The Pharma Innovation Journal 2023; 12(6): 4564-4568

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 4564-4568

www.thepharmajournal.com
Received: 09-03-2023
Accepted: 12-04-2023

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Influence of comparative application of conventional and nano urea on paddy growth and yield

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Abstract
Faulty and imbalanced application of NPK based fertilizers to paddy not only threatens the environment also affecting the sustainable food security of country. Variation in method and quantity of N fertilizer application has higher impact on the sustainability of paddy production. A field study was carried out to study the effect of foliar feeding of nano and conventional urea growth, yield traits and yield of paddy. The experiment was laid out in RBD with three replications making eleven treatment combinations. The results revealed, paddy growth and yield was significantly varied with application of both conventional and nano urea compared to control (T_1) and RDF (T_2). Application of 100% RDN + One spray of 0.4% nano urea fertilizer at 30 DAT (T_6) increased plant height (80.2 cm), number of tillers (11.6) and dry matter accumulation (66.3) followed by 75% RDN + Two spray of 0.4% nano urea fertilizer at 30 & 45 DAT (T_5) and 100% RDN+2% conventional urea at 30 DAT (T_{10}). These treatments also had highest number of fertile tiller number (15%), panicle length (20%), filled and unfertile grain number (23 and 13%) compared to control. There was 24.4% improvement in yield (4715.0 kg/ha) was noted due T_6 compared to RDF (T_2). Compared to conventional urea 9.1% increment in yield was noted, irrespective of treatments. 75% RDN + one nano N spray at 30 DAT saved ~25-40% of nitrogen compared to 100% RDN + one spray of urea.

Keywords: Foliar application, growth, nano nitrogen, paddy, urea, yield, dry matter accumulation

Introduction

Nano technology is the current researchable issue in the world for its reliable results of higher input use efficiency, higher production potential, ecologically friendly and economically affordability. Nitrogen is major plant nutrient required by the crop for physiological growth and development. To feed the increasing population of India, chemical fertilizers have a vital role in increasing the production potential and food security. However, due to excess and non-scientific application methods, nitrogen is causing the nitrogen pollution in paddy growing ecologies of the world. Cereals are having lower N use efficiency, higher/ excess application of N may not be used in the production rather increase the cost of production, declined sustainability and environmental pollution. Thus there is a need to improve nitrogen application efficiency for sustainable production. A change in traditional application methods at maximum requirement stage improves the nitrogen uptake.

Nano urea is ultra-fine nitrogen containing liquid fertilizer with higher surface area. Nano nutrients due to their minute size have various advantages in agricultural production due to higher retention on the surface area of leaf (Midde *et al.*, 2022; Chandana *et al.*, 2022) [8, 3]. Higher availability of nutrient at sink is possibly improving the yield due to taller plants, higher number of tillers addicting to the dry matter accumulation. Paddy requires N at maximum tillering and panicle initiation for increased sink number and size. Basal N application initially improve yield but losses are higher due to lower uptake and demand. N application at reproductive stage of crop improves the yield. Foliar application of nutrients directly influences the source area and thus improved source sink relations (Mahamoodi *et al.*, 2022; Wei *et al.*, 2014). Bhuyan *et al.*, (2012) [2] reported increased higher NUE due to foliar application of nitrogen. Similarly, robust plant growth was noted with application of nano-N (Mahmoodi *et al.* 2020) [6]. However, Chandana *et al.*, (2022) [3] observed no variation in the number of tillers due to complete foliar application, indicating soil based N requirements in paddy. Paddy is a staple food for the world feeding 1/3rd of the population. Nitrogen management in paddy growing ecosystems is an crucial for both environmental and sustainability point of view.

Nano urea an important intervention for nitrogen use efficiency and economical profitability. The current study is conducted to explore the time and concentration of nano nitrogen and conventional urea and response of paddy for higher growth and yield, especially morphological characters, straw yield, and yield components.

Materials and Method

Crop management and data collection

The field experiment was conducted at AHRS Bhaviekere, Karnataka India during Kharif season of 2022 on sandy loam soils, which are low in organic carbon and available N and P and medium in K, slightly acidic (pH-5.6) but non-saline. The experiment was laid out in randomized block design (RBD) with three replication and eleven treatments. The treatments comprised of combination of basal N and foliar applied Nano and conventional urea. The treatments are T_1, recommended dose of Fertilizer (100:50:50 N: P: K kg ha^{-1}) (T_2). 50% RDN + Two spray of nano N (T3). T4 (75% RDN+ one nano N spray), T5 (75% RDN + two nano N spray) T6 (100% RDN + One nano N spray). T7 (50% RDN + Two spray of 2% urea) T8 (75% RDN + One spray of 2% urea) T9 (75% RDN + Two spray of 2% urea) T10 (100% RDN + One spray of 2% urea) T11 (Four spray of 0.4% nano N at 15, 30, 45 & 60 DAT) was tested against T1 (absolute control). Two week old seedlings were transplanted at a distance of 30×10 cm, the gross plot size was 4.5×5m. The plot was fertilized treatment wise. 50% of recommended N was applied as basal and remaining N was applied as two splits at tillering and panicle initiation stage. Two water sprays were taken at 30 and 45 DAT in T_1 and T_2, to avoid the treatmental bias with battery Knapsack sprayer (16 litre capacity). No fertilizer was applied in absolute control (T_1). Plant protection and regular hand weeding was done on requirement basis. Data were statistically analysed using the analysis of variance (ANOVA) technique applicable to the randomized block design (Gomez and Gomez. 1984) [4]. The significance of the treatment effect was determined using F-test; the means of the treatments are tested using the least significant differences (LSD) at the 5% probability level.

Results and Discussion

Growth and Yield of Paddy

In the current study, the application of foliar N at different stages considerably affected the growth parameters of paddy when compared to control and RDF. Foliar application of nano urea fertilizer demonstrated a significant increase in plant height in all the treatment except control. According to the results T6, which received a foliar treatment of 100% RDN+ one spray of 0.4% nano urea fertiliser at 30 DAT, had had taller plants (80.2 cm) followed by T_5, which received a foliar application of 75% RDN+ two sprays of 0.4% nano urea fertiliser at 30 and 45 DAT (75.7 cm). Lowest was recorded in control (53.9 cm). It might due to nitrogen that has been nano-encapsulated efficiently release nutrients, controlling plant growth and boosting target activity. The nano fertilizer is a colloidal farming fertilization additive that aids in nutrient uptake, transportation, and absorption. Foliar nitrogen application was shown by Bahmaniar and Sooaee Mashaee (2010) [1] to positively influence plant height. Plant height may have increased because of an increase in cell development caused by nitrogen. Exogenous use of nanoparticles has been shown in several studies to considerably boost plant development (Mandeh *et al*., 2012; Song *et al*., 2013) [7, 10]. Another important growth parameter, leaf area index (LAI) shown significant response for leaf area index (LAI). The LAI enhanced in T6 (7.7), followed T5 (7.7) and on par with 100% RDN+ one spray of 2% urea fertilizer applied at 30 DAT (7.7). It was caused due to nano urea nano urea boosted the production of chlorophyll, which in turn raised the rate of photosynthesis, cell division and caused leaf growth. Higher plant height accommodating more number of leaves (Midde *et al*., 2022) [8].

Plant dry matter accumulation (DMA) was significantly impacted by foliar treatments and various nitrogen levels. At 30 DAT, although significant differences were found the pattern of DMA was non-consistent. However, at 60 and 90 DAT 100% RDN+ one spray of 0.4% nano urea fertiliser applied at 30 DAT (T_6) had the highest DMA (66.3 &104.6 g/plant), however, it was on par with T_5, 75% RDN+ two sprays of 0.4% nano urea spray at 30 and 45 DAT (55.2 & 96.3 g/plant) and T_{10} (100% RDN+ 2% urea spray at 30 DAT) (54.9 &93.9 g). foliar application of nitrogen resulted in greater surface area, easier penetration into the plant by particles smaller than the leaves, and improved nutrient utilisation efficiency, which had the effect on photosynthesis and it resulted in high dry matter production (Mahmoodi *et al*. 2020) [6] Midde *et al*., (2022) [8] recorded higher dry matter of paddy with application of 50% RDN+50% foliar application of nano N.

The rise in nitrogen level has led to an increase in the number of tillers at various stages of crop (Table 1). Tillers at 30 DAT were not significantly varied with both nano and conventional urea application. However, application of nano–N at 60 and 90 DAT significantly increased the number of tillers. At 60 DAT, highest numbers of tillers were found in T_6 and T_{10} i.e., 100% RDN+ one spray of 0.4% nano urea and T_{11}, complete nano-N applied at 15,30,45 and 60 DAT (12.0 and 12.0) respectively and they were on par with T_{10} & T_5 (10.8 each), T_2 and T_9 (10.5 &10.3), respectively. At 90 DAT reductions in number of tillers were observed. Treatments receiving basal nitrogen produced higher number of tillers. Complete Nano-N treatment (T_{11}) although produced higher tillers at 60 DAT (12.0), 50% of reduction were observed at 90 DAT (7.4). This was because reducing particle size increased a fertilizer's specific surface area and the quantity of particles per unit area. This increased the fertilizer's opportunities for penetration led to higher synthesis and mobilization of carbohydrates, proteins resulted in cell division, thus increased the number of tillers (Chandana *et al*., 2021) [3]; Mahmoodi *et al*. 2020) [6].

Yield components of paddy

Components of yield directly influence the yield levels of paddy which intern depend on the growth attributes. The yield traits of paddy in present experiment were significantly influenced by application of foliar application of N at various stages compared to control and RDF. Application of 100% RDN+0.4% nano urea at 30 DAT (T6) produced significantly higher number of panicles per hill (14.9), followed by T_5 (75% RDN+0.4% nano-N at 30 and 45 DAT). Application of nano urea (T_3, T_4, T_5 & T_6) had more number of panicles (12.5) compared to conventional urea treatments (T_7, T_8, T_9 & T_{10}) (9.8). Complete nano urea at 15, 30, 45 and 60 DAT (T_{11}) produced lower number of panicles (7.9) compared to RDF (11.0). Midde *et al*., (2022) [8] also recorded beneficial effect of nano urea in paddy.

Similarly, longer panicle length of paddy was recorded in 100% RDN+ one spray of 0.4% nano urea fertilizer applied at 30 DAT (T_6) (23.1 cm) and it was on par with 100%RDN+2% conventional urea (23.8 cm), 75% RDN+0.4% nano N applied at 30 and 45 DAT (22.7 cm). Although panicle length is genetic character, it was influenced by soil, weather and N management practices (Mustafa *et al*. 2011) [9]. Interestingly, more number of N applications had longer panicles might be due higher N availability around reproductive stage of paddy.

Although higher LAI, tillers are found in complete nano urea applied treatments (T_{11}) produced less number of panicles, might be due to imbalanced source sink relationships. Foliar application of N (irrespective of nano or conventional) encourages the vegetative growth, but failed to produce large sink and sink filing capacity. Similar results were observed by Wei *et al*., (2011) [12], they noted essentiality of nitrogen to achieve higher sink.

Similarly Number of spikelet's per panicle and grains/panicle are influenced by nutrient management at reproductive stage. Nano urea applied 30 and 45 DAT along with 75% and 100% RDN (T_5 and T_6), had higher number of spikelet's (84.4& 76.3) respectively. 100% RDN+ 2% conventional urea applied at 30 DAT also increased the spikelet's (77.8). Readily available to the reproductive parts instead of storing in stem and vegetative parts, indicating higher sink accumulation. Higher dry matter and more number of panicles might have caused higher number of spikelets per hill. Death of the tillers at grain filling stage in conventional urea applied treatment was noted in the experiment that might have caused the decline in number of spikelets.

Effect of nano and conventional urea had non-significant effect on test weight of paddy. However, on average application of nano urea had had higher test weight (23.7 g) compared to conventional urea (23.01 g). Complete nano nitrogen foliar application treatment (T_{11}) devoid of basal dosage failed to improve the test weight, and recorded lower weight (21.5 g) compared to RDF (23.9 g). Mahmoodi *et al*. (2020) [6] recorded non-significant response for test weight with foliar application of nutrients across the stages. Our results are in contradict to previous studies by Khursheed *et al*., (2018) [5] and Sultana *et al*., (2018) [11] they reported significant effects of foliar application test weight.

Grain and straw yield

The results in Table 2, indicates foliar application of nano nitrogen significantly influenced both grain straw yield of paddy. Among the different combinations of RDN and nano-N, significantly highest grain and straw yield was recorded in application of 100% RDN+ one spay of 0.4% nano N applied at 30 DAT (4715.0 & 6481.2 kg/ha), respectively. However, among RDN and conventional urea applied at 100% RDN + one spay of 2% urea applied at 30 DAT had higher yield. Nano urea applied treatments had 10.4% increased yield irrespective of the stage of paddy. Four spray of 0.4% nano urea fertilizer (100% Nano) at 15, 30, 45 & 60 DAT (T_{11}) had 7.9% of higher yield compared to RDF (T_2). Nitrogen deficiency during reproductive stages usually causes poor filling and lower test weight due to slower accumulation of photosynthates to sink might have caused the lower yields in conventional urea and RDF treatments. Nano urea applied treatments remained green after reaching the physiological maturity, continuously supplying the photosynthates to sink. Similar results noted previously by Wei *et al*., (2011) [12]; Midde *et al*., (2022) [8]; Chandana *et al*., (2022) [3].

Straw yield increment was significant due to application of N in nano farm. Robust growth, Higher tillering, more accumulation of dry matter, and longer plant height in 100% RDN+ one spay of 2% urea applied at 30 DAT (T_6) and 30 and 45 DAT (T_5) respectively had straw yield of 6181.0 and 6026.0 kg/ha. The best treatment (T_6) had 15.1% higher than the RDF, while entire N applied as foliar spray (T_{11}) produced 5.4% higher straw yield compared to control. Improvement in tillers, leaf area and vegetative in paddy due to foliar application of nitrogen was noted by Midde *et al*., (2022) [8], Bhuyan *et al*., (2012) [2] and Chandana *et al*., (2022) [3].

Table 1: Effect of foliar application of nano urea and conventional urea on growth of paddy

	Treatments	Plant height (cm)				LAI		Dry matter accumulation (g hill^{-1})			
		30 DAT	60 DAT	90 DAT	Harvest	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	Harvest
T1	Absolute control.	20.1	42.9	56.8	53.9	2.1	2.9	2.8	9.5	30.8	53.8
T2	Recommended dose of Fertilizer (100:50:50 N:P: K kg/ha).	18.7	54.1	71.4	68.6	2.5	4.9	2.5	14.1	44.3	68.9
T3	50% RDN + Two spray of 0.4% nano urea fertilizer at 30 & 45 DAT.	18.0	50.2	63.3	62.5	2.2	4.1	3.2	12.8	41.0	70.4
T4	75% RDN + One spray of 0.4% nano urea fertilizer at 30 DAT.	16.5	55.9	79.3	75.8	3.6	5.5	2.4	16.0	54.1	85.0
T5	75% RDN + Two spray of 0.4% nano urea fertilizer at 30 & 45 DAT.	19.5	57.0	78.2	75.7	4.4	6.2	1.6	17.4	55.2	96.3
T6	100% RDN + One spray of 0.4% nano urea fertilizer at 30 DAT.	20.2	60.3	84.1	80.2	4.5	6.4	3.7	18.6	66.3	104.6
T7	50% RDN + Two spray of 2% urea fertilizer at 30 & 45 DAT.	21.4	60.3	53.5	49.7	2.3	4.7	2.5	10.0	39.4	65.0
T8	75% RDN + One spray of 2% urea fertilizer at 30 DAT.	18.7	53.4	66.9	63.0	3.2	4.4	3.7	10.9	42.5	86.0
T9	75% RDN + Two spray of 2% urea fertilizer at 30 & 45 DAT.	17.7	50.5	75.7	72.5	3.1	5.1	4.6	11.7	46.1	90.6
T10	100% RDN + One spray of 2% urea fertilizer at 30 DAT.	18.7	56.8	79.5	78.7	4.3	5.5	3.3	16.3	54.9	93.9
T11	Four spray of 0.4% nano urea fertilizer (100% Nano) at 15, 30, 45 & 60 DAT	17.3	45.0	63.9	64.4	2.9	4.9	2.0	11.2	36.4	63.0
	S.Em.±	0.34	1.70	2.33	1.14	0.06	0.16	0.38	1.40	3.03	4.92
	CD 5%	1.00	5.03	6.87	3.28	0.17	0.47	1.13	4.12	8.95	14.52

Table 2: Effect of foliar application of nano urea and conventional urea on yield parameters of paddy

	Treatments	No' of Tillers/hill			No' of panicles per hill	No' spikelet panicle^{-1}	Panicle length (cm)	1000-seed weight
		30 DAT	60 DAT	90 DAT				
T1	Absolute control.	3.5	5.2	4.8	6.1	60.72	19.3	19.26
T2	Recommended dose of Fertilizer (100:50:50 N:P:K kg/ha).	4.2	10.3	8.6	11.0	72.79	20.9	23.92
T3	50% RDN + Two spray of 0.4% nano urea fertilizer at 30 & 45 DAT.	3.1	6.3	6.3	10.6	70.08	21.5	21.49
T4	75% RDN + One spray of 0.4% nano urea fertilizer at 30 DAT.	3.5	9.7	9.5	11.6	69.52	22.5	23.45
T5	75% RDN + Two spray of 0.4% nano urea fertilizer at 30 & 45 DAT.	4.2	10.8	10.1	13.1	76.30	22.7	24.10
T6	100% RDN + One spray of 0.4% nano urea fertilizer at 30 DAT.	4.2	12.0	12.3	14.9	84.35	23.1	26.10
T7	50% RDN + Two spray of 2% urea fertilizer at 30 & 45 DAT.	3.5	6.2	6.0	8.5	64.27	20.2	21.33
T8	75% RDN + One spray of 2% urea fertilizer at 30 DAT.	3.5	9.0	8.3	9.4	69.64	21.2	22.31
T9	75% RDN + Two spray of 2% urea fertilizer at 30 & 45 DAT.	3.5	10.5	9.9	10.2	72.61	21.9	23.28
T10	100% RDN + One spray of 2% urea fertilizer at 30 DAT.	3.1	10.8	11.6	11.2	77.78	22.3	25.11
T11	Four spray of 0.4% nano urea fertilizer (100% Nano) at 15, 30, 45 & 60 DAT	3.5	12.0	7.4	7.9	70.78	23.8	21.53
	S.Em.±	0.31	0.62	0.49	0.46	2.43	0.84	1.28
	CD 5%	NS	1.82	1.43	1.36	7.16	2.47	NS

Treatments	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Harvest Index
Absolute control.	2989.4	3693.9	0.45
Recommended dose of Fertilizer (100:50:50 N:P:K kg/ha).	4219.7	5363.4	0.44
50% RDN + Two spray of 0.4% nano urea fertilizer at 30 & 45 DAT.	3992.4	5255.4	0.43
75% RDN + One spray of 0.4% nano urea fertilizer at 30 DAT.	4103.6	5755.4	0.42
75% RDN + Two spray of 0.4% nano urea fertilizer at 30 & 45 DAT.	4307.0	6026.0	0.42
100% RDN + One spray of 0.4% nano urea fertilizer at 30 DAT.	4715.0	6181.0	0.43
50% RDN + Two spray of 2% urea fertilizer at 30 & 45 DAT.	3679.4	4151.2	0.47
75% RDN + One spray of 2% urea fertilizer at 30 DAT.	4004.0	4605.8	0.47
75% RDN + Two spray of 2% urea fertilizer at 30 & 45 DAT.	4152.9	4999.9	0.45
100% RDN + One spray of 2% urea fertilizer at 30 DAT.	4361.0	5468.2	0.45
Four spray of 0.4% nano urea fertilizer (100% Nano) at 15, 30, 45 & 60 DAT	3922.5	5645.4	0.41
S.Em.±	89.35	179.35	0.01
CD 5%	263.59	529.07	0.03

Conclusion

Foliar feeding of both conventional and nano-N has significantly influenced the paddy growth and yield traits. Irrespective of sources of N, foliar application has improved the growth and yield components. The experiment observed complete foliar application devoid of basal dosage, improves the vegetative growth, but slowly increasing reproductive parts. Thus, combined application of basal and foliar nano urea should be considered for higher yield. Among the conventional and nano urea sources application of nano urea @ 30 and 45 DAT saved up to 50% of the recommended nitrogen. It is concluded that application of nano urea along with 50-75% of RDN as basal is promising for sustainable yield and ecologically safer paddy ecosystems.

Acknowledgements

The authors are thankful to the Director of Research, KSNUAHS, Shivamogga, Karnataka, India for financial support through Staff Research Project (SRP).

Conflict of interest

The authors declare no competing interests.

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