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Effect of Nano Urea on Growth indices and Grain Yield of Wheat (*Triticum aestivum* L.) under Southern Rajasthan Conditions

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ABSTRACT: To improve nutrient use efficiencies, production and productivity nano urea is a critical component. As the major way to supplement nitrogen is with urea. It becomes more difficult to top dress, which also reduces efficiency. Thus, the recent experiment was conducted at the Research Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan) during 2021-22 and 2022-23 at different levels of recommended dose of nitrogen (RDN) for soil application and levels of Nano Urea and Urea for foliar spray were studied. The experiment was laid out in split plot design with three replications and comprised twenty five treatment combinations (five-soil application and five-foliar application). Soil application of 125% RDN was significantly increased plant height at (25, 50, 75 DAS and at harvest), CGR, RGR, Grain yield over soil application of 75% RDN, 50% RDN and control, respectively on pooled basis. However, 125% RDN and 100% RDN were found at par with each other. foliar application of nano urea at 25-30 DAS and 45-50 DAS significantly increased plant height at (50, 75 DAS and at harvest), CGR, RGR, Grain yield as compared to control (water spray), which was at par with foliar application of nano urea at 25-30 DAS, urea at 25-30 DAS and urea at 25-30 DAS and 45-50 DAS.

Keywords: Wheat, Nano urea, RDN, Foliar spray, Yield.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the important and widely grown cereal crop of the globe. It is a self-pollinated crop having chromosome (2n = 42) belonging to the family Poaceae. It is an annual, hexaploid, long-day plant, having C_3 anatomy and grown largely as a staple food crop in the world.

Wheat is the most important winter food crop in India, accounting approximately 13.33% of global wheat production from an area of 31.36 Mha and a production of 107.86 Mt (Govt. of India, 2020). The crop occupies 3.09 Mha area in Rajasthan, with an annual production of 11.8 Mt, contributing around 9.85% in area and 10.94% in production to the national wheat economy with an average yield of 3839 kg ha^{-1} (Govt. of Rajasthan, 2020-21). Wheat has lot of nutritive values in the form of carbohydrates (70%), protein (10-12%), fat (2.0%), minerals (1.8%), water (12%) and crude fibers (2.2%) and vitamins *viz*., thiamin, riboflavin, niacin and small amounts of vitamin A, but during the milling process, most of the nutrients removes with the bran and germ (Britannica, 2021).Wheat cropping system is currently constrained by climatic fluctuations, poor soil health, and an increased risk of disease and insect-pest epidemic outbreaks. To address these challenges, nanotechnology is gaining attention due to its broad range of applications in agriculture and related sectors (Jasrotia *et al*., 2018).

Nutrient management has played an important role in achieving self-sufficiency in food-grain production, but the conventional application of the fertilizers to increase productivity and profitability has brought about higher consumption of the nutrients, which ultimately leads to low nutrient use efficiencies, lower profits and increased

environmental issues (Pampolino *et al*., 2012).

The major way to supplement nitrogen is with urea. Crops effectively use the basal dose of urea, but as they progress, it becomes more difficult to top dress, which also reduces efficiency. So urea can also be sprayed on foliage as an alternative. Another effective method of fertilisation that increases the availability of nutrients, particularly nitrogen, is the foliar application of urea (Khan *et al*., 2009). Nano urea, which is also applied to the leaves as a foliar spray, is a novel technology that is emerging in the area of fertiliser management. In this context, using nano-urea is a critical component of efficient N fertiliser use. By utilising the special characteristics of nanoparticles with a range of nano dimensions from 1 to 100 nm, nano-fertilizers can aid in improving nutrient use efficiencies (Suppan, 2017). Although, in the management aspects, efforts have made to increase the efficiency of applied fertilizer with the help of nano clays and zeolites and restoration of soil fertility by releasing fixed nutrients (Jyothi and Hebsur 2017). Up to the optimum applied doses and concentrations, nitrogen-based nano-fertilizers increase crop growth and production. However, if concentrations are higher than the optimum, they can limit crop growth and yield. Under Indian circumstances, there is a dearth of knowledge on these aspects, requiring thorough research.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of the years 2021-22 and 2022-23 under climatic and edaphic condition of Udaipur (Rajasthan). Which is located at 74° 42' E longitude and 24° 35' N latitude with an altitude of 581.13 m above mean sea level. This area is located in Rajasthan's NARP agro-climatic zone IV a, which includes the Aravalli Hills and Sub-Humid Southern Plains. The experiment was laid out in split plot design with three replications and comprised twenty five treatment combinations (five-soil application and five-foliar application). Main plot treatments were A. Soil application of nitrogen: Control (No Nitrogen), 50% RDN (Half N as basal and half N at first Irrigation), 75% RDN (Half N as basal and half N at first Irrigation), 100% RDN (Half N as basal and half N at first Irrigation), 125% RDN (Half N as basal and half N at first Irrigation). Recommended dose of N for wheat is 90 kg ha^{-1} in Agro-climatic Zone-IVa. Nitrogen fertilizer was applied in 2 splits, *i.e*., at the time of sowing (50%) as per treatment and first irrigation (50%) as per treatment through urea. Sub plot treatments were B. Foliar spray of nitrogen: Control (Water Spray), Nano urea application @ 2.5 ml L^{-1} at 25-30 DAS, Nano urea application @ 2.5 ml L^{-1} at 25-30 DAS and 45-50 DAS, Urea application @ 4% at 25-30 DAS, Urea application @ 4% at 25-30 DAS and 45-50 DAS. Foliar spray of nano urea @ 2.5 ml L^{-1} and urea @ 4% (with 500 litre water ha^{-1}) was done at 25 and 45 DAS as per treatments. Nano Urea contain 4% nitrogen as encapsulated nitrogen analogues or forms embedded on an organic matrix.

For recording destructive observations, plants were collected from 0.5 meter row length in the destructive sampling area of the plot, *i.e*., border rows. Plant height was recorded from five randomly selected plants (tagged) in the net plot area. The plant height of wheat was measured from the ground level to tip of the terminal growing point and expressed in cm. Crop growth rate(g m^{-2} day^{-1}) was computed between 50-75 DAS and 75 DAS - harvest. Crop growth rate was calculated from the dry weight taken at different time intervals. It denotes overall growth rate of crop plant and it is measured after fix period of the time, irrespective of the previous growth rate. The value was calculated by using the formula suggested by Leopold and Kridemann (1975).

$$CGR\left(g\ m^{-2}\ day^{-1}\right)=\frac{W_2-W_1}{T_2-T_1}$$

Where, W_2 _ W_1 = Difference in oven dry biomass at the time interval

T_2-T_1 =Time interval in days

Relative growth rate(g g^{-1} day^{-1}) indicate rate of growth per unit dry matter. It was computed by using formula as suggested by Dhopte and Manual (1989).

$$RGR\left(g\ g^{-1}\ day^{-1}\right)=\frac{Log_e\ W_2-Log_e W_1}{T_2-T_1}$$

Where, W_2 and W_1 are dry matter at time T_2 and T_1, respectively

Grain yield (q ha^{-1}) were measured by the total biomass harvested from each net plot was threshed, winnowed, cleaned and dried. Grains thus obtained were weighed in terms of kg net $plot^{-1}$ and then converted in terms of q ha^{-1}.

RESULTS AND DISCUSSION

A. Plant height

Soil application. Table 1 shows that increment in soil application of RDN up to 125% significantly increased plant height over soil application of 50% RDN and control during both the years and on pooled basis. Data indicates that soil application of 100% RDN was significantly increased plant height at over soil application of 75% RDN, 50% RDN and control, respectively on pooled basis. However, 125% RDN and 100% RDN were found at par with each other.

Foliar spray: It was noted from the data (Table 1) that foliar application of nano urea and urea didn't influence plant height at 25 DAS over control during both the years and on pooled basis. foliar application of nano urea at 25-30 DAS and 45-50 DAS significantly increased plant height at 50 DAS as compared to control (water spray), which was at par with foliar application of nano urea at 25-30 DAS, urea at 25-30 DAS and urea at 25-30 DAS and 45-50 DAS. Further spray of nano urea at 25-30 DAS and 45-50 DAS significantly increased plant height of wheat at 75 DAS over spray of nano urea at 25-30 DAS, spray of urea at 25-30 DAS and water spray and it was at par with spray of urea at 25-30 DAS and 45-50 DAS during both the years as well as on pooled data basis. Tallest plant of wheat at harvest was observed under foliar application of nano urea at 25-30 DAS and 45-50 DAS during 2021-22, 2022-23 and on pooled basis.

These gains may be attributable to early and abundant nitrogen availability as evidenced from improvement in the nutritional status of plants at various growth stages of crop, which created a superior nutritional environment for root zone growth and development.

Table 1: Effect of RDN and foliar application of nano-urea and urea on plant height at different growth stages.

Treatments	Plant height (cm)											
	At 25 DAS			At 50 DAS			At 75 DAS			At harvest		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Soil application												
Control (No Nitrogen)	20.63	20.78	20.70	40.01	41.13	40.57	82.40	82.56	82.48	86.39	86.56	86.48
50% RDN (Half N as basal and half N at first Irrigation)	22.68	22.83	22.76	47.67	47.94	47.80	89.02	89.19	89.11	93.17	93.36	93.26
75% RDN (Half N as basal and half N at first Irrigation)	22.85	23.00	22.92	49.13	49.41	49.27	93.55	93.72	93.63	95.10	95.27	95.19
100% RDN (Half N as basal and half N at first Irrigation)	24.13	24.29	24.21	52.16	52.42	52.29	100.27	100.29	100.28	102.25	102.42	102.33
125% RDN (Half N as basal and half N at first Irrigation)	24.26	24.41	24.33	52.24	52.50	52.37	100.56	100.73	100.64	103.10	103.27	103.18
SEm±	0.41	0.42	0.29	0.93	1.30	0.80	2.01	2.02	1.43	2.25	2.23	1.58
C.D. (P=0.05)	1.34	1.36	0.88	3.02	4.23	2.39	6.57	6.60	4.28	7.33	7.28	4.75
Foliar spray												
Control (water Spray)	22.74	22.89	22.81	46.05	46.31	46.18	87.17	87.33	87.25	90.15	90.31	90.23
Nano urea application at 25-30 DAS	22.96	23.11	23.03	49.01	49.27	49.14	93.31	93.47	93.39	96.46	96.62	96.54
Nano urea application at 25-30 DAS and 45-50 DAS	23.02	23.17	23.09	49.29	49.58	49.44	97.52	97.54	97.53	100.20	100.37	100.29
Urea application @ 4% at 25-30 DAS	22.86	23.02	22.94	48.24	49.36	48.80	92.47	92.64	92.55	94.62	94.78	94.70
Urea application @ 4% at 25-30 DAS and 45-50 DAS	22.97	23.12	23.05	48.62	48.88	48.75	95.34	95.51	95.43	98.59	98.78	98.69
SEm±	0.35	0.35	0.25	0.68	0.62	0.46	1.41	1.42	1.00	1.29	1.29	0.91
C.D. (P=0.05)	NS	NS	NS	1.94	1.77	1.29	4.04	4.06	2.82	3.68	3.68	2.56

These are accordance with the results of Ghafoor *et al*. (2021); Sharma *et al*. (2022).

B. Crop growth rate

Soil application: A perusal of data (Table 2) shows that maximum crop growth rate between 50-75 DAS and 75 DAS-harvest were recorded in application of 100% RDN over 75, 50% RDN (half N as basal and half N at first irrigation) and control and the treatment was at par with application of 125% RDN (half N as basal and half N at first irrigation) during 2021-22, 2022-23 and on pooled data basis.

Foliar spray: It is evident from the data in Table 2 that crop growth rate between 50-75 DAS was enhanced due to foliar spray of nano urea and urea during both the years as well as on pooled data basis. Highest crop growth rate between 50-75 DAS and 75 DAS-at harvest were obtained with two foliar spray of nano urea at 25-30 DAS and 45-50 DAS as compared to rest of the treatments except two foliar spray of urea at 25-30 DAS and 45-50 DAS during both the year of experimentations as well as on pooled data basis.

CGR was increased with application of 100% RDN. It might be due to increased levels of growth-promoting chemicals and naturally occurring phyto hormones with higher nitrogen supplies. These gains may be attributable to early and abundant nitrogen availability as evidenced from improvement in the nutritional status of plants at various growth stages of crop, which created a superior nutritional environment for root zone growth and development. These are accordance with the results of Satyanarayana *et al*. (2017); Rehman *et al*. (2021); Yadav *et al*. (2023).

C. Relative growth rate

Soil application: The data (Table 3) reveal that application of nitrogenous fertilizer brought about significant increase in relative growth rate between 50-75 DAS during 2021-22, 2022-23 and on pooled data basis. The maximum and significantly higher relative growth rate between 50-75 DAS was recorded with 50% RDN (0.0418 g g^{-1} day^{-1}) over soil application of 75, 125% RDN and control. Whereas, it was remained at par with soil application of 100% RDN during first year of experimentation. The significantly highest relative

growth rate between 50-75 DAS was recorded in soil application of 50% RDN (0.0417 g g^{-1} day^{-1}) over rest of the treatments during second year of experimentation. On pooled data basis, application of 50% RDN (0.0417 g g^{-1} day^{-1}) recorded significantly higher relative growth rate between 50-75 DAS over rest of the treatments. Between 75 DAS–harvest RGR was not influenced graded levels of nitrogen fertilizer during both the years as well as on pooled data basis.

Foliar spray: Data (Table 3) shows that significant increase in the relative growth rate between 50-75 DAS was observed with foliar spray of nano urea at 25-30 DAS and 45-50 DAS (0.0425, 0.0422 and 0.0423 g g^{-1} day^{-1}) as compared to rest of the treatments except two foliar spray of urea at 25-30 DAS and 45-50 DAS during both the years of experimentation as well as on pooled data basis, respectively. Between 75 DAS–harvest didn't alter due to foliar spray of nano urea and urea at different stages during both the years as well as on pooled basis.

Table 2: Effect of RDN and foliar application of nano-urea and urea on crop growth rate.

Treatments	Crop growth rate (g m^{-2} day^{-1})					
	Between 50–75 DAS			Between 75 DAS–harvest		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Soil application						
Control (No Nitrogen)	8.20	8.41	8.31	20.44	20.60	20.52
50% RDN (Half N as basal and half N at first Irrigation)	10.22	10.52	10.37	25.14	25.26	25.20
75% RDN (Half N as basal and half N at first Irrigation)	10.82	11.03	10.93	26.92	27.08	27.00
100% RDN (Half N as basal and half N at first Irrigation)	11.66	11.81	11.73	28.92	29.10	29.01
125% RDN (Half N as basal and half N at first Irrigation)	11.62	11.81	11.71	28.92	29.09	29.00
SEm±	0.25	0.24	0.17	0.58	0.59	0.41
C.D. (P=0.05)	0.80	0.78	0.51	1.89	1.92	1.24
Foliar spray						
Control (water Spray)	9.40	9.58	9.49	24.03	24.20	24.11
Nano urea application at 25-30 DAS	10.45	10.66	10.56	25.94	26.11	26.03
Nano urea application at 25-30 DAS and 45-50 DAS	11.27	11.50	11.38	27.48	27.63	27.55
Urea application @ 4% at 25-30 DAS	10.33	10.54	10.44	25.78	25.94	25.86
Urea application @ 4% at 25-30 DAS and 45-50 DAS	11.07	11.30	11.18	27.11	27.26	27.19
SEm±	0.13	0.21	0.12	0.35	0.39	0.26
C.D. (P=0.05)	0.36	0.59	0.34	1.01	1.13	0.74

Table 3: Effect of RDN and foliar application of nano-urea and urea on relative growth rate.

Treatments	Relative growth rate (g g^{-1} day^{-1})					
	Between 50–75 DAS			Between 75 DAS–harvest		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Soil application						
Control (No Nitrogen)	0.0409	0.0402	0.0406	0.028110	0.027800	0.027955
50% RDN (Half N as basal and half N at first Irrigation)	0.0418	0.0417	0.0417	0.028140	0.027761	0.027950
75% RDN (Half N as basal and half N at first Irrigation)	0.0409	0.0406	0.0407	0.028124	0.027861	0.027993
100% RDN (Half N as basal and half N at first Irrigation)	0.0411	0.0407	0.0409	0.028106	0.027926	0.028016
125% RDN (Half N as basal and half N at first Irrigation)	0.0408	0.0405	0.0406	0.028104	0.027886	0.027995
SEm±	0.0003	0.0003	0.0002	0.000005	0.000136	0.000068
C.D. (P=0.05)	0.0009	0.0009	0.0006	NS	NS	NS
Foliar spray						
Control (water Spray)	0.0397	0.0393	0.0395	0.028253	0.028013	0.028133
Nano urea application at 25-30 DAS	0.0408	0.0403	0.0405	0.028033	0.027765	0.027899
Nano urea application at 25-30 DAS and 45-50 DAS	0.0425	0.0422	0.0423	0.028123	0.027839	0.027981
Urea application @ 4% at 25-30 DAS	0.0404	0.0401	0.0403	0.028069	0.027793	0.027931
Urea application @ 4% at 25-30 DAS and 45-50 DAS	0.0421	0.0418	0.0419	0.028106	0.027824	0.027965
SEm±	0.0003	0.0006	0.0003	0.000003	0.000310	0.000155
C.D. (P=0.05)	0.0008	0.0018	0.0010	NS	NS	NS

D. Grain yield

Soil application: During the two years of experiment and on pooled basis, it was observed that significantly higher grain yield was recorded with application of 125% RDN over soil application of 75% RDN, 50% RDN and control during 2021-22, 2022-23 and on pooled basis. However, 125% RDN and 100% RDN were at with each other.

Foliar spray: It is explicit from data presented in Table 4 that grain yield of wheat was increased significantly due to foliar application of nano urea and urea during both the years and on pooled basis. Foliar spray of nano urea at 25-30 DAS and 45-50 DAS proved significantly superior over foliar spray of nano urea at 25-30 DAS, foliar spray of urea at 25-30 DAS and water spray (control) and increased grain yield by 5.53, 7.38 and 14.83 per cent, respectively on pooled mean basis.

The observed increase in grain yield might be on account of beneficial effect of nitrogen nutrition in exploiting inherent potential of the crop for vegetative and reproductive growth. In the present investigation the estimated inter-relationship between grain yield and

various yield attributes also supports strong dependence of crop productivity on vegetative and reproductive growth. These are accordance with the results of Teshome (2020); Seifu *et al*. (2022); Yadav *et al*. (2023).

Table 4: Effect of RDN and foliar application of nano-urea and urea on grain yield of wheat.

Treatments	Grain yield		
	2021-22	2022-23	Pooled
Control (No Nitrogen)	31.42	32.60	32.01
50% RDN (Half N as basal and half N at first Irrigation)	40.34	42.54	41.44
75% RDN (Half N as basal and half N at first Irrigation)	47.68	48.63	48.15
100% RDN (Half N as basal and half N at first Irrigation)	53.36	54.11	53.74
125% RDN (Half N as basal and half N at first Irrigation)	53.49	54.60	54.05
SEm±	1.04	0.97	0.71
C.D. (P=0.05)	3.41	3.15	2.13
Control (water Spray)	41.66	42.77	42.21
Nano urea application at 25-30 DAS	45.27	46.60	45.93
Nano urea application at 25-30 DAS and 45-50 DAS	48.00	48.95	48.47
Urea application @ 4% at 25-30 DAS	44.47	45.81	45.14
Urea application @ 4% at 25-30 DAS and 45-50 DAS	46.89	48.35	47.62
SEm±	0.60	0.62	0.43
C.D. (P=0.05)	1.71	1.77	1.21

CONCLUSIONS

The plant height of wheat was significantly increased with soil application of 125% RDN as compared to other treatments. Maximum crop growth rate was observed with soil application of 100% RDN and maximum relative growth rate at 50-75 DAS was found with soil application of 50% RDN, whereas relative growth rate at 75 DAS-at harvest remained statistically unchanged due to soil application of nitrogen fertilizer.It is concluded that wheat crop should be fertilized with 90 kg nitrogen per hectare and 2.5 ml L^{-1} nano urea or 4% urea as foliar application at 25-30 and 45-50 days after sowing to get higher growth and yield in prevailing agro-climatic conditions of Zone IVa (Sub-humid Southern Plain and Aravali Hills) of Rajasthan.

FUTURE SCOPE

Nano Urea was used in this experiment and it was found effective for growth and yield of wheat so it can be used commercially for the benefit of farmer.

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Conflict of Interest. None.

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