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Assessment of Growth Parameters in Oats (*Avena sativa* L.) with Application of Nano Urea Fertilizer: A Field-based Study

Rajesh [a,b], Madhu Choudhary [c], Rakesh Kumar [b], Rajesh Kumar Meena [b], Hardev Ram [b], Manoj Kumar [e*], Vijendra Kumar [a], Govind Makarana [d], Dinesh Kumar [b,f] and Umer Basu [a]

[a] ICAR-Indian Agricultural Research Institute, New Delhi, India.
[b] ICAR-National Dairy Research Institute, Karnal, Haryana, India.
[c] ICAR-Central Soil Salinity Research Institute Karnal, Haryana, India.
[d] ICAR-Research Complex for Eastern Region, Patna, Bihar, India.
[e] ICAR-AICRP on Pearl Millet, Agriculture University, Jodhpur, Rajasthan, India.
[f] ICAR-Central Coastal Agricultural Research Institute Old Goa, Goa, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study aimed to evaluate the efficacy of Nano nitrogen on various growth parameters of oats leads to growth and yield, including plant height, plant population, number of leaves, leaf length, leaf width, and the total number of tillers per plant. During the study, growth parameters were recorded

**Corresponding author: E-mail: mkagro86@gmail.com;*

at 30 days after sowing and after the I and II cuts. Results revealed that 30 days after seeding, applying 100% recommended dose of nitrogen (RDN) through Urea and 75% RDN with 25% nitrogen through Nano-N resulted in significantly greater plant heights as compared to the rest of the treatment combinations. Similarly, these treatments also had significantly higher plant heights during the I and II cuts. The number of leaves significantly increased with the application of nitrogen through all sources, either individually or in combination, highest number of leaves was observed when 100% RDN was applied through Urea or when 75% RDN was applied combined with 25% nitrogen through Nano-N. The leaf length and width of the oats were also significantly improved by nitrogen management practices, with the maximum leaf length observed when 100% RDN was applied through Urea or when 75% RDN was applied combined with 25% nitrogen through Nano-N. Similarly, the highest leaf width was observed with the application of 100% RDN through Urea at all stages, while 75% RDN + 25% Nano-N was comparable to 100% RDN through Urea. The number of tillers per plant was significantly affected by different nitrogen management practices at 30 days after sowing and after the I and II harvests, highest number of tillers per plant was observed through the application of 100% RDN through Urea. Overall, the results show that the use of Nano nitrogen can significantly improve the growth attributing characteristics as well as yield attributes and yield of oats, particularly when combined with traditional nitrogen sources. These findings are consistent with previous research in this area.

Keywords: Growth; Nano-N; oats; recommended dose of nitrogen; tillers; yield.

1. INTRODUCTION

India agricultural sector spans 157.35 million hectares of land, supporting about 14.3% of the world's cattle and 17.7% of the global human population [1]. Livestock farming is an essential component of the country's agriculture, with approximately 536 million animals [2]. Although India is the world's largest milk producer, the productivity of its cattle remains below the global average, with feed and fodder management contributing to about 70% of the gains. A shortfall of green fodder, dry crop residue, and concentrate feed, continues to be a major challenge for the livestock sector in India [3]. Therefore, it is critical to increasing fodder production to meet the growing demand for animal feed.

Among various fodder crops, oats (*Avena sativa* L.) is an important *rabi* season fodder crop that can be grown under different climatic conditions in the north, central, and western regions of India, providing succulent and nutritious fodder to animals during the winter [4]. Oats have a high nutritional value, with an average of 10-11.5% crude protein, 55-63% neutral detergent fiber, 30-32% acid detergent fiber, 22-23.5% cellulose, and 17-20% hemicelluloses [5].

Proper nitrogen management in agriculture is crucial for increasing crop yields and productivity. With the increasing demand for food production and the need to feed a growing global population, there is a pressing need to develop more sustainable and efficient agricultural practices. One promising area of research is the use of nano-fertilizers to improve nitrogen efficiency and enhance the quality of fodder crops. Studies have shown that traditional urea fertilizers have low nitrogen efficiency, with a significant amount of nitrogen lost through leaching and volatilization, leading to a higher cost of production and reduced crop yields. In contrast, nano-fertilizers have been shown to offer a more targeted and efficient release of nutrients, leading to improved nitrogen use efficiency and better crop yields [6]. The use of nano-fertilizers in agriculture has gained considerable attention due to their potential benefits. These nano-scale particles and emulsions allow for the controlled release of nutrients over an extended period, resulting in improved nutrient use efficiency, reduced nutrient losses, and a more sustainable approach to fertilization [7,8]. However, despite their potential benefits, research on the use of nano-fertilizers in fodder crops is still limited. There is a need for further studies to determine the optimal combination and source of nitrogen fertilizer for enhancing the quality of fodder crops such as oats.

In conclusion, the use of nano-fertilizers in agriculture has the potential to revolutionize nitrogen management and improve crop productivity. More research is needed to explore the benefits and drawbacks of these novel fertilizers, particularly in the context of fodder crop production, to develop more sustainable and efficient agricultural practices.

2. MATERIALS AND METHODS

The present study was conducted during spring season of 2020 at the research farm of the Agronomy section, ICAR-National Dairy Research Institute, Karnal, Haryana located at 29º45' North latitude and 76º58' East longitude with an altitude of 245 m above sea level. The climate of the region is semi-arid with a mean annual rainfall of 707mm, with 70-80% of rainfall received during the months of July-September and the rest during winter and spring. The relative humidity was recorded at 41.4% and 100% in the 3^{rd} and 43^{rd} standard week, respectively. The highest maximum temperature of 34.5°C was recorded in the 40th and 41st standard weeks, while the lowest minimum temperature of 5.9°C was recorded in the 2nd standard week. The soil properties of the experimental site were classified as clay loam with a pH of 7.70, the electrical conductivity of 0.25dS/m, organic carbon of 0.67%, and available nitrogen, phosphorus, and potassium of 172.60, 25.70, and 185.40 kg/ha, respectively.

The experiment was laid out in a randomized block design with six treatments and four replications. The treatments included an absolute control, 100% recommended dose of nitrogen (RDN) through urea, 75% (RDN) through urea + 25% RDN through Nano-N, 50% (RDN) through urea + 50% RDN through Nano-N and 25% (RDN) through urea + 75 % RDN through Nano-N, and 100% RDN through Nano-N. The land preparation involved one deep plowing with a disc plow followed by one disc harrow and planking. The recommended dose of nitrogen (120 kg/ha) was applied through traditional and nano urea, with 1/3rd dose of nitrogen (Urea) and full doses of P_2O_5 (40 kg/ha) and K_2O (40 kg/ha) applied to the soil at the time of sowing. The remaining dose of nitrogen (Urea and Nano-N) was applied in two split doses at 30 DAS (Urea as top dressing and Nano-N as a foliar spray) and after the first cutting (Urea and Nano-N in soil) as per treatment. The remaining package of practices was followed as per the standard procedure for oats cultivation, with oats *cv*. Kent sowed using 100 kg seed per hectare and maintaining a spacing of 25 cm from row to row and 10 cm from plant to plant.

Five plants were randomly selected and tagged from the net plot area, with observations on growth parameters recorded on those tagged plants at 30 DAS, at the I cut, and at the II cut. The average height and the total number of tillers of the five tagged plants were worked out to get the mean at 30 DAS, at I cut and at II cut. The number of leaves per plant was recorded by counting the fully opened leaves of the same five tagged plants and the average was worked out at both stages of observation. The length and width of ten leaves randomly selected were measured from the same five tagged plants, and the average values were worked out. The first cutting was taken at 60 DAS (50% flowering stage) from 8-10 cm above the ground level, and the second cutting was taken 45 days after the first cutting. All data recorded were analyzed with the help of analysis of variance [9] at 5% level of significance ($P<0.05$).

3. RESULTS AND DISCUSSION

To assess the efficacy of Nano nitrogen, various growth parameters of oats such as plant height, plant population, number of leaves, leaf length, leaf width, and the total number of tillers per plant were meticulously recorded 30 days after sowing and after the first and second harvests. Plant height is an important parameter for assessing crop growth and development and it can be influenced by improved agronomic practices in addition to genetics. The study on the effect of nitrogen management practices on plant height (Table 1 and Fig. 1) of oats showed that at 30 days after seeding (DAS), applying 100% recommended dose of nitrogen (RDN) through Urea and 75% RDN with 25% nitrogen through Nano-N resulted into significantly higher plant heights as compared to rest of the treatments. Similarly, at the first and second cut, these treatments had significantly greater plant heights than other nitrogen management treatments. The increase in plant height can be attributed due to the higher availability of nitrogen during photosynthetic activities, as well as the supply of nitrogen through soil and foliar applications during the vegetative and reproductive stages [10]. The results of this study are consistent with previous research by [11-16]; and [17].

The number of leaves of oats significantly increased with the application of nitrogen through all sources, either individually or in combination (Table 1). At 30 DAS, the application of 100% RDN through Urea and 75% RDN with 25% nitrogen through Nano-N resulted in significantly more leaves, as did these treatments at the first and second cuts. The increase in the number of leaves may be due to the abundant supply of nitrogen through various nitrogen management practices, which could have increased protoplasmic constituents and accelerated cell division and elongation processes [18].

The length and width of oat leaves were significantly impacted by nitrogen management practices. Applying nitrogen through Urea, Nano-N, or their combinations resulted in improved leaf length and width compared to the control at all stages. The highest leaf length was observed when 100% RDN was applied through Urea or when 75% RDN was combined with 25% nitrogen through Nano-N at 30 DAS. Similarly, the highest leaf width was observed with the application of 100% RDN through Urea at all stages, while 75% RDN + 25% nano-Nitrogen was comparable to 100% RDN through Urea. These findings are consistent with previous research by [11,19,12,15] and [17].

The plant population of oats was not affected significantly by any of the nitrogen management strategies, although slightly higher numbers of plants were counted with 100% RDN through Urea and 75% RDN with 25% nitrogen through Nano-N compared to other treatments (Table 1).

Data on the number of tillers per plant are presented in Table 2 and revealed that the number of tillers per plant was significantly affected by different nitrogen (N) management practices at 30 days after sowing (DAS), I cut and II cuts. At 30 DAS the application of 100% recommended dose of nitrogen (RDN) through Urea (3.68), 75% RDN + 25% N through Nano-N (3.58) and 50% RDN + 50% N through Nano-N (3.45) showed statistical equal numbers of tillers per plant and were observed to be higher than the rest of the treatments. At I cut, 100% RDN through Urea (9.25) and 75% RDN + 25% N through Nano-N (9.22) had significantly more tillers than the remaining treatments. Further results revealed that at this stage, 50% RDN + 50% N through Nano-N (8.18) and 25% RDN + 75% N through Nano-N (7.78) remained at par with 100% RDN through Nano-N (7.55) and were noted to be markedly higher than the control. At II cut, the maximum number of tillers was counted in the 100% RDN through Urea treatment (8.60). At this stage, increments were noticed by 1.38, 1.34, 1.29, 1.21, and 1.14 in folds due to the application of 100% RDN through Urea, 75% RDN + 25% N through Nano-N, 50% RDN + 50% N through Nano-N, 25% RDN + 75% N through Nano-N, and 100% RDN through Nano-N, respectively. The supply of sufficient N promotes higher nutrient absorption, quicker leaf development, increased plant height via cell division and expansion, improved photosynthetic rate, and ultimately improved plant growth traits such as the number of tillers under different N application practices. These results are consistent with previous research by [19,9,15]; [20] and [16] as well as the previous reference to [17].

A critical analysis of the data shows that both nitrogen sources significantly enhanced the green fodder yield (GFY) of oats compared to the control, at the first as well as the second cut, and in total (Table 2 and Fig. 2). At the first and second cut, the application of 100% recommended dose of nitrogen (RDN) through urea (32.81 t/ha and 24.44 t/ha) and 75% RDN + 25% nitrogen through nano-N (32.05 t/ha and 23.65 t/ha) resulted in significantly higher GFY compared to other nitrogen management practices. Similarly, the application of 100% RDN through urea (57.25 t/ha) and 75% RDN + 25% nitrogen through nano-N (55.71 t/ha) resulted in significantly superior total GFY compared to other nitrogen management strategies and were at par with each other.

The enhancement in GFY ranged from 13.1% to 38.3% at the first cut, 13.6% to 40.4% at the second cut, and 25.1% to 38.3% in total GFY, by the application of 100% RDN through urea, 75% RDN + 25% nitrogen through nano-N, 50% RDN + 50% nitrogen through nano-N, 25% RDN + 75% nitrogen through nano-N, and 100% RDN through nano-N, respectively, over the control. These increased yields through nitrogen applications were attributed to favorable impacts on cell elongation and differentiation, production of nucleotides and co-enzymes, enhanced operation of meristematic tissues, and photosynthetic area. The combination of these factors also contributed to the increase in green fodder yield. These results are consistent with previous studies [21,22] and [13].

Table 1. Effect of different nitrogen treatments on plant height, total number of leaves plant, leaf length and plant population of oats

Treatments	Plant height (cm)			Total number of leaves plant^{-1}			Leaf length (cm)			Plant population m^{-2}
	30 DAS	I Cut	II Cut	30 DAS	I Cut	II Cut	I Cut	II Cut	Total	
Absolute control	44.70	108.1	83.5	11.88	56.10	44.70	31.13	45.05	37.35	94.94
100% RDN through Urea	57.93	148.8	120.1	14.48	77.70	61.73	37.60	58.80	51.08	98.83
75% RDN + 25% N through Nano-N	56.85	146.1	115.4	14.20	76.25	61.15	37.50	57.80	49.95	98.58
50% RDN + 50% N through Nano-N	52.45	134.2	111.0	13.40	70.20	58.30	36.85	54.40	47.15	97.95
25% RDN + 75% N through Nano-N	50.25	125.7	100.3	12.95	65.30	53.45	35.70	51.65	44.44	97.33
100% RDN through Nano-N	49.33	124.5	98.4	12.75	64.65	52.80	35.40	50.52	42.50	96.73
SEm±	0.72	2.9	2.8	0.24	1.23	0.56	0.50	0.90	0.54	1.19
CD (P=0.05)	2.16	8.7	8.4	0.72	3.71	1.68	1.51	2.72	1.64	NS

Table 2. Effect of different nitrogen treatments on leaf width, total number of tillers plant^{-1} and green fodder yield of oats

Treatments	Leaf width (cm)			Total number of tillers plant^{-1}			Green fodder yield (t ha^{-1})		
	30 DAS	I Cut	II Cut	30 DAS	I Cut	II Cut	I Cut	II Cut	Total
Absolute control	0.98	1.62	1.54	2.98	6.85	6.23	23.99	17.41	41.40
100% RDN through Urea	1.15	2.08	1.95	3.63	9.25	8.60	32.81	24.44	57.25
75% RDN + 25% N through Nano-N	1.14	2.03	1.91	3.58	9.22	8.35	32.05	23.65	55.71
50% RDN + 50% N through Nano-N	1.13	1.91	1.83	3.45	8.18	8.03	29.06	22.74	51.80
25% RDN + 75% N through Nano-N	1.10	1.85	1.77	3.25	7.78	7.55	27.78	20.56	48.35
100% RDN through Nano-N	1.10	1.81	1.74	3.20	7.55	7.13	27.13	19.78	46.91
SEm±	0.03	0.04	0.03	0.14	0.30	0.16	0.46	0.59	0.87
CD (P=0.05)	0.09	0.13	0.09	0.43	0.91	0.49	1.39	1.78	2.63

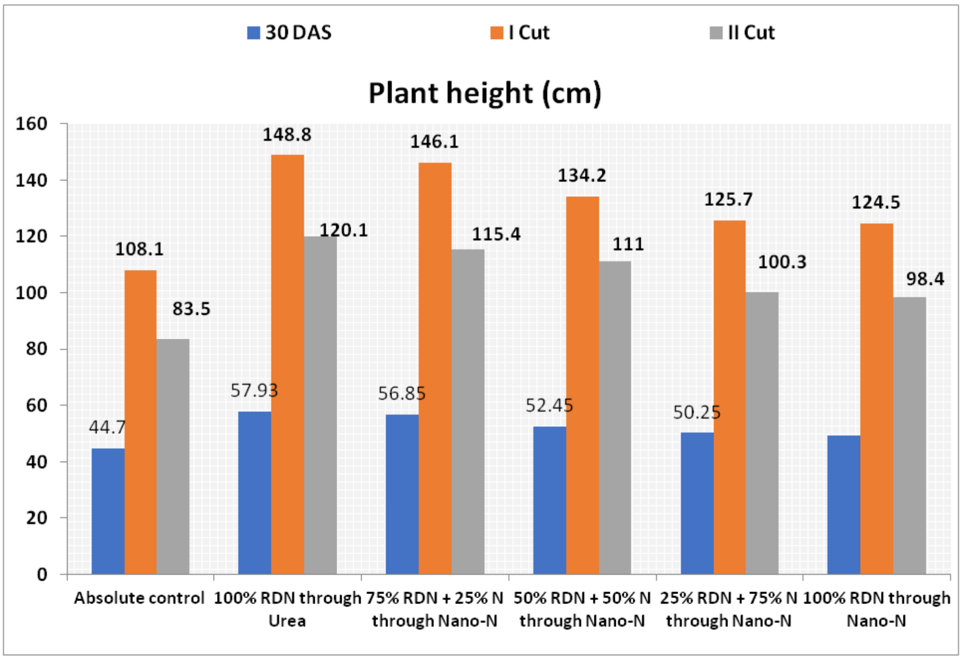

Fig. 1. Effect of different nitrogen treatments on plant height of oats

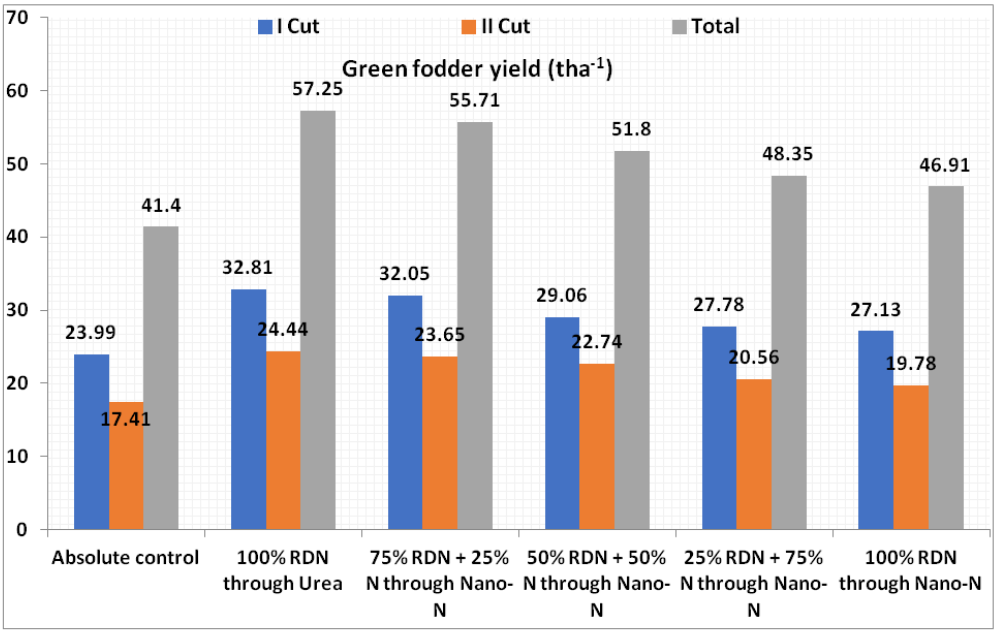

Fig. 2. Effect of different nitrogen treatments on green fodder yield of oats

4. CONCLUSION

The results of the current experiment suggested that the most effective nitrogen management practices for achieving high-quality fodder oats, which in turn provides maximum energy to support sustainable livestock production are the application of 100% RDN through urea or 75% RDN in combination with 25% nitrogen through Nano-N. These nitrogen management practices have been found to improve the yield and quality of fodder oats, resulting in increased energy for animals, which is essential for sustainable livestock production. The use of urea has been shown to increase the number of tillers per plant the length and width of the leaves and ultimately the yield of fodder oats. Similarly, the application of Nano-N in combination with RDN has also shown significant improvements in the number of tillers per plant as well as the length and width of the leaves. Overall, the current experiment suggests that the proper application of nitrogen management practices is essential for the successful cultivation of high-quality fodder oats. By using either 100% RDN through urea or 75% RDN in combination with 25% nitrogen through Nano-N, farmers can produce high-quality fodder oats that provide maximum energy to support sustainable livestock production.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO. FAOSTAT. Food and Agriculture Organization of the United Nations; 2022. Available: http://www.fao.org/faostat/en/#data
2. DAHD. Livestock statistics. Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India; 2021. Available: https://dahd.nic.in/livestock-statistics
3. NDDB. Nanotechnology in agriculture: prospects and challenges. Anand, Gujarat: National Dairy Development Board; 2020.
4. Kumar A, Singh SK, Singh PK. Nanofertilizers for sustainable agriculture. In nanotechnology in agriculture: sustainable agriculture reviews. Springer. 2022a;293-314.
5. Kumar A, Sahoo B, Panda AK, Samal P, Sarangi DN, Srivastava SK. Forage crops in eastern India for Improved Livestock Productivity. 2019;7.
6. Kumar Y, Tiwari KN, Nayak RK, Rai A, Singh SP, Singh AN et al. Nanofertilizers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Uttar Pradesh. Indian J Fertilisers. 2020a;16(8): 772-86.
7. Rai V, Acharya S, Dey N. Implications of nanobiosensors in agriculture. J Biomater Nanobiotechnology. 2012;03(2):315-24. DOI: 10.4236/jbnb.2012.322039
8. Mahil SK, Kumar P. Nano-fertilizers and their smart delivery system: A comprehensive review. J Cleaner Prod. 2019;214:366-77.
9. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley & Sons. 1984;680.
10. Rai M, Ingle A, Pandit R. Nanotechnology in agro-food: from field to plate. Food Res Int. 2012;48(1):9-16.
11. El-Gewely MR, Al-Mohammadi AA, Ibrahim GA, El-Bassiouny HM, Taha HS. Nano-urea and nano-biochar enhance the growth, yield, and quality of wheat grown under salinity stress. Agronomy. 2020;10(7):981.
12. Babubhai M, Pandey A, Bhatt P, Shah A, Sarsaiya S. Application of nano-urea for crop improvement: a review. Mater Today Proc. 2019;19:867-70.
13. Al-Juthery SN, Al-Mamoori AH, Al-Musawi TJ, Al-Jumaili AH. Effect of nano-urea fertilizer on the yield and quality of barley (*Hordeum vulgare* L.). Int J Agric Biol. 2019;23(1):107-12.
14. Al-Saray KH, Al-Naddawi MA, Al-Salihi RK. Effect of nanourea fertilizer on growth and yield of wheat plants. Int J Agric Biol. 2019;22(5):1017-23.
15. Al-Juthery SN, Al-Jumaili AH, Al-Musawi TJ, Al-Mamoori AH. Effect of foliar application of nanourea fertilizer on some growth characteristics of barley (*Hordeum vulgare* L.) plant. Int J Sci Res. 2018;7(6):422-5.
16. Kaur G, Goyal N. Nanotechnology: A new frontier for enhancing crop productivity and food security-an overview. J Appl Nat Sci. 2017;9(1):435-48.
17. Raliya R. Application of nanoparticles on plant system and associated rhizospheric microflora [Ph.D. thesis]. Jodhpur, Rajasthan, India: Jai Press Narain Vyas University. 2012;199.
18. Kumar D, Yadav MR, Makarana G, Rajput, V.D. B, B, Kashyap S et al. Effects, uptake, translocation and toxicity of Ti-based nanoparticles in plants. In: Rajput, VD MT, Sushkova S, Mandzhieva SS, Rensing C, editors. Toxicity of nanoparticles in plants. Academic Press, Elsevier. 2022b;211-39.

19. Biswas BK, Khanam D, Saha S. Nanofertilize-A novel approach for nutrient management in agriculture: a review. J Nanostructure Chem. 2020;10(1): 1-7.
20. Rathnayaka RMNN, Mahendran S, Iqbal YB, Rifnas LM. Influence of urea and nano-nitrogen fertilizers on the growth and yield of rice (*Oryza sativa* L.) cultivar 'bg 250'.International Journal of Research Publications. 2018;5(2):1-10.
21. Abdel-Aziz NM, Salem NM, Ali AM, Kholif AM. Impact of using nanotechnology in fertilization and pesticides on improving crop production: a review. J Radiat Res Appl Sci. 2018;11(3):265-76.
22. Davarpanah S, Modarres-Sanavy SAM, Sharifi M, Gholizadeh A, Nour-Mohammadi G, Karimmojeni H. Response of winter wheat to foliar application of nitrogen under different sources and rates of nitrogen. Arch Agron Soil Sci. 2017;63(11):1541-55.
23. Benzon B, Deleuran LC, Støving H, Larsen RM, Jensen LS. Effect of nitrogen form and slow-release urea on barley yield, protein content and nitrogen recovery under controlled environmental conditions. J Plant Nutr. 2015;38(8):1203-17.

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