The Pharma Innovation Journal 2023; 12(10): 1547-1552

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(10): 1547-1552

www.thepharmajournal.com
Received: 06-08-2023
Accepted: 10-09-2023

Mahipal Singh Choudhary
Ph.D. Research Scholar, Department of Agronomy RCA, MPUAT, Udaipur, Rajasthan, India

SK Intodia
Professor, Department of Agronomy RCA, MPUAT, Udaipur, Rajasthan, India

MK Kaushik
Professor, Department of Agronomy RCA, MPUAT, Udaipur, Rajasthan, India

J Chaudhary
Associate Professor, Department of Agronomy RCA, MPUAT, Udaipur, Rajasthan, India

Manju Choudhary
Ph.D. Research Scholar, Department of Agronomy, Anand Agriculture University Anand, Gujarat, India

Aadarsh Sharma
Ph.D. Research Scholar, Department of Agronomy RCA, MPUAT, Udaipur, Rajasthan, India

Corresponding Author:
Mahipal Singh Choudhary
Ph.D. Research Scholar, Department of Agronomy RCA, MPUAT, Udaipur, Rajasthan, India

Optimizing wheat (*Triticum aestivum* L.) production and quality in Southern Rajasthan through nano urea foliar sprays and nitrogen fertility management

Mahipal Singh Choudhary, SK Intodia, MK Kaushik, J Chaudhary, Manju Choudhary and Aadarsh Sharma

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 Grain yield, straw yield, biological yield, hectoliter weight, grain hardness index and protein content 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 Grain yield, straw yield, biological yield, hectoliter weight, grain hardness index and protein content 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) [2]. 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) [3]. 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) [1]. 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) [4]. 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) [8].
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 fertilization that increases the availability of nutrients, particularly nitrogen, is the foliar application of urea (Khan *et al*., 2009) [6]. Nano urea, which is also applied to the leaves as a foliar spray, is a novel technology that is emerging in the area of fertilizer management.

In this context, using nano-urea is a critical component of efficient N fertilizer use. By utilizing 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) [14]. 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) [5]. 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 IVa, 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. 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}.Straw yield net $plot^{-1}$ was calculated by subtracting the seed yield from the biological yield and then converted in kg ha^{-1}.After, completely thorough sun dried, harvested bundles of each net plot were weighed for biological yield and then converted in terms of kg ha^{-1}.

Hectoliter weight is an indicator of wheat quality (It is related to the flour volume obtained from a specific weight of grain). Hectolitre weight was determined by hectolitre instrument and expressed in kilogram per hectolitre. Grain hardness (It is related to milling properties and the degree of adhesion between starch and protein) was determined by particle size index by application of milling with rotary mill and determining percentage of grains left on the mill to those passed through the mill. The protein content in grain was calculated by multiplying per cent nitrogen in the grain to the factor 6.25 and expressed as per cent protein content.

Results and Discussion

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) [15]; Seifu *et al*. (2022) [10]; Yadav *et al* (2023) [17].

Straw yield

Soil application: Soil Application: Soil application of nitrogenous fertilizers, especially at 125% of the recommended dose of nitrogen (RDN), resulted in a significant increase in wheat straw yield in both years and when data was pooled. The application of 125% RDN, 100% RDN, and 75% RDN led to substantial increases in straw yield, with 125% RDN showing the most significant improvement, surpassing the others by 13.18%, 39.16%, and 87.66% when compared to 75%, 50% RDN, and the control, respectively. Soil application of 100% RDN also had a notable effect, increasing straw yield by 10.51%, 35.86%, and 83.25% over the same comparison groups. Even the application of 75% RDN demonstrated a significantly higher straw yield compared to 50% RDN and the control, with a notable increase of 34.85% over the control group.

Foliar Spray: The data reveals that foliar application of nano urea and urea significantly enhanced wheat straw yield during both years and when data was pooled. Two sprays of nano urea at specific growth stages, 25-30 DAS and 45-50 DAS, resulted in a substantial increase in straw yield when compared to one foliar spray of nano urea at 25-30 DAS, one foliar spray of urea at 25-30 DAS, and the control group, with increases of 5.49%, 6.17%, and 14.23% on average. Similar effects were observed with two foliar sprays of urea at these growth stages, leading to increases of 4.21%, 4.87%, and 12.84% over the same comparison groups. Additionally, even a single foliar spray of nano urea at 25-30 DAS had a significant impact, increasing straw yield by 8.27% when

compared to the control group.
Significant improvement in straw yield due to nitrogen fertilizer in the present investigation might be due to its direct influence on dry matter accumulation and number of tillers at various growth stages. Ullah *et al*. (2022) [16] and Sharma *et al*. (2022) [12] also concur the similar result.

Biological yield
Soil Application: The results clearly indicate that soil application of nitrogen had a substantial and statistically significant effect on the biological yield of wheat. This impact was consistent across both individual years and when the data was combined. Notably, increasing the soil application of nitrogen up to 125% of the recommended dose (RDN) resulted in a remarkable increase in biological yield, outperforming the effects of 75% and 50% RDN, as well as the control group. The application of 125% RDN, in particular, led to an impressive increase of 12.75%, 35.07%, and a staggering 78.66% when compared to 75%, 50% RDN, and the control group, respectively, when the data was pooled. Similarly, the application of 100% RDN exhibited a significant enhancement in biological yield, with increases of 10.99%, 32.97%, and 75.88% over the same comparison groups on a pooled basis. Even the application of 75% RDN showed a substantial improvement, recording an increase of 58.46% over the control group when the data was pooled.

Foliar Spray: The data also highlights that foliar application of both nano urea and urea had a notably positive impact on the biological yield of wheat, and this effect was consistent across both individual years and when the data was pooled. The maximum biological yield was achieved with the foliar application of nano urea at specific growth stages, 25-30 DAS and 45-50 DAS, surpassing the effects of one foliar spray of nano urea at 25-30 DAS, one foliar spray of urea at 25-30 DAS, and the control group. Remarkably, foliar application of nano urea at 25-30 DAS and 45-50 DAS led to a significant increase of 5.50%, 6.73%, and an impressive 14.50% when compared to one foliar spray of nano urea at 25-30 DAS, one foliar spray of urea at 25-30 DAS, and the control group, respectively, on a pooled basis. Additionally, two foliar sprays of urea at 25-30 DAS and 45-50 DAS also outperformed one foliar spray of nano urea at 25-30 DAS, one foliar spray of urea at 25-30 DAS, and the control group in enhancing biological yield, resulting in increases of 3.97%, 5.18%, and 12.83% when data was pooled.
Biological yield is a sum of grain yield and straw yield. Thus, significant increase in biological yield with application of 100% RDN could be ascribed to significant increase in grain and straw yield. Saini *et al*. (2023) [9] also found similar result.

Quality parameters
Hectoliter weight
Soil Application: Soil application of nitrogenous fertilizer up to 125% of the recommended dose (RDN) resulted in a substantial improvement in the hectolitre weight of wheat grain, both in individual years and when data was pooled. The maximum and significantly higher hectolitre weight was achieved with 125% RDN, outperforming 50% RDN and the control. Remarkably, this treatment was comparable to the effects of 100% and 75% RDN during both years of experimentation. When data was pooled, soil application of 125% RDN led to a significantly higher hectolitre weight compared to 75%, 50% RDN, and the control, with increases of 4.17%, 5.39%, and 6.66%, respectively. Application of 100% RDN also increased hectolitre weight, remaining on par with 75% RDN. Additionally, soil application of 75% RDN exhibited a significant improvement in hectolitre weight over the control, being on par with 50% RDN in the pooled data analysis.

Foliar Spray: The hectolitre weight of wheat grain was influenced by foliar sprays of nano urea and urea during both individual years and when data was pooled. The most significant improvement was observed with two foliar sprays of nano urea at specific growth stages, 25-30 DAS and 45-50 DAS, significantly increasing the hectolitre weight of wheat grain over the control. This treatment demonstrated consistency by performing equally well as two foliar sprays of urea at the same growth stages, as well as one foliar spray of nano urea at 25-30 DAS and one foliar spray of urea at 25-30 DAS during both years. On a pooled data basis, it became clear that two foliar sprays of nano urea at the specified growth stages increased the hectolitre weight of wheat grain by 1.90%, 2.46%, and 4.43% over one foliar spray of urea at 25-30 DAS, one foliar spray of nano urea at 25-30 DAS, and the control, respectively. Importantly, this effect was at par with two foliar sprays of urea at the same growth stages. The control group consistently exhibited the lowest hectolitre weight of wheat grain. Application of 100% RDN also improved hectoliter weight over lower levels RDN and this improvement may be probable due to higher test weight obtained with application of 100% RDN. Seifu *et al*. (2022) [10] observed that the highest hectoliter weight was recorded from the highest NPSZnB rate (175 kg ha^{-1}) in Vertisol, while the lowest hectoliter weight was recorded with the control treatment in Cambisol.

Grain hardness index
Soil application: It is elucidate form (Table 2) that soil application of nitrogen significantly influenced the grain hardness index in grain of wheat during both the years as well as on pooled basis. Maximum grain hardness index in wheat grain was recorded with soil application of 125% RDN over soil application of 75, 50% RDN and control and it was proved at par with 100% RDN during the years 2021-22, 2022-23 and on pooled basis. Grain hardness index in grain of wheat increased with soil application of 125% RDN by 4.72, 7.99 and 13.78 per cent over 75, 50% RDN and control, respectively on pooled basis. The soil application of 100% RDN also significantly increased grain hardness index over soil application of 75, 50% RDN and control. The least grain hardness index was found in control during both the years as well as on pooled basis.

Foliar spray: It is explicit from the data (Table 2) that grain hardness index of wheat was significantly influenced due to foliar application of nano urea and urea during both the years and on pooled basis. Foliar sprays of nano urea twice at 25-30 DAS and 45-50 DAS significantly increased grain hardness index over only water spray treatment by 7.34 per cent on pooled mean basis. Further, it was also at par with two spray of urea at 25-30 DAS and 45-50 DAS, one foliar spray of nano urea at 25-30 DAS and one foliar spray of urea at 25-30 DAS. Foliar sprays of urea at 25-30 DAS and 45-50 DAS

significantly increased grain hardness index over control and was at par with one spray of nano urea and urea at 25-30 DAS on pooled mean basis. The lowest grain hardness index was observed in water spray treatment (Control).

Increase in grain hardness with increasing levels of nitrogen up to 100% RDN might be due to higher protein content in grains as grain hardness is depends on degree of adhesion between starch and protein. Seifu *et al*. (2022) [10] also noted a comparable pattern.

Protein content

Soil application: The data presented in Table 2 shows that protein content in grain of wheat significantly enhanced with application of 125% RDN over 75, 50% RDN and control and being at par with 100% RDN during 2021-22, 2022-23 and on pooled basis. The magnitude of increase due to 125% RDN was 3.50 and 10.50 per cent over 75, 50% RDN and control, respectively on pooled data basis. Similarly, 100% RDN also had significant effect in increasing protein content in grain of wheat over 75, 50% RDN and control by 2.17, 3.25 and 10.24 per cent, respectively.

Further, 50% RDN also significantly increased protein content in grain of wheat over control by 6.77 per cent in pooled mean basis.

Foliar spray: It is apparent from the data in Table 2 that protein content in grain of wheat was influenced due to foliar spray of nano urea and urea during both the years as well as on pooled data basis. Significant increases in protein content in grain was estimated with foliar spray of nano urea at 25-30 DAS and 45-50 DAS over control and being at par with two foliar spray of urea at 25-30 DAS and 45-50 DAS, one foliar spray of nano urea at 25-30 DAS and one foliar spray of urea at 25-30 DAS during first year of experimentation. During second year of experimentation, protein content in grain was found significantly higher with two foliar spray of nano urea at 25-30 DAS and 45-50 DAS over one foliar spray of nano urea at 25-30 DAS, one foliar spray of urea at 25-30 DAS and control and being at par with two foliar spray of urea at 25-30 DAS and 45-50 DAS.

On basis of pooled data, two foliar spray of nano urea at 25-30 DAS and 45-50 DAS was increased significant in protein content in grain over one foliar spray of urea at 25-30 DAS, one foliar spray of nano urea at 25-30 DAS and control by 1.69, 1.77 and 8.40 per cent, respectively. It was at par with two foliar spray of urea at 25-30 DAS and 45-50 DAS. Data further reveals that the two foliar spray of urea at 25-30 DAS and 45-50 DAS was found significantly higher in protein content in grain over control and being at par with one spray of nano urea at 25-30 DAS and one spray of urea at 25-30 DAS. The significantly lowest protein content in grain was found in water spray (control) as compared to rest of the treatments.

Increased nitrogen uptake was seen when a higher nitrogen dose was administered in splits. The action of nitrogen, an active component of protein molecules and a building block of amino acids, may be the primary cause of the rise in crude protein content seen with nitrogen application. Singh and Singh (2017) [13], Nazir *et al*. (2021) [7], Seifu *et al*. (2022) [10] and Shapep and Mahmud (2023) [11] also noted a comparable pattern.

Table 1: Effect of RDN and foliar application of nano-urea and urea on grain yield, straw yield and biological yield of wheat

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Biological yield (q ha^{-1})		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Soil Application									
Control (No Nitrogen)	31.42	32.60	32.01	33.84	35.87	34.86	65.26	68.47	66.87
50% RDN (Half N as basal and half N at first Irrigation)	40.34	42.54	41.44	46.11	47.91	47.01	86.45	90.45	88.45
75% RDN (Half N as basal and half N at first Irrigation)	47.68	48.63	48.15	57.03	58.58	57.80	104.71	107.20	105.96
100% RDN (Half N as basal and half N at first Irrigation)	53.36	54.11	53.74	63.39	64.36	63.88	116.75	118.48	117.61
125% RDN (Half N as basal and half N at first Irrigation)	53.49	54.60	54.05	65.15	65.70	65.42	118.64	120.30	119.47
SEm±	1.04	0.97	0.71	1.12	1.15	0.80	1.92	1.95	1.37
C.D. at 0.05	3.41	3.15	2.13	3.66	3.75	2.41	6.27	6.37	4.11
Foliar spray									
Control (water Spray)	41.66	42.77	42.21	48.91	50.16	49.54	90.57	92.93	91.75
Nano urea application at 25-30 DAS	45.27	46.60	45.93	52.94	54.35	53.64	98.21	100.95	99.58
Nano urea application at 25-30 DAS and 45-50 DAS	48.00	48.95	48.47	55.86	57.32	56.59	103.86	106.27	105.06
Urea application @ 4% at 25-30 DAS	44.47	45.81	45.14	52.61	53.98	53.30	97.08	99.79	98.43
Urea application @ 4% at 25-30 DAS and 45-50 DAS	46.89	48.35	47.62	55.19	56.61	55.90	102.09	104.97	103.53
SEm±	0.60	0.62	0.43	0.96	0.84	0.64	1.12	1.04	0.77
C.D. at 0.05	1.71	1.77	1.21	2.74	2.41	1.80	3.21	2.97	2.15

Table 2: Effect of RDN and foliar application of nano-urea and urea on quality parameters of wheat

Treatments	Hectoliter weight			Grain hardness index			Protein content (%)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Soil Application									
Control (No Nitrogen)	71.00	71.39	71.19	62.57	62.66	62.61	11.43	11.61	11.52
50% RDN (Half N as basal and half N at first Irrigation)	71.77	72.34	72.05	65.86	66.08	65.97	12.21	12.38	12.30
75% RDN (Half N as basal and half N at first Irrigation)	72.70	73.09	72.89	67.98	68.08	68.03	12.34	12.52	12.43
100% RDN (Half N as basal and half N at first Irrigation)	75.51	75.91	75.71	70.98	71.08	71.03	12.61	12.79	12.70
125% RDN (Half N as basal and half N at first Irrigation)	75.73	76.12	75.93	71.19	71.29	71.24	12.64	12.82	12.73
SEm±	0.95	0.96	0.68	0.83	0.90	0.61	0.08	0.08	0.06
C.D. at 0.05	3.11	3.12	2.02	2.70	2.94	1.83	0.25	0.27	0.17
Foliar spray									
Control (water Spray)	71.50	72.07	71.79	64.31	64.60	64.45	11.57	11.74	11.66
Nano urea application at 25-30 DAS	73.37	73.77	73.57	68.13	68.24	68.18	12.34	12.52	12.43
Nano urea application at 25-30 DAS and 45-50 DAS	74.77	75.17	74.97	69.13	69.23	69.18	12.55	12.73	12.64
Urea application @ 4% at 25-30 DAS	72.98	73.37	73.17	68.01	68.10	68.05	12.33	12.51	12.42
Urea application @ 4% at 25-30 DAS and 45-50 DAS	74.08	74.47	74.27	69.02	69.02	69.02	12.44	12.62	12.53
SEm±	0.68	0.67	0.48	0.74	0.68	0.50	0.07	0.07	0.05
C.D. at 0.05	1.93	1.92	1.34	2.12	1.94	1.41	0.20	0.19	0.14

Conclusions

Among the treatments of RDN, 100% RDN remained at par with soil application of 125% RDN and recorded significantly improved quality parameters *viz.*, hectoliter weight, grain hardness index and protein content in grain over application of 75% RDN, 50% RDN and control. 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 good quality and yield in prevailing agro-climatic conditions of Zone IVa (Sub-humid Southern Plain and Aravali Hills) of Rajasthan.

Acknowledgement

The authors are thankful to Department of Agronomy RCA, Udaipur, MPUAT, Udaipur for providing all the facilities and relevant literature to conduct this experiment.

Conflict of Interest

None.

References

1. Britannica. The Editors of Encyclopaedia. What is the nutritional composition of wheat? Encyclopedia Britannica, 7 May. 2021; c2021. https://www.britannica.com/question/What-is-the-nutritional-composition-of-wheat. Accessed 12 March 2023.
2. Govt. of India Agricultural Statistics at a Glance. Department of Agriculture, Cooperation and Farmers Welfare. Ministry of Agriculture and Farmers Welfare; c2020. Available online at: https://eands.dacnet.nic.in/Advance_Estimates.html
3. Govt. of Rajasthan. Vital Agriculture Statistics, Statistical Cell, Directorate of Agriculture, Pant Krishi Bhawan, Jaipur; c2020-21.
4. Jasrotia P, Kashyap PL, Bhardwaj AK, Kumar S, Singh GP. Scope and applications of nanotechnology for wheat production: A review of recent advances. Wheat and Barley Research. 2018;10(1):1-14.
5. Jyothi TV, Hebsur NS. Effect of nanofertilizers on growth and yield of selected cereals-A review. Agricultural Research Communication Centre. 2017;38(2):112-120.
6. Khan P, Memon MY, Imtiaz M, Aslam M. Response of wheat to foliar and soil application of urea at different growth stages. Pakisthan Journal of Botany. 2009;41(3):1197-1204.
7. Nazir Q, Wang X, Hussain A, Ditta A, Aimen A, Salmeen I, *et al*. Variation in growth, physiology, yield and quality of wheat under the application of different zinc coated formulations. Applied Sciences. 2021;11:4797-4802.
8. Pampolino MF, Witt C, Pasuquin JM, Johnston A, Fisher MJ. Development approach and evaluation of the nutrient expert software for nutrient management in cereal crops. Computers and Electronics in Agriculture. 2012;88:103-110.
9. Saini LH, Saini AK, Malve SH, Patel JP, Nand B, Chaudhary HS. Growth and yield attainment of wheat under different levels of vermicompost, biofertilizers and nitrogen. The Pharma Innovation Journal. 2023;12(6):1245-1249.
10. Seifu W, Elias E, Gebresamuel G, Tefera W. Soil type and fertilizer rate affect wheat (*Triticum aestivum* L.) yield, quality and nutrient use efficiency in Ayiba, northern Ethiopia. Peer J. 2022;10:e13344.
11. Shapep EK, Mahmud MR. Effect of distances between lines and levels of nitrogen fertilizer on yield and quality characteristics of wheat. Fifth International Conference for Agricultural and Environment Sciences. 2023;1158:062025, doi:10.1088/1755-1315/1158/6/062025.
12. Sharma S, Kaur G, Singh P, Alamri S, Kumar R, Manzer H, *et al*. Nitrogen and potassium application effects on productivity, profitability and nutrient use efficiency of irrigated wheat (*Triticum aestivum* L.). PLoS ONE. 2022;17(5):e0264210.
13. Singh DP, Singh D. Effect of nitrogen and FYM on yield, quality and uptake of nutrients in wheat (*Triticum aestivum*). Annals of Plant and Soil Research. 2017;19(2):232-236.
14. Suppan S. Applying nanotechnology to fertilizer: Rationales, research, risks and regulatory challenges. Institute for Agriculture and Trade Policy, Brazil; c2017.
15. Teshome W. Determination of nitrogen fertilizer requirement of durum wheat on growth and grain yield at Butajira Ethiopia. International Journal of Advanced Research in Biological Sciences. 2020;7(3):7-16.

16. Ullah A, Tian Z, Xu L, Abid M, Lei K, Khanzada A, *et al*. Improving the effects of drought priming against post-anthesis drought stress in wheat (*Triticum aestivum* L.) using nitrogen. Frontiers in Plant Science. 2022;13:965996.
17. Yadav G, Anshuman K, Singh A, Yadav S, Singh P. Impact of azotobacter and nitrogen on growth and productivity of wheat (*Triticum aestivum* L.). International Journal of Plant & Soil Science. 2023;35(5):109-115.