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EFFECT OF NANO-UREA AND FERTILIZER DEEP PLACEMENT ON GROWTH AND YIELD OF WET DIRECT SEEDED RICE

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ABSTRACT

A field experiment was conducted during the *kharif* seasons of 2022 and 2023 at Assam Agricultural University, Jorhat, to study the effect of nano-urea and fertilizer deep placement (FDP) on growth and yield of wet direct seeded rice (*Oryza sativa* L.). Thirteen nitrogen treatments comprising different levels of recommended dose of nitrogen (RDN), nano-urea sprays, and FDP were evaluated in a randomized block design with three replications. Results indicated that application of 125% RDN + nano-urea (T_9) significantly enhanced plant height, tiller number, dry matter accumulation, crop growth rate, grain yield (48.67 q ha^{-1}), and straw yield (63.75 q ha^{-1}), and was statistically at par with 100% and 125% RDN applied through FDP (T_{12} and T_{13}). The lowest growth and yield were recorded under the control treatment. Improved performance under nano-urea and FDP treatments was attributed to higher nitrogen use efficiency and sustained nutrient availability. The study concludes that integrated nitrogen management using nano-urea or FDP is an effective approach for improving productivity of wet direct seeded rice.

Keywords **:** Nano Urea, Rice (*Oryza sativa* L.), Fertilizer Deep Placement (FDP)

Introduction

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population. Rice is commonly regarded as a semi-aquatic annual grass species. About 20 species of the genus Oryza are identified, although practically all farmed rice is *O. sativa* L. cultivated over 165.25 million hectares, with an estimated global production of 503.27 million metric tons in year. India is the world's second-biggest producer and largest exporter of rice after China. Rice is India's most important crop, growing on 46.38 million hectares and contributing 130.29 million tons of production with a productivity of 2809 kg/ha (Agriculture statistics at a Glance, 2022). Rice is produced in over 120 nations worldwide, with China (approximately 149.0 Mmt) and India (approximately 122.3 Mmt) accounting for more than half of total rice output. China has the highest productivity (kg/ha) with 6710, followed by Vietnam (5573), Indonesia (5152), and Bangladesh (4375), (FAO-2022). The increased frequency and intensity of high temperatures, together with their considerable variability, will result in a 40% yield drop in rice by the end of the twenty-first century. A 20-degree Celsius increase in temperature could reduce rice productivity by around 0.75 t/ha in high- yielding locations. Rice grain production decreases by 10% for every 10^0C increase in lowest temperature (Kingra *et al.,* 2018).

Direct seeded rice (DSR) is a growing production system in Asia due to its benefits, including labour savings, improved soil quality for subsequent crops, lower methane emissions, faster planting, earlier crop maturity (7-10 days), increased tolerance to water deficits, comparable yield, and a high benefit-cost ratio. To save irrigation water in DSR, omit puddling, which requires 10-15 cm of water, and use alternate wetting and drying conditions to regulate crop irrigation (Kumar *et al.,* 2018). Nitrogen (N) is a crucial nutrient for rice production and is widely used during various growth stages (Mahajan *et al.,* 2011).

Nitrogen is essential for plant growth and is found in chlorophyll, protoplasm, enzymes, and amino acids.

Nanotechnology is a recent innovation that is used in all areas of agriculture. Nano fertilizers stand out as one of the most useful instruments due to their high productivity, functionality, and ease of usage. Nano urea is urea that has been manufactured with nanoparticles to increase its efficiency and effectiveness as a nitrogen fertilizer (Botewad *et al*., 2023). Nano urea comprises 4 percent nitrogen by weight in its nano form. Nitrogen in Nano Urea successfully provides agricultural nitrogen requirements. It has a higher use efficiency than conventional urea. Nano urea has various advantages, including reducing the need for traditional urea by fifty percent (Kantwa and Yadav, 2022). Fertilizer deep placement is the application of ammoniacal nitrogenous fertilizers to the reduction zone of soil, notably in paddy fields, where ammoniacal nitrogen is still available to the crop. This strategy ensures a better distribution of fertilizer in the root zone soil and prevents nutrient loss through runoff. Deep placement could be a better option to current rice production systems in terms of energy input and efficiency. Deep fertilizer placement can minimize fertilizer application without impacting crop yields while also lowering harmful gas emissions, making it an alternative to typical surface broadcasting methods. Deep fertilization could significantly increase rice yields in direct-seeding and transplanting rice (Wang *et al.,* 2022).

Materials and Methods

The field experiment was conducted during *kharif* seasons of 2022 and 2023 at the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat, which is situated at 26º71' N latitude, 94º18' E longitudes and at an altitude of 86.6 m above mean sea level. The experiment was laid out in a randomized block design and replicated thrice with thirteen treatments *viz.*, **T_1**-N zero (Control), **T_2**-50% Recommended dose of nitrogen (RDN), **T_3**-75% Recommended dose of nitrogen (RDN), **T_4**-100% Recommended dose of nitrogen (RDN), **T_5**-125% Recommended dose of nitrogen (RDN), **T_6**-50% RDN (15 kg N as basal only) + Two sprays of nano-urea (at AT and PI) @ 2 ml /l, **T_7**-75% RDN (22.5 kg N as basal only + Two sprays of nano-urea (at AT and PI) @ 2 ml /l, **T_8**-100% RDN (30 kg N as basal only + Two sprays of nano-urea (at AT and PI) @ 2 ml /l, **T_9**-125%RDN (37.5 kg N as basal only + Two sprays of nano-urea (at AT and PI) @ 2 ml /l, **T_{10}**-50% RDN as Fertilizer Deep Placement (FDP), **T_{11}**-75% RDN as Fertilizer Deep Placement (FDP), **T_{12}**-100% RDN as Fertilizer Deep Placement (FDP), **T_{13}**-125%RDN as Fertilizer Deep Placement (FDP). The initial soil of the experimental area was sandy loam in texture, acidic in reaction (P^H – 5.5), medium in organic carbon (0.61%), medium in available N (290.62 kg ha^{-1}), low in available P_2O_5 (22.5 kg ha^{-1}) and low in available K_2O (117.33kg ha^{-1}) analysed just before starting the experiment in 2022.

Results and Discussion

Plant height

The data related to plant height, especially when combined with nano urea and Fertilizer Deep Placement (FDP) methods, significantly boosts the plant height of Wet Direct Seeded Rice (DSR). The highest plant height recorded was 39.15 cm, by applying 125% RDN + nano-urea (T_9). This treatment surpassed all others, except for the 125% RDN as FDP (T_{13}), at 30 days after sowing (DAS). At later growth stages 60, 90, and 120 DAS, and at harvest, the average plant heights for T_9 were 84.72 cm, 115.71 cm, 126.86 cm, and 124.25 cm, respectively. These results were significantly higher compared to other treatments, though they were similar to those achieved with 100% RDN as FDP (T_{12}) and 125% RDN as FDP (T_{13}). The increase in plant height observed with the application of nitrogen, especially in the form of nano urea and through FDP methods, can be attributed to several physiological and agronomic factors. The deep placement of fertilizers allows for better root penetration and nutrient uptake, which is essential during critical growth stages. The synergistic effect of nano urea may play a significant role in enhancing nitrogen absorption efficiency, as it is designed to provide a slow and steady release of nutrients, thereby sustaining plant growth over an extended period (Kowsalya *et al.,* 2023). The significant differences in plant height across treatments also highlight the importance of tailored nitrogen management practices to optimize growth and yield in DSR systems. Foliar applications of nano-urea significantly enhanced plant height, leaf area index, and yield in rice (Anushka *et al*., 2023).

Number of tillers per m^2

Results related to the number of tillers per m² in wet direct seeded rice significantly increased with the application of nitrogen, particularly when combined with nano urea and fertilizer deep placement methods at different growth stages. In wet direct seeded rice the treatment with 125% RDN + nano-urea (T_9) resulted in significantly higher tiller counts per m² was 387.69, 376.44, 370.93, and 367.43 at 60, 90, 120 DAS, and at harvest, respectively. Compared to all other treatments.

However, these results were statistically on par with 100% RDN as FDP (T_{12}) and 125% RDN as FDP (T_{13}). Lowest number of tillers were recorded in T_1 (Control) treatment. The significant increase in tiller counts observed with nitrogen application, particularly through the combination of nano urea with basal application of nitrogen, can be attributed to several physiological and agronomic factors. Nitrogen is a vital nutrient that plays a crucial role in promoting cell division and growth, which are essential for tiller formation (Shrestha *et al.,* 2020). Foliar application of liquid nano urea led to increase tiller numbers in rice compared to traditional NPK fertilizers (Velmurugan *et al*., 2021).

Dry weight (g/m^2)

In Direct Seeded Rice (DSR) results increased significantly with the application of nitrogen, at various growth stages. The highest dry weights, 99.21, 481.78, 924.90, 1234.94, and 1369.94 g/m² were recorded with the application of 125% RDN + nano-urea (T_9). These values were significantly higher than those of all other treatments, and treatment 100% RDN as FDP (T_{12}) and 125% RDN as FDP (T_{13}) at 30, 60, 90, and 120 DAS, and at harvest, were statistically at par with T_9 treatment. This results in better growth and higher biomass accumulation in rice plants. Kumar *et al.* (2021) also observed maximum dry weight values with the application of 125% RDN combined with nano-urea. Similar results were found by Singh and Sharma (2019).

Crop Growth Rate (g/m^2/day)

In wet direct seeded rice, the highest crop growth rate 3.36, 12.75, 14.77, 10.34, and 4.50 g/m²/day was recorded with the application of 125% RDN + nano-urea (T_9). These values were significantly higher than those of all other treatments, except for 100% RDN as FDP (T_{12}) and 125% RDN as FDP (T_{13}) at 0-30, 30-60, 60-90, and 90-120 DAS, and from 120 DAS to harvest, respectively. Lowest CGR was recorded in T_1 (Control). The significant increase in Crop Growth Rate (CGR) due to the application of nano-urea can be linked to its improved nutrient availability and uptake efficiency. The smaller particle size of nano-urea offers a larger surface area for nutrient absorption. This leads to better growth and greater biomass accumulation in rice plants (Mehta and Singh, 2020).

Grain yield(q/ha)

Perusal of the data presents the grain yield under various nitrogen treatments over two years, with pooled results showed significant effect on treatments in direct seeded rice. The highest grain yield was achieved with treatment T_9 (125% RDN + nano-urea), resulting in a average of 48.67 q/ha. This was followed by Treatment T_{12} (100% RDN as FDP) with 45.29 q/ha and treatment T_{13} (125% RDN as FDP) with 44.75 q/ha, both are statistically at par to treatment T_9 (125% RDN + nano-urea). The lowest yield was observed with treatment T_1 (control), averaging 19.82 q/ha. The notable variations in grain yield among treatments highlight the critical role of effective nitrogen management in direct seeded rice cultivation. Application of higher dose of nitrogen at critical stages enhances crop growth and results in higher yield. Foliar nitrogen supply enhances plant growth and development by promoting tillering and leaf area expansion, which are critical for maximizing photosynthesis and biomass accumulation (Kumar *et al.,* 2020). Nitrogen levels, such as 125% RDN, can substantially boost grain yield by promoting better plant growth and development in direct seeded rice (Chauhan *et al*., 2020). Singh *et al.* (2021), Sharma *et al.* (2022) and Sandhu *et al.* (2012) also recorded similar results with higher nitrogen levels, particularly 125% RDN, resulted in significant yield improvements in direct-seeded rice.

Straw yield(q/ha)

In wet direct seeded rice, application of 125% RDN + nano-urea (T_9) resulted in the highest straw yield of 63.75 q/ha. This was followed by treatment T_{13} (125% RDN as FDP) with 61.08 q/ha and treatment T_{12} (100% RDN as FDP) at 60.68 q/ha. Treatment T_8 (100% RDN + nano-urea) and treatment T_5 (125% RDN) also showed high straw yields, with pooled averages of 59.04 q/ha and 59.51 q/ha, respectively and were statistically comparable to T_9. The lowest straw yield was observed with Treatment T_1 (Control), averaging 34.96 q/ha. Application of 50% recommended dose of nitrogen (RDN) combined with 50% nano urea resulted in the highest straw yield of rice (Midde *et al.*, 2021). This improvement is attributed to the slow and controlled release of nitrogen from nano-urea, which reduces nitrogen losses through leaching and volatilization (Akter *et al.,* 2022). Foliar spray of nano-urea had positive effect on straw yield (Attri *et al.,* 2022). Presence of straw can improve microbial activity in the soil, fostering a more diverse and active soil microbiome that aids in nutrient mineralization and enhances overall soil fertility. This synchronization between nitrogen availability and plant growth stages enhances overall growth and yield potential. Similar results were reported by Kumar *et al.* (2022) and Song *et al.* (2024).

Conclusion

The present study clearly demonstrates that nitrogen management strategies integrating nano-urea and fertilizer deep placement (FDP) significantly enhance growth and productivity of wet direct seeded rice (DSR). Among all treatments, application of 125% RDN + nano-urea (T_9) consistently recorded superior performance in terms of plant height, number of tillers per m², dry matter accumulation, crop growth rate, grain yield, and straw yield. The improvements observed under this treatment were largely attributed to enhanced nitrogen availability, improved uptake efficiency, and sustained nutrient release throughout critical growth stages. Although T_9 produced the highest values for most parameters, its performance was statistically comparable with 100% RDN as FDP (T_{12}) and 125% RDN as FDP (T_{13}), indicating that deep placement of nitrogen fertilizers can be an equally effective alternative for improving nitrogen use efficiency and crop performance in DSR systems.

Table 1 : Effect of nano-urea and fertilizer deep placement on plant height of wet direct seeded *kharif* rice

Treatment	Plant height (cm)														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1 - Control	31.82	30.07	30.95	52.76	50.26	51.51	81.45	78.46	79.96	90.75	88.45	89.60	89.81	88.31	89.06
T_2- 50% RDN	33.86	35.67	34.77	58.74	61.45	60.10	88.69	92.24	90.47	98.19	99.79	98.99	97.17	97.67	97.42
T_3- 75% RDN	33.77	35.62	34.70	63.54	65.08	64.31	90.87	98.50	94.69	100.37	102.77	101.57	99.24	100.14	99.69
T_4- 100% RDN	35.36	37.25	36.31	62.27	68.16	65.22	94.72	100.72	97.72	104.42	107.32	105.87	103.27	104.37	103.82
T_5- 125% RDN	36.17	38.12	37.15	66.80	69.73	68.27	98.17	98.73	98.45	108.17	111.97	110.07	106.16	107.86	107.01
T_6- 50% RDN + Nano-urea	32.73	34.56	33.65	61.89	64.58	63.24	89.75	93.36	91.56	99.25	101.35	100.30	98.38	99.18	98.78
T_7- 75% RDN + Nano-urea	35.40	37.28	36.34	64.55	67.33	65.94	94.05	97.77	95.91	104.03	106.73	105.38	102.85	103.85	103.35
T_8- 100% RDN + Nano-urea	35.55	37.52	36.54	73.55	76.51	75.03	99.80	103.73	101.77	110.18	114.48	112.33	108.99	110.79	109.89
T_9- 125% RDN + Nano-urea	37.90	40.40	39.15	82.97	86.47	84.72	113.26	118.16	115.71	124.26	129.46	126.86	122.85	125.65	124.25
T_{10}- 50% RDN as FDP	32.22	34.13	33.18	68.36	66.29	67.33	96.14	94.54	95.34	106.14	109.54	107.84	104.12	105.42	104.77
T_{11}- 75% RDN as FDP	33.18	35.11	34.15	65.27	71.21	68.24	96.87	99.95	98.41	106.67	110.27	108.47	105.27	106.87	106.07
T_{12}- 100% RDN as FDP	35.47	37.67	36.57	80.56	83.56	82.06	109.25	113.25	111.25	120.25	124.95	122.60	119.32	121.72	120.52
T_{13}- 125% RDN as FDP	37.07	39.17	38.12	75.45	78.43	76.94	102.55	106.21	104.38	112.08	116.58	114.33	110.68	112.78	111.73
SEm (±)	0.58	0.59	-	3.07	3.25	-	4.52	3.89	-	2.33	2.33	-	2.34	2.34	-
CD (P=0.05)	1.71	1.72	-	8.96	9.48	-	13.20	11.35	-	6.79	6.79	-	6.84	6.84	-

Table 2 : Effect of nano-urea and fertilizer deep placement on number of tillers of wet direct seeded *kharif* rice

Treatment	Number of tillers/m^2											
	60 DAS			90 DAS			120 DAS			At harvest		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1 - Control	259.08	253.68	256.38	236.18	230.38	233.28	235.88	232.98	234.43	234.70	232.80	233.75
T_2- 50% RDN	265.65	271.15	268.40	243.24	250.24	246.74	238.57	244.07	241.32	235.54	241.04	238.29
T_3- 75% RDN	272.18	299.65	285.92	265.87	293.48	279.68	260.77	284.17	272.47	256.10	279.67	267.89
T_4- 100% RDN	291.65	321.41	306.53	281.98	315.60	298.79	276.17	307.52	291.85	272.17	301.51	286.84
T_5- 125% RDN	327.56	336.56	332.06	319.03	332.03	325.53	314.95	324.95	319.95	310.75	319.75	315.25
T_6- 50% RDN + Nano-urea	271.34	277.84	274.59	257.08	265.58	261.33	251.37	257.87	254.62	246.70	252.70	249.70
T_7- 75% RDN + Nano-urea	274.07	281.57	277.82	267.59	277.59	272.59	261.59	269.09	265.34	258.36	265.36	261.86
T_8- 100% RDN + Nano-urea	340.63	351.13	345.88	334.30	347.80	341.05	329.27	339.77	334.52	325.27	334.77	330.02
T_9- 125% RDN + Nano-urea	381.19	394.19	387.69	368.69	384.19	376.44	364.68	377.18	370.93	361.68	373.18	367.43
T_{10}- 50% RDN as FDP	300.90	279.18	290.04	292.69	274.87	283.78	285.49	267.77	276.63	282.49	262.60	272.55
T_{11}- 75% RDN as FDP	311.91	309.40	310.66	303.10	304.69	303.90	298.02	293.99	296.01	293.01	290.49	291.75
T_{12}- 100% RDN as FDP	368.50	380.50	374.50	353.35	368.38	360.87	349.02	360.52	354.77	346.02	356.52	351.27
T_{13}- 125% RDN as FDP	349.37	360.37	354.87	339.84	353.84	346.84	332.08	343.08	337.58	326.41	339.41	332.91
SEm (±)	10.71	12.91		9.40	10.38		11.01	12.22		11.74	12.11	
CD (P=0.05)	31.26	37.63		27.45	30.30		32.14	35.67		34.29	35.36	

Table 3 : Effect of nano-urea and fertilizer deep placement on dry weight of wet direct seeded *kharif* rice.

Treatment	Dry weight (g/m^2)														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1 - Control	54.42	52.32	53.37	238.56	235.06	236.81	450.43	443.70	447.07	623.48	613.75	618.62	675.48	632.75	654.12
T_2- 50% RDN	59.98	62.38	61.18	284.35	289.05	286.70	524.23	534.55	529.39	697.86	716.21	707.04	758.86	771.21	765.04
T_3- 75% RDN	67.81	71.91	69.86	348.12	354.62	351.37	661.42	685.40	673.41	901.32	935.60	918.46	981.32	1010.60	995.96
T_4- 100% RDN	73.57	78.17	75.87	376.60	383.80	380.20	719.54	749.32	734.43	965.26	1007.72	986.49	1066.26	1098.72	1082.49
T_5- 125% RDN	76.64	81.34	78.99	383.01	390.61	386.81	743.72	776.28	760.00	1007.48	1054.22	1030.85	1114.48	1152.22	1133.35
T_6- 50% RDN + Nano-urea	61.17	63.97	62.57	309.54	314.74	312.14	584.94	597.31	591.13	763.23	785.12	774.18	823.23	847.12	835.18
T_7- 75% RDN + Nano-urea	65.78	69.58	67.68	332.26	338.16	335.21	642.37	661.82	652.10	877.36	905.85	891.61	948.36	976.85	962.61
T_8- 100% RDN + Nano-urea	81.20	86.10	83.65	402.56	410.66	406.61	781.95	817.49	799.72	1048.20	1099.49	1073.85	1166.20	1207.49	1186.85
T_9- 125% RDN + Nano-urea	96.21	102.21	99.21	477.28	486.28	481.78	904.25	945.55	924.90	1203.67	1266.21	1234.94	1343.67	1396.21	1369.94
T_{10}- 50% RDN as FDP	63.45	66.65	65.05	319.67	325.27	322.47	624.19	639.88	632.04	828.25	853.71	840.98	893.25	922.71	907.98
T_{11}- 75% RDN as FDP	70.43	74.83	72.63	354.33	361.13	357.73	684.53	710.77	697.65	928.01	966.57	947.29	1019.01	1051.57	1035.29
T_{12}- 100% RDN as FDP	90.91	96.51	93.71	456.45	465.15	460.80	863.46	902.80	883.13	1146.53	1204.87	1175.70	1275.53	1326.87	1301.20
T_{13}- 125% RDN as FDP	85.68	90.98	88.33	427.83	436.13	431.98	821.74	859.06	840.40	1091.53	1145.79	1118.66	1211.53	1260.79	1236.16
SEm (±)	3.46	4.19	-	13.17	14.64	-	38.90	43.32	-	52.50	56.55	-	52.50	56.55	-
CD (P=0.05)	10.11	12.25	-	38.43	42.74	-	113.56	126.45	-	153.25	165.05	-	153.25	165.55	-

Table 4 : Effect of nano-urea and fertilizer deep placement on crop growth rate of wet direct seeded *kharif* rice

Treatment	Crop growth rate (g/m^2/day)														
	0-30 DAS			30-60 DAS			60-90 DAS			90-120 DAS			120 DAS - At harvest		
	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1 - Control	1.85	1.81	1.83	6.14	6.09	6.12	7.06	6.95	7.01	5.77	5.67	5.72	1.73	0.63	1.18
T_2- 50% RDN	2.06	2.11	2.09	7.48	7.56	7.52	8.00	8.18	8.09	5.79	6.06	5.93	2.03	1.83	1.93
T_3- 75% RDN	2.23	2.32	2.28	9.34	9.42	9.38	10.44	11.03	10.74	8.00	8.34	8.17	2.67	2.50	2.59
T_4- 100% RDN	2.25	2.35	2.30	10.10	10.19	10.15	11.43	12.18	11.81	8.19	8.61	8.40	3.37	3.03	3.20
T_5- 125% RDN	2.40	2.45	2.43	10.21	10.31	10.26	12.02	12.86	12.44	8.79	9.26	9.03	3.57	3.27	3.42
T_6- 50% RDN + Nano-urea	2.06	2.12	2.09	8.28	8.36	8.32	9.18	9.42	9.30	5.94	6.26	6.10	2.00	2.07	2.04
T_7- 75% RDN + Nano-urea	2.28	2.36	2.32	8.88	8.95	8.92	10.34	10.79	10.57	7.83	8.13	7.98	2.37	2.37	2.37
T_8- 100% RDN + Nano-urea	2.77	2.88	2.83	10.71	10.82	10.77	12.65	13.56	13.11	8.87	9.40	9.14	3.93	3.60	3.77
T_9- 125% RDN + Nano-urea	3.29	3.42	3.36	12.70	12.80	12.75	14.23	15.31	14.77	9.98	10.69	10.34	4.67	4.33	4.50
T_{10}- 50% RDN as FDP	2.15	2.22	2.19	8.54	8.62	8.58	10.15	10.49	10.32	6.80	7.13	6.97	2.17	2.30	2.24
T_{11}- 75% RDN as FDP	2.38	2.48	2.43	9.46	9.54	9.50	11.01	11.65	11.33	8.12	8.53	8.33	3.03	2.83	2.93
T_{12}- 100% RDN as FDP	2.71	2.71	2.71	12.18	12.29	12.24	13.57	14.59	14.08	9.44	10.07	9.76	4.30	4.07	4.19
T_{13}- 125% RDN as FDP	3.03	3.03	3.03	11.41	11.51	11.46	13.13	14.10	13.62	8.99	9.56	9.28	4.00	3.83	3.92
SEm (±)	0.09	0.10	-	0.42	0.47	-	0.86	0.97	-	0.53	0.59	-	0.06	0.06	-
CD (P=0.05)	0.27	0.31	-	1.25	1.37	-	2.53	2.84	-	1.56	1.74	-	0.19	0.18	-

Table 5 : Effect of nano-urea and fertilizer deep placement on grain yield and straw yield in wet direct seeded *kharif* rice.

Treatment	Grain yield (q/ha)			Straw yield (q/ha)		
	2022	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
T_1 - Control	20.43	19.20	19.82	35.75	34.18	34.96
T_2- 50% RDN	25.51	26.26	25.89	41.59	42.55	42.07
T_3- 75% RDN	32.75	33.96	33.36	48.80	50.27	49.53
T_4- 100% RDN	35.81	37.09	36.45	51.57	53.41	52.49
T_5- 125% RDN	41.25	42.58	41.91	58.57	60.46	59.51
T_6- 50% RDN + Nano-urea	26.87	27.73	27.30	42.45	43.54	43.00
T_7- 75% RDN + Nano-urea	31.84	32.32	32.08	48.08	49.80	48.94
T_8- 100% RDN + Nano-urea	41.80	43.15	43.97	58.10	59.97	59.04
T_9- 125% RDN + Nano-urea	47.94	49.39	48.67	62.80	64.70	63.75
T_{10}- 50% RDN as FDP	28.90	30.00	29.45	44.80	46.21	45.50
T_{11}- 75% RDN as FDP	34.75	35.99	35.37	51.43	52.91	52.17
T_{12}- 100% RDN as FDP	44.58	46.01	45.29	60.18	61.19	60.68
T_{13}- 125% RDN as FDP	44.06	45.44	44.75	60.37	61.80	61.08
SEm (±)	1.59	1.40	0.42	2.37	2.37	0.66
CD (P=0.05)	4.64	4.09	NS	6.92	6.91	NS
Year (Y)			NS			NS
Y*T			NS			NS

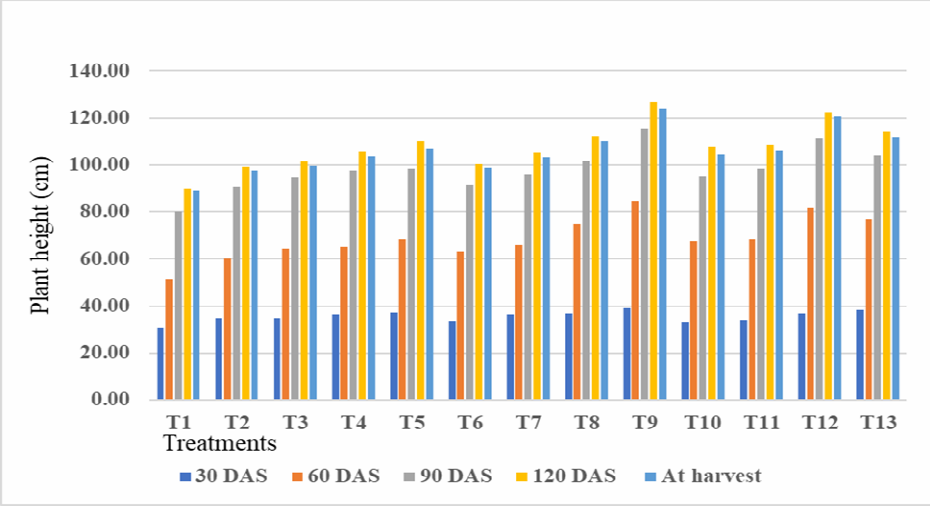

Fig. 1 : Effect of nano-urea and fertilizer deep placement on plant height of wet direct seeded *kharif* rice

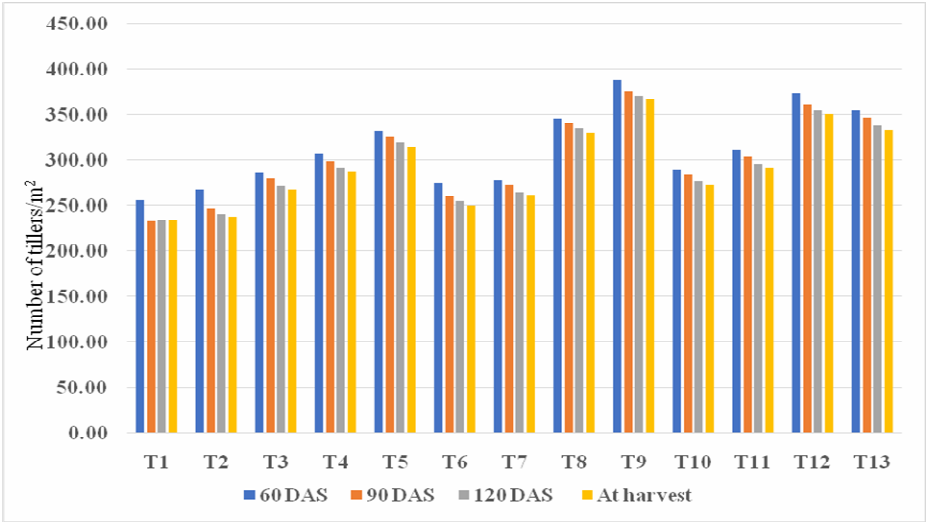

Fig. 2 : Effect of nano-urea and fertilizer deep placement on number of tillers of wet direct seeded *kharif* rice

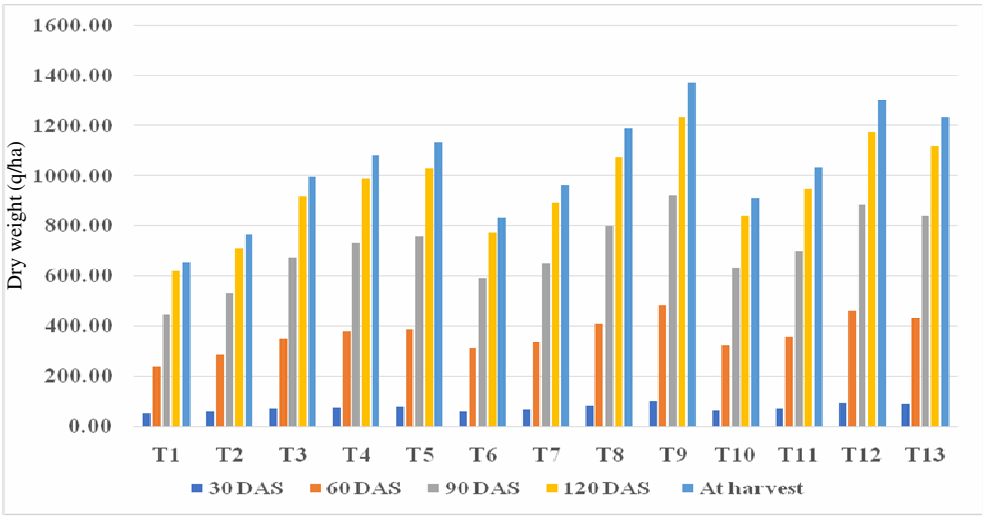

Fig. 3 : Effect of nano-urea and fertilizer deep placement on dry weight of wet direct seeded *kharif* rice.

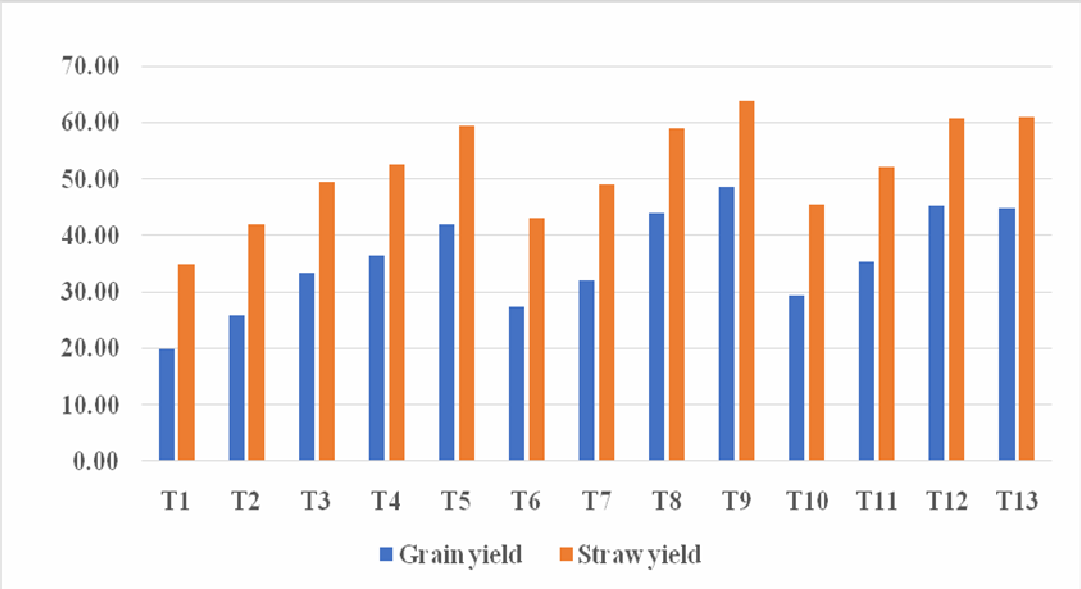

Fig. 4 : Effect of nano-urea and fertilizer deep placement on grain yield and straw yield of wet direct seeded *kharif* rice

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