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Nutrient management in green gram (*Vigna radiata* L. Wilczek) and its effect on growth and yield

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Abstract
A field study was carried out to study the nutrient management in green gram (*Vigna radiata* L. Wilczek) and its effect on growth and yield during summer season of 2022 and 2023 at Instructional Farm, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra. The experiment was laid out in split plot design with three replications and consisted of four conventional fertilizer treatments: T_1 - control, T_2 - 100% RD of N and P + 100% RD of K, T_3 - 75% RD of N and P + 100% RD of K and T_4 - 50% RD of N and P + 100% RD of K and five sub-plot treatments consisting of nano fertilizer treatments: N_1 - control, N_2 - 25% RD of N through Nano-urea + 25% RD of P through Nano-phosphorous, N_3 - 50% RD of N through Nano-urea + 25% RD of P through Nano-phosphorous, N_4 - 25% RD of N through of Nano-urea + 50% RD of P through Nano-phosphorous and N_5 - 50% RD of N through of Nano-urea + 50% RD of P through Nano-phosphorous. The conventional fertilizer treatment T_2 (100% RD of N and P + 100% RD of K) and the nano fertilizer treatment N_5 [50% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)] recorded significantly higher growth and yield. Among the treatment combinations, T_2N_5 [100% RD of N and P + 100% RD of K and 50% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 30 and 45 DAS)] recorded maximum number of functional leaves plant^{-1}, number of branches plant^{-1}, weight of pods plant^{-1} and grain yield during both the years of experimentation and in the pooled mean.

Keywords: Green gram, conventional fertilizers, nano fertilizers, growth, and yield

Introduction
Locally known as moong, mung, or green gram, mungbean (*Vigna radiata* L. Wilczek) is a member of the *leguminoceae* (fabaceae) family. It is thought to be the healthiest pulse because it doesn't cause heaviness or flatulence. Green gram, green pods are used as a vegetable, and haulm is fed to cattle. It is cultivated as a soil binder and cover crop. It breaks down quickly and makes a great green manure. Green gram's protein content ranged from 22.5% to 27.94%, while its moisture content varied from 5.26% to 9.95%. The reported fat contents ranged from 0.12% to 2.31%, the lowest and highest, respectively. Green gram's crude fiber content ranged from 2.9% to 17.04%, while its ash percentage varied from 2.91% to 4.26%. The percentage of carbohydrates was between 32.14% and 66.33%. Macro minerals such as calcium, magnesium, phosphorus, potassium, and sodium, as well as micro minerals like manganese, iron, copper, and zinc, are found in green grams (Sudhakaran and Bukkan, 2021) [13].

It has been reported that India has been growing green grams since prehistoric times. Green gram is thought to have originated in India and Central Asia and been cultivated there since prehistoric times. Asia, including India, Pakistan, Bangladesh, Sri Lanka, Thailand, Laos, Cambodia, Vietnam, Indonesia, Malaysia, south China, and Formosa, is a region where it is extensively grown (Post harvest profile of green gram). Green gram was planted on approximately 40.38 lakh hectares in 2021-2022, yielding 31.5 lakh tonnes with a productivity of 783 kg/ha. This yield accounts for 11% of the entire output of pulses (Anonymous, 2022) [1]. The top producers of green gram in India in 2021-2022 were the states of Rajasthan (23.25 lakh ha), Madhya Pradesh (5.08 lakh ha), Maharashtra (4.21 lakh ha), Karnataka (4.14 lakh ha), Bihar (1.69 lakh ha) and Gujarat (1.39 lakh ha).

Increasing food yield and nutritional quality has become dependent on fertilizers, especially with the development of crop varieties that are fertilizer-responsive. Nitrogen (N) is the most significant mineral nutrient required by crop plants and is essential for their vegetative growth because it is a component of numerous proteins and enzymes in addition to chlorophyll. Nitrogen can be released into the atmosphere by a number of processes, such as volatization, denitrification, leaching and runoff. Phosphorus (P) is essential for all life and plays a major role in preserving and improving the fertility of natural soil. The increasing cost of P fertilizer is creating financial hardships, which is why there is an increasing interest in improving P use efficiency. Furthermore, the transfer of soil P from cultivated land via runoff or erosion is a major cause of P-induced eutrophication in surface waters. While reports indicate that, only 10-25% of phosphorous fertilizers are used, it is unfortunate that modern profit-driven agricultural systems only use 45–50% of nitrogenous fertilizers (Iqbal, 2020) [6].

Nanotechnology research is a promising field that may offer long-term solutions to pressing issues facing modern intensive agriculture. Nano fertilizers are made from conventional fertilizers, bulk fertilizer materials or extracted from various plants or plant parts by encapsulating/coating them with nano materials in order to achieve controlled and gradual release of nutrients for the development of soil fertility, productivity and the quality of agricultural products (Zulfiqar *et al*., 2019) [15]. When applied correctly, nano fertilizers can feed plants gradually while lowering leaching, decreasing volatilization, increasing nutrient usage efficiency (NUE), and reducing overall environmental concerns (Chen *et al.*, 2018) [4].

Materials and Methodology

The experiment was conducted at the Instructional Farm, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, College of Agriculture, Dapoli, during the summer seasons of 2021-2022 and 2022-2023. Geographically speaking, the experimental plot (B-42) of the Department of Agronomy's teaching farm at the College of Agriculture, Dapoli, is situated at 17°45'57" N and 73°10'29" E in the subtropical zone. Standing at an altitude of 157.8 meters, slightly above mean sea level.

Split plot design was used in the trial. In total, there were twenty treatment combinations and three replications. The main plot consisted of four conventional fertilizer treatments: T_1 - control, T_2 - 100% RD of N and P + 100% RD of K, T_3 - 75% RD of N and P + 100% RD of K and T_4 - 50% RD of N and P + 100% RD of K; the five nano fertilizer treatments that made up the sub-plot were as follows: N_1 - control, N_2 - 25% RD of N through Nano-urea + 25% RD of P through Nano-phosphorous, N_3 - 50% RD of N through Nano-urea + 25% RD of P through Nano-phosphorous, N_4 - 25% RD of N through of Nano-urea + 50% RD of P through Nano-phosphorous and N_5 - 50% RD of N through of Nano-urea + 50% RD of P through Nano-phosphorous. The gross plot size was 3.60 m × 3.60 m, the net plot size was 3.00 m × 3.40 m and the green gram seeds were sown at a spacing of 30 cm × 10 cm.

The nutrients N and P_2O_5 were applied using urea and single super phosphate (SSP), fertilizers, respectively. For green gram, the recommended dose of fertilizers applied was 25:50:00 NPK kg ha^{-1}. Full doses of urea, SSP and MOP were given at the time of sowing of green gram. The nano 17:44:00 formulation of Geolife Agritech India Private Limited was utilized as a source of nano phosphorous, while IFFCO nano urea was used as a source of nano nitrogen. Nano urea and nano phosphorous were sprayed 30 and 45 days after sowing of green gram.

Results and Discussions

1. Effect of conventional fertilizers

The data given in the Table 1 indicates that the number of functional leaves plant^{-1} and number of branches plant^{-1} were significantly influenced due to conventional fertilizer treatments during both the years and in the pooled mean. The treatment T_2 (100% RD of N and P + 100% RD of K) recorded significantly higher number of functional leaves plant^{-1} and number of branches plant^{-1} over rest of the treatments during 2021-2022 and 2022-2023 and in the pooled mean.

As per the data presented in the Table 2, the conventional fertilizer treatment T_2 (100% RD of N and P + 100% RD of K) recorded significantly higher weight of pods plant^{-1} and grain yield (kg ha^{-1}) over the remaining treatments during both the years of experimentation and in the pooled data.

The superior growth attributes under the treatment T_2 (100% RD of N and P + 100% RD of K) indicated that the plants under this treatment were metabolically more active. The higher number of leaves increased the surface area for capturing solar energy. As a result, the greater interception of solar energy led to the production of more photosynthates. The crop produced more source because of the increased number of functional leaves and number of branches resulting from improved photosynthetic efficiency. The increased availability of major nutrients under treatment T_2 led to the production of more assimilates, which subsequently enhanced the number of functional leaves and the number of branches compared to other conventional fertilizer treatments. Similar results were obtained by Awasarmal *et al.* (2015) [3], Somalraju *et al.* (2021) [11] who reported that, the increased supply of nutrients led to a higher production of assimilates and proteins, enhancing metabolic processes and subsequently improving growth parameters. The crop treated with T_2 (100% RD of N and P + 100% RD of K) showed higher physiological activity, as indicated by significantly higher growth parameter values, leading to better source creation. The increased source availability under T_2 has proportionally generated more sink in terms of weight of pods plant^{-1} further producing higher grain yield. These findings are in line with Singh *et al.* (2007) [9], Awasarmal *et al.* (2015) [3], and Somalraju *et al.* (2021) [11], who reported that increased nutrient supply led to higher production and translocation of assimilates to the sink, resulting in improved yield attributes and subsequently better grain yield.

2. Effect of nano fertilizers

Different nano fertilizer treatments significantly influenced the number of functional leaves plant^{-1} and number of branches plant^{-1} of green gram during 2021-2022, 2022-2023 and in the pooled mean (Table 1). The treatments N_5 [50% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)] and N_4 [25% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 30 and 45 DAS)] were at par and both of them recorded significantly higher values of number of functional leaves plant^{-1} and number of branches plant^{-1}over the remaining treatments.

It is clear from the data given in the Table 2 that the nano fertilizer treatment N_5 [50% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)] recorded significantly higher weight of pods plant^{-1} and grain yield (kg ha^{-1}) over the remaining treatments during 2021-2022, 2022-2023 and in the pooled mean.

Nano fertilizers, with their large surface area and smaller size, are easily absorbed by plants through stomatal and pore openings, enhancing their nutrient use efficiency. According to Razauddin *et al.* (2023) [8], once absorbed these nano fertilizers dissolve quickly in the plant's internal aqueous environment. As a result, even small quantities of nutrients in nano form are highly effective for the plants. Considering the major nutrients, nitrogen is a vital component of chlorophyll, protein, and nucleic acids, and it is crucial for cell division and enlargement. According to Srivastava and Singh (2023) [12], increased nitrogen availability improves the processes of protein synthesis and photosynthesis, causing cells to proliferate and lengthen quickly, ultimately leading to improved plant growth. Phosphorus significantly enhances root growth and is essential for the formation of nodules in leguminous plants, which increases nitrogen availability to the plants. Additionally, phosphorus is a key component of energy compounds such as ADP and ATP. This led to the plants under the treatments N_5 and N_4 becoming physiologically and metabolically more active resulting into superior growth characters under these treatments. The improved growth attributes under the treatment N_5 resulted in better translocation of photsynthates from source to sink leading to enhancement of yield character i.e. weight of pods plant^{-1} and ultimately producing higher grain yield under the treatment N_5. This results are similar to those of Khemshetty *et al.* (2024) [7], Yomso *et al.* (2023) [14] and Prakash *et al.* (2023) [10] who stated that, the role of nano urea and nano phosphorus in plant metabolic activities facilitated effective translocation of assimilates from source to sink, leading to improved yield attributing traits.

Table 1: Number of functional leaves plant^{-1} and number of branches plant^{-1} of green gram as influenced periodically by different treatments during 2021-2022; 2022-2023 and in the pooled mean

Treatments	Number of functional leaves plant^{-1}			Number of branches plant^{-1}		
	2021-2022	2022-2023	Pooled data	2021-2022	2022-2023	Pooled data
A) Main plot (conventional fertilizers)						
T_1 - control	19.58	19.90	19.74	5.52	5.74	5.63
T_2 - 100% RD of N and P + 100% RD of K	24.06	23.73	23.90	6.79	6.85	6.82
T_3 - 75% RD of N and P + 100% RD of K	23.03	23.09	23.06	6.43	6.47	6.45
T_4 - 50% RD of N and P + 100% RD of K	21.97	22.61	22.29	6.16	6.18	6.17
S.E.(m)±	0.28	0.13	0.15	0.07	0.08	0.04
C.D. at 5%	0.98	0.44	0.52	0.23	0.29	0.14
B) Sub plot (nano fertilizers)						
N_1- control	19.47	19.38	19.42	5.28	5.42	5.35
N_2- 25% RD of N through nano-urea + 25% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)	21.37	21.16	21.26	5.99	6.04	6.02
N_3- 50% RD of N through nano-urea + 25% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)	22.41	22.62	22.51	6.29	6.44	6.37
N_4- 25% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)	23.60	24.03	23.81	6.72	6.76	6.74
N_5- 50% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)	23.96	24.48	24.22	6.83	6.89	6.86
S.E.(m)±	0.29	0.38	0.37	0.09	0.09	0.09
C.D. at 5%	0.82	1.10	1.06	0.25	0.27	0.25
Interaction effects						
S.E.(m)±	0.57	0.76	0.76	0.17	0.19	0.18
C.D. at 5%	N.S	N.S	N.S	0.50	0.54	0.51

Table 2: Weight of pods plant^{-1} (g) and Grain yield (kg ha^{-1}) of green gram as influenced periodically by different treatments during 2021-2022; 2022-2023 and in the pooled mean

Treatments	Weight of pods plant^{-1} (g)			Grain yield (kg ha^{-1})		
	2021-2022	2022-2023	Pooled data	2021-2022	2022-2023	Pooled data
A) Main plot (conventional fertilizers)						
T_1 - control	12.225	12.733	12.479	947.60	1005.60	976.60
T_2 - 100% RD of N and P + 100% RD of K	15.576	16.105	15.841	1467.93	1502.80	1485.37
T_3 - 75% RD of N and P + 100% RD of K	15.143	15.673	15.408	1419.00	1462.00	1440.50
T_4 - 50% RD of N and P + 100% RD of K	14.623	15.145	14.884	1366.20	1409.13	1387.67
S.E.(m)±	0.029	0.014	0.013	1.738	1.79	1.32
C.D. at 5%	0.100	0.049	0.044	6.014	6.19	4.58
B) Sub plot (nano fertilizers)						
N_1- control	10.614	11.133	10.873	883.08	928.33	905.71
N_2- 25% RD of N through nano-urea + 25% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)	12.795	13.312	13.053	1240.67	1323.17	1281.92
N_3- 50% RD of N through nano-urea + 25% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)	14.593	15.132	14.862	1363.42	1400.75	1382.08
N_4- 25% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)	16.917	17.435	17.176	1500.92	1529.92	1515.42
N_5- 50% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)	17.042	17.560	17.301	1512.83	1542.25	1527.54
S.E.(m)±	0.014	0.022	0.019	1.06	1.00	0.96
C.D. at 5%	0.041	0.063	0.053	3.05	2.87	2.77
Interaction effects						
S.E.(m)±	0.03	0.04	0.04	2.12	1.99	1.92
C.D. at 5%	0.08	0.13	0.11	6.11	5.74	5.54

3. Interaction effect

The data presented in the Table 3 indicates that the interaction effect between the conventional fertilizers and nano fertilizers in case of number of branches plant^{-1} was found to be significant. The T_2N_5 recorded significantly higher number of branches than the rest of the treatment combinations except T_2N_4, T_2N_3 and T_3N_5 during 2022-2023 and T_2N_4, T_2N_3, T_3N_5 and T_1N_5 treatment combinations during 2021-2022 and in the pooled mean.

Table 3: Interaction effects between conventional fertilizers and nano fertilizers on number of branches plant^{-1} of green gram during 2021-2022; 2022-2023 and in the pooled data

Nano fertilizers ↓	Conventional fertilizers											
	2021-2022				2022-2023				Pooled data			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
N_1	4.27	6.00	5.60	5.27	4.57	5.90	5.63	5.57	4.42	5.95	5.62	5.42
N_2	4.70	6.67	6.47	6.13	5.07	6.67	6.17	6.27	4.88	6.67	6.32	6.20
N_3	5.30	7.00	6.60	6.27	5.53	7.13	6.83	6.27	5.42	7.07	6.72	6.27
N_4	6.60	7.13	6.60	6.53	6.73	7.13	6.83	6.33	6.67	7.13	6.72	6.43
N_5	6.73	7.13	6.87	6.60	6.80	7.40	6.90	6.47	6.77	7.27	6.88	6.53
S.E.(m)±	0.17				0.19				0.18			
C.D. at 5%	0.50				0.54				0.51			

Table 4: Interaction effects between conventional fertilizers and nano fertilizers on weight of pods plant^{-1} of green gram during 2021-2022; 2022-2023 and in the pooled data

Nano fertilizers ↓	Conventional fertilizers											
	2021-2022				2022-2023				Pooled data			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
N_1	8.68	11.66	11.30	10.81	9.16	12.18	11.85	11.34	8.92	11.92	11.58	11.08
N_2	10.76	13.86	13.51	13.05	11.24	14.38	14.05	13.58	11.00	14.12	13.78	13.32
N_3	12.25	15.97	15.33	14.83	12.78	16.52	15.85	15.37	12.52	16.24	15.59	15.10
N_4	14.67	18.13	17.72	17.14	15.19	18.65	18.23	17.66	14.93	18.39	17.98	17.40
N_5	14.77	18.26	17.86	17.28	15.29	18.79	18.39	17.77	15.03	18.53	18.12	17.53
S.E.(m)±	0.03				0.04				0.04			
C.D. at 5%	0.08				0.13				0.11			

The treatment combination T_2N_5 recorded significantly higher weight of pods plant^{-1} and grain yield over the rest of the treatment combinations during both the years and in the pooled data (Table 4 and Table 5).

The adequate supply of major nutrients, nitrogen and phosphorus, from conventional fertilizers and the foliar spray of nano fertilizers ensured sufficient nutrient availability for the treatment combinations T_2N_5, T_2N_4, T_2N_3, and T_3N_5. This ample supply resulted in greater growth in terms of number of functional leaves and number of branches. As previously mentioned, nitrogen plays a crucial role in the vegetative growth of plants, while phosphorus supports efficient metabolic activities, root development, and nodulation in leguminous plants due to its role as a source of energy compounds. Consequently, the T_2N_5 treatment combination exhibited the best growth, followed by T_2N_4, T_2N_3, and T_3N_5. The improved growth characters i.e. number of functional leaves and number of branches under the treatment combination T_2N_5 led to better interception of solar energy and production of more photosynthates or source. The higher source available under the treatment combination T_2N_5 resulted in proportionally production of higher sink further leading to significantly higher weight of pods plant^{-1} and grain yield.

Table 5: Interaction effects between conventional fertilizers and nano fertilizers on grain yield (kg ha^{-1}) of green gram during 2021-2022; 2022-2023 and in the pooled data

Nano fertilizers ↓	Conventional fertilizers											
	2021-2022				2022-2023				Pooled data			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
N_1	673.00	997.67	948.33	913.33	636.33	1063.33	1030.00	983.67	654.67	1030.50	989.17	948.50
N_2	862.00	1417.67	1368.67	1314.33	982.33	1478.33	1446.33	1385.67	922.17	1448.00	1407.50	1350.00
N_3	983.00	1542.67	1490.67	1437.33	1053.67	1563.67	1517.67	1468.00	1018.33	1553.17	1504.17	1452.67
N_4	1104.67	1681.00	1638.33	1579.67	1168.67	1692.00	1657.00	1602.00	1136.67	1686.50	1647.67	1590.83
N_5	1115.33	1700.67	1649.00	1586.33	1187.00	1716.67	1659.00	1606.33	1151.17	1708.67	1654.00	1596.33
S.E.(m)±	2.12				1.99				1.92			
C.D. at 5%	6.11				5.74				5.54			

Conclusion

Based on two years of experimentation, it can be concluded that the treatment T_2N_5 [100% RD of N and P + 100% RD of K and 50% RD of N through nano-urea + 50% RD of P through nano-phosphorous (2 sprays at 45 and 60 DAT)] resulted in higher growth attributes, such as number of functional leaves plant^{-1} and number of branches plant^{-1} as well as higher yield attribute *viz.*, weight of pods plant^{-1} and grain yield in the green gram crop.

References

1. Anonymous. Green gram outlook report - January to December 2022. Available from: https://angrau.ac.in/downloads/AMIC/OutlookReports/2022/8-Greengram%20Outlook%20Report%20-%20January%20to%20December%202022.pdf.
2. Anonymous. Annual report 2022-2023, Directorate of pulses development. Available from: https://dpd.gov.in/Final%20%20Annual%20Report%20(2022-23)%20with%20Preface%20(As%20on%2020.02.2024).pdf.
3. Awasarmal VB, Vyavahare SP, Pawar SU. Effect of sowing time and levels of fertilizer on growth and yield of green gram. Int J Trop Agric. 2015;33(2):891-895.
4. Chen S, Yang M, Ba C, Yu S, Jiang Y, Zou H, *et al*. Preparation and characterization of slow-release fertilizer encapsulated by biochar-based waterborne copolymers. Sci Total Environ. 2018;615:431-437.
5. Hangsing N, Tzudir L, Singh AP. Effect of spacing and levels of phosphorus on the growth and yield of green gram (*Vigna radiata*) under rainfed condition of Nagaland. Agric Sci Digest. c2019.
6. Iqbal MA. Nano-fertilizers for sustainable crop production under changing climate: A global perspective. In: Sustainable Crop Production. c2020. IntechOpen.
7. Khemshetty A, Patil DH, Rathod PS, Patil ASP, Basavaraj K. Studies on nano DAP on growth, yield and quality of chickpeas under rainfed conditions of Northeastern dry zone of Karnataka. J Exp Agric Int. 2024;46(3):139-145.
8. Razauddin N, Ninama J, Sachan K, Salochna Y, Yadav B, Satapathy SN, *et al*. Effects and consequences of nano fertilizer application on plant growth and developments: A review. Int J Environ Clim Change. 2023;13(10):2288-2298.
9. Singh AK, Tripathi PN, Singh R. Effect of Rhizobium inoculation, nitrogen and phosphorus levels on growth, yield and quality of kharif cowpea [*Vigna unguiculata* (L.) Walp.]. Crop Res. 2007;33(1, 2 & 3):71-73.
10. Prakash N, Naik A, Siddaram, Ravi MV, Bellakki MA. Response of nano DAP on growth, yield and quality of soybean. J Pharm Innov. 2023;12(12):2002-2005.
11. Somalraju S, Goyal G, Gurjar LS, Chaturvedi M, Singh R. Effect of organic and inorganic fertilizer on the growth and yield of green gram (*Vigna radiata* L.). J Pharm Innov. 2021;10(12):1959-1962.
12. Srivastava A, Singh R. Effect of nitrogen and foliar spray of urea and nano urea on growth and yield of rabi maize (*Zea mays* L.). Int J Plant Soil Sci. 2023;35(18):2037-2044.
13. Sudhakaran SM, Bukkan DS. A review on nutritional composition, antinutritional components and health benefits of green gram (*Vigna radiata* (L.) Wilczek). J Food Biochem. 2021;45(6):1-19.
14. Yomso J, Menon S, Sale MN, Yumnam J. Performance of mung bean as influenced by different levels of fertilizers and cropping systems in the semi-arid region of India. J Appl Biol Biotechnol. 2023;11(5):152-156.
15. Zulfiqar F, Navarro M, Ashraf M, Akram NA, Munné-Bosch S. Nanofertilizer use for sustainable agriculture: Advantages and limitations. Plant Sci. 2019;289:110270.