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To study the nitrogen management for enhancing productivity and profitability of transplanted rice (*Oryza sativa* L.)

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Abstract
A field experiment was executed during *kharif* season 2022 at Instructional farm, BTC CARS, Bilaspur (C.G.). The experiment was executed with a perspective "To study the nitrogen management for enhancing productivity and profitability of transplanted rice (*Oryza sativa* L.)." The experiment comprised of ten treatments and three replications. The results imparted that administer of recommended dose of fertilizer (100:60:40 NPK kg ha^{-1}) yielded maximum values for growth and yield attributes. However, it was closely followed by 75% recommended dose of nitrogen with 2 spray of Nano urea at tillering and panicle initiation stage.

Keywords: Nano urea, rice, growth, yield attributes

1. Introduction
Rice (*Oryza sativa* L.) is a major cereal. It belongs to family Poaceae. As a matter of fact a decent amount of population is dependent on rice for their energy requisite. Additionally, because the world's poorest and most malnourished people live in Asia and Africa and cannot afford nutrient-dense foods, rice serves as their primary source of nourishment. Since, rice fulfils the energy requisite of such large population, rice is usually considered an important commodity.
Globally, 503.8 million tonnes of rice were produced in the year 2019-20 which increased to 518.1 million tonnes in the year 2020-21 (FAO, 2022) [2]. The total production of rice in India during 2021-22 is estimated to be 127.93 million tonnes. It is higher by 11.49 million tonnes than the last five year's average production of 116.44 million tonnes (Anonymous, 2022) [3]. It is also noteworthy that, rice production in Chhattisgarh (2019-20), total area of production was reported to be 3876.13 ha and the productivity accounting to 3002 kg ha^{-1}. However, the total area of production in the year 2020-21 was recorded to be 3903.92 ha and the productivity was 3438 kg ha^{-1} (Anonymous, 2021) [1].
Fertilizers are one of the crucial pre-requisite that govern the grain production. Production in rice is mostly dependent on soil characteristics and to a greater extent on the availability of nutrients including nitrogen, phosphorus, potassium, sulphur and zinc (Masum *et al.*, 2013) [4]. Although many nutrients are important for production in rice, nitrogen is eminent.
Urea is the one of the most significant nitrogenous fertilizer in the nation due to its high N concentration (46% N). However, leaching, denitrification and ammonia volatilization are a few of the processes through which nitrogen given to rice crop is partially lost. These losses may result in soil contamination and groundwater pollution and may also lead to decrease in nitrogen availability because of which excessive use of nitrogenous fertilizer is common. These problems cannot be alleviated completely but the use of Nano urea and foliar urea can reduce the loss of nutrient and increase nitrogen use efficiency. It also holds the potential of reducing urea's import from foreign nation.
Nano urea has been developed with an objective of minimizing the urea demand by as much as 50 per cent. The rate of application of Nano urea is 2.0 - 4.0 ml L^{-1}. It is also evident that 500 ml Nano urea incorporates nitrogen @ 40,000 mg/l.

Thus, Nano urea fulfils the nitrogen requirement of crop without compromising on the environmental issues.

2. Materials and Methods

The present demonstration was examined during *kharif*, 2022 at the Instructional farm of BTC CARS, Bilaspur (Chhattisgarh). The experiment consisted of ten treatments and three replications. Randomised Block Design (RBD) was employed for analysing the results. The concerned variety was "Zinco Rice MS" which was transplanted at a distance of 20 cm × 10 cm. The crop was transplanted on 28th July, 2022. The gross plot size of 5 m × 4.5 m and net plot size of 4.60 m × 4.30 m was laid out.

The experiment comprised of ten treatments T_1: Control, T_2: RDF (100:60:40 NPK kg ha^{-1}), T_3: 50% RDN + 1 spray of Nano urea at tillering stage, T_4: 50% RDN + 2 spray of Nano urea at tillering and panicle initiation stage, T_5: 50% RDN + 1 spray of 2% urea at tillering stage, T_6: 50% RDN + 2 spray of 2% urea at tillering and panicle initiation stage, T_7: 75% RDN + 1 spray of Nano urea at tillering stage, T_8: 75% RDN + 2 spray of Nano urea at tillering and panicle initiation stage, T_9: 75% RDN + 1 spray of 2% urea at tillering stage, T_{10}: 75% RDN + 2 spray of 2% urea at tillering and panicle initiation stage.

3. Result

3.1 Plant height (cm)

The results have been pertained in table 1. However, 30 DAT maximum value for plant height (61.23 cm) was achieved under treatment T_2: RDF (100:60:40 NPK kg ha^{-1}) it was followed by T_8 (60.64 cm), T_{10} (59.79 cm), T_7 (59.49 cm) and T_9 (58.47 cm). Comparable trends were seen under 60 DAT, 90 DAT and at harvest. The results also indicated that proper fertilization accelerates plant height.

3.2 Number of tillers (m^{-2})

The observations were made at an interval of 30 DAT, 60 DAT and 90 DAT correspondingly (354.75), (565.21) and (596.51) tillers were noted in T_2. However, the least number of tillers were observed under treatment T_1 (control.)

The results are demonstrated in Table 2

3.3 Dry matter accumulation (g m^{-2})

The dry matter accumulation (g m^{-2}) was recorded using five hills. Five hills were chosen their dry matter was noted and then total dry matter for m^{-2} was worked out. As table 3 suggests that dry matter accumulation increased in T_2 with administer of RDF (100:60:40 NPK kg ha^{-1}) it was followed by treatment T_8, T_{10}, T_7 and T_9.

However, Dry matter accumulation was steady up to 30 DAT and augmented after 30 DAT until harvest.

Table 1: Effect of nitrogen on plant height of rice at 30 DAT, 60 DAT, 90 DAT and at harvest

Plant height (cm)				
Treatment	**30 DAT**	**60 DAT**	**90 DAT**	**At harvest**
T_1	41.71	70.26	89.37	84.45
T_2	61.23	94.45	117.18	114.78
T_3	50.82	81.76	102.54	99.69
T_4	51.86	83.10	103.29	100.05
T_5	49.74	81.03	101.87	99.47
T_6	51.15	82.17	103.03	99.84
T_7	59.49	92.39	115.28	113.33
T_8	60.64	93.89	116.94	114.03
T_9	58.47	91.93	114.36	113.14
T_{10}	59.79	93.46	116.65	113.61
S.Em (±)	2.19	2.82	3.49	4.05
CD (5%)	6.51	8.38	10.39	12.03

Table 2: Effect of nitrogen on number of tillers at 30 DAT, 60 DAT and 90 DAT.

Total number of tillers (m^{-2})			
Treatment	**30 DAT**	**60 DAT**	**90 DAT**
T_1	279.67	472.53	516.52
T_2	354.75	565.21	596.51
T_3	314.65	526.12	557.11
T_4	322.13	533.96	565.17
T_5	312.04	522.51	554.74
T_6	319.90	531.38	562.48
T_7	346.84	555.83	588.57
T_8	351.71	562.45	592.89
T_9	343.75	551.15	583.00
T_{10}	349.99	558.59	589.90
S.Em (±)	4.24	4.98	5.19
CD (5%)	12.61	14.80	15.43

Table 3: Effect of nitrogen on dry matter accumulation at 30 DAT, 60 DAT, 90 DAT and at harvest.

	Dry matter accumulation (g m^{-2})			
Treatment	**30 DAT**	**60 DAT**	**90 DAT**	**At harvest**
T_1	164.75	920.23	1546.90	1646.19
T_2	189.45	1088.21	1712.6	1821.53
T_3	176.22	1033.01	1650.35	1758.66
T_4	177.91	1038.31	1654.21	1763.65
T_5	174.35	1029.99	1648.00	1754.16
T_6	176.81	1035.47	1653.39	1760.76
T_7	187.46	1079.07	1700.78	1813.85
T_8	188.33	1085.62	1706.50	1819.50
T_9	186.03	1074.28	1696.56	1809.79
T_{10}	187.82	1082.42	1703.28	1816.20
S.Em (±)	2.20	11.15	13.86	15.46
CD (5%)	6.56	33.14	41.20	45.94

3.4 Number of effective tillers (m^{-2})
The table 4 depicts that maximum number of effective tillers were observed under treatment T_2 where, RDF (100:60:40 NPK kg ha^{-1}) was at par with T_8 (75% RDN + 2 spray of Nano urea at tillering and panicle initiation stage), T_{10} (75% RDN + 2 spray of 2% urea at tillering and panicle initiation stage), T_7 (75% RDN + 1 spray of Nano urea at tillering stage) and T_9 (75% RDN + 1 spray of 2% urea at tillering stage). The lowest number of effective tillers were observed under treatment T_1 (control).

3.5 Panicle length (cm)
The maximum panicle length (24.58 cm) was observed under treatment T_2 with application of RDF (100:60:40 NPK kg ha^{-1}). However, it was at par with T_8 (24.32 cm) with application of 75% RDN + 2 spray of Nano urea at tillering and panicle initiation stage, T_{10} (24.23 cm) 75% RDN + 2 sprays of (2%) urea at tillering and panicle initiation stage, T_7 (23.99 cm) 75% RDN + 1 spray of Nano urea at tillering stage and T_9 (23.46 cm) 75% RDN + 1 spray of (2%) urea at tillering stage.
The data has been presented in table 4

3.6 Number of grains panicle^{-1}
As table 4 depicts maximum grains panicle^{-1} (151.78) were observed under treatment T_2 with application of RDF (100:60:40 NPK kg ha^{-1}). However, minimum number of grains panicle^{-1} (126.54) were observed under treatment T_1.
The results are in accordance with Ullah *et al.* (2018) [5].

3.7 Test weight (g)
Treatment T_2 prompted maximum test weight (22.97 g) which was at par with treatment T8 (75% RDN + 2 spray of Nano urea at tillering and panicle initiation stage), T_{10} (75% RDN + 2 spray of 2% urea at tillering and panicle initiation stage), T_7 (75% RDN + 1 spray of Nano urea at tillering stage) and T_9 (75% RDN + 1 spray of 2% urea at tillering stage) and it was significant over T_4 (50% RDN + 2 spray of Nano urea at tillering and panicle initiation stage), T_6 (50% RDN + 2 spray of 2% urea at tillering and panicle initiation stage), T_3 (50% RDN + 1 spray of Nano urea at tillering stage) and T_5 (50% RDN + 1 spray of 2%urea at tillering stage). However, lowest test weight was recorded under treatment T_1 (19.75 g) control.
The increased test weight presumably is an outcome of nitrogen application which in turn hastened dry matter production. The observations are presented in table 4.

Table 4: Effect of nitrogen on yield attributing characters of rice.

Treatments	Effective tillers at harvest	Panicle length (cm)	Number of grains panicle^{-1}	Test weight (g)
T_1	479.75	14.24	126.54	19.75
T_2	530.06	24.58	151.78	22.97
T_3	502.63	19.73	139.32	21.22
T_4	508.60	20.02	141.08	21.47
T_5	501.93	19.64	138.87	20.62
T_6	506.46	19.96	139.74	21.38
T_7	524.03	23.99	148.76	22.47
T_8	528.01	24.32	150.75	22.76
T_9	522.60	23.46	148.02	22.34
T_{10}	526.14	24.23	149.89	22.64
S.Em (±)	3.75	0.98	2.34	0.40
CD (5%)	11.16	2.92	6.97	1.21

3.7 Grain yield (q ha^{-1})
Grain yield is a paramount character. Data revealed that highest grain yield (52.74 q ha^{-1}) was recorded under treatment T_2 RDF (100:60:40 NPK kg ha^{-1}). The lowest grain yield was recorded under treatment T_1 (31.69 q ha^{-1}).
The data has been illustrated in table 5.

3.8 Straw yield (q ha^{-1})
Table 5 depicts that maximum straw yield was observed under treatment T_2 (58.02 q ha^{-1}) which was at par with T_8 (57.87 q ha^{-1}), T_{10} (57.68 q ha^{-1}), T_7 (54.40 q ha^{-1}) and T_9 (54.30 q ha^{-1}). Lowest straw yield was observed in T_1 (41.51 q ha^{-1}).
Elevated straw yield can be accounted to improved plant population which in turn led to more number of tillers and ultimately increased straw yield.

Table 5: Effect of nitrogen on grain yield and straw yield of rice.

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1 - Control	31.69	41.51
T_2 - RDF (100:60:40 NPK kg ha^{-1})	52.74	58.02
T_3 - 50% RDN + 1 spray of nano urea at tillering stage	41.51	48.74
T_4 - 50% RDN + 2 spray of nano urea at tillering and panicle initiation stage	43.52	49.67
T_5 - 50% RDN + 1 spray of 2% urea at tillering stage	41.25	48.67
T_6 - 50% RDN + 2 spray of 2% urea at tillering and panicle initiation stage	43.35	49.48
T_7 - 75% RDN + 1 spray of nano urea at tillering stage	48.91	54.40
T_8 - 75% RDN + 2 spray of nano urea at tillering and panicle initiation stage	52.31	57.87
T_9 - 75% RDN + 1 spray of 2% urea at tillering stage	48.43	54.30
T_{10} - 75% RDN + 2 spray of 2% urea at tillering and panicle initiation stage	51.95	57.68
S.Em (±)	1.64	1.54
CD (5%)	4.89	4.58

4. Conclusion

It was observed that grain yield and straw yield were highest under treatment T_2 (RDF@ 100:60:40 NPK kg ha^{-1}) which was followed by T_8 (75% RDN + 2 spray of Nano urea at tillering and panicle initiation stage). The lowest values were recorded under treatment T_1.

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