2 FS with nano DAP each@4ml/litre	42.97	95.39	45.06	100724	1.91

Acknowledgement

This work was supported by the IFFCO.

References

Attri M, Sharma N and Sharma BC 2022. Effect of foliar application of nano urea on productivity and profitability of fine rice under irrigated subtropics of Jammu region. Ind. J. Ecol. **5**: 1935-1938.

Bhat TR, Kotru R, Ahmad L, Ganai MA and Mahdi SS 2015. Response of rice genotypes (*Oryza sativa*) to leaf colour chart based nitrogen management under temperate environment. Int. J. Eco. Env. Sci.**41:** 95.-100.

Chinnamuthu CR and Boopathi PM 2017. Nano-technology and Agroecosystem. Madras Agri. J. **96**: 17-31.

Gomez KA and Gomez AA 1984. Statistical procedures for agricultural research, John Wiley and sons. 175 pp.

Kumar Y, Tiwari KN, Singh T, Sain NK, Laxmi S and Verma R 2020. Nano fertilizers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Rajasthan. Annals of Plant and Soil Res. **22**: 324-335.

Poudel A, Singh SK, Jimenez-Ballesta, Jatav R, Patra SS and Pandey A 2023. Effect of nano-phosphorus formulation on growth, yield and nutritional quality of wheat under semi-arid climate. Agron. **13**: 768.

Saraiva R, Ferreira Q, Rodrigues GC and Oliveira M 2022. Phosphorous nanofertilizers for precise application in rice cultivation as an adaptation to climate change. Climate.**10**:183.

Singh R, Sarma NR, Rao SS, Pant TN, H, Vadali H, Venkata S, Satya VV and Kumar R 2021. Cryo-milled nano-DAP for enhanced growth of monocot and dicot plants. Nanosc. Adv. **3**: 4834-4842.

Swetha MK, Rao PC, Padmaja G, Ramulu V, Saritha JD and Ramakrishna K 2017. Effect of bio and nano phosphorus on yield, yield attributes and oil content of crop growth and yield benefits to soil applications together with greater groundnut (*Arachis hypogaea* L). Env. Cons. J. **18**: 21-26.

Talboys PJ, Healey JR, Withers PJA, Roose T, Edwards AC, Pavinato, PS and Jones, DL 2020. Combining seed dressing and foliar applications of phosphorus fertilizer can give similar recovery rates. Front. in Agron. **2**:605-655.

Tarafdar JC, Raliya R, Mahawar H and Rathore I 2014. Development of zinc nanofertilizer to enhance crop production in pearl millet (*Pennisetum americanum*). Agri. Res. **3**: 257- 262.

(Manuscript received on 10 July, 2023; revised on 20 November, 2023)