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EFFECT OF UREA AND FOLIAR APPLICATION OF NANO UREA ON GROWTH, NUTRIENT UTILIZATION AND YIELD OF WHEAT (*Triticum aestivum* L.)

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ABSTRACT

Utilization of chemical fertilizers has long been condemned because of their harmful impacts on the environment and quality of agricultural products, and researchers are looking for better alternatives. Nano fertilizers offer benefits in nutrition management through their strong potential to increase nutrient use efficiency. Traditional fertilizers are not only costly for the producer but may be harmful to humans and the environment. Nano-fertilizers are appropriate alternatives to conventional fertilizers for gradual and controlled supply of nutrients. The field experiment was conducted during Rabi season of 2021-22 at research plot of Department of Agricultural Chemistry and Soil Science, Udai Pratap (Autonomous) College, Varanasi (U.P.). The field experiment was conducted under randomized block design with six treatments. Treatments were replicated thrice. The treatments were T_1= Control (RDF:: P:K @ 60 kg ha^{-1}) T_2= T_1 + N @ 120 kg ha^{-1} (50% basal + 30 kg ha^{-1} at CRI +30 kg ha-^{1} at PI stage), T_3= T_1 + N @ 140 kg ha^{-1} (50% basal + 35 kg ha^{-1} at CRI +35 kg ha^{-1} at PI stage), T_4 (N @ 120 kg ha^{-1} (50% basal) + FS of NU @ 4ml/L at CRI + 4ml/L at PI stage), T_5=(N @ 120 kg ha^{-1} (50% basal) + FS of NU @ 4ml/L at CRI + 4ml/L at PI stage), and T_6=(N @ 140 kg ha^{-1} (50% basal +35 kg ha^{-1} at CRI) + FS of NU @ 4ml/L at PI stage).Results revealed that application of nitrogen through urea alone and combined with foliar application of nano urea significantly and positively affected the growth, nutrient utilization and yield of wheat crop. Soil application of nitrogen @120 kg ha^{-1} (50% as basal) through urea with two foliar sprays of nano urea @ 4ml/L at CRI (crown root initiation) and PI (panicle initiation) stages recorded maximum growth, nutrient utilization and yield.

KEYWORDS: Urea, Nano Urea, Foliar Application, Wheat, Nutrient Utilization, *Triticum aestivum* L.

Wheat (*Triticum aestivum* L.) is one of the most widely consumed cereal crops followed by rice worldwide. Uttar Pradesh is the largest wheat producer in India. Nitrogen (N) is an important element in the life of plants because of its key part in chlorophyll production, which is basic for the photosynthesis process. A wide range of nitrogen-containing compounds is available in the world market, with different formulations and efficiencies. Urea is present in most fertilizer applications; however, nano-nitrogen products are becoming popular although there is only limited information on their field efficiency. Nonetheless, soil nitrogen supply is often limited, which forces farmers to increase the amount of N-fertilizers in order to accomplish better crop yield. However, farmers may provoke nitrogen over fertilization, which thwarts optimum plant productivity, as plants are not able to absorb the excess of N-fertilizer. Consequently, to achieve sustainable agriculture with more yield and maintaining the society's health is the goal of researchers in agriculture. In such manner, utilization of chemical fertilizers has long been condemned because of their harmful impacts on the environment and quality of agricultural products, and researchers are looking for better alternatives. Nano fertilizers offer benefits in nutrition management through their strong potential to increase nutrient use efficiency. Traditional fertilizers are not only costly for the producer but may be harmful to humans and the environment. Furthermore, nano-fertilizers may also be used for enhancing abiotic stress tolerance. Nano urea in the form of a nano particle is a nutrient (liquid) to provide nitrogen to plants as an alternative to the conventional urea. Nano urea fertilizers are important in increasing the efficiency of nutrients, having a higher yield, better quality, and safe environment. It reduces soil contamination as well as potential adverse effects when conventional mineral fertilizers are applied. Nano urea fertilizers (NU) are more efficient and effective than conventional fertilizers because of their positive effects on the quality and yield of food crops, reduce stresses that occur to the plant, small applied quantities and costs, their fast of absorption by plant cells and penetration of cells and the fats of transport and representation within plant tissue Prakash *et al.*, 2023 and Parameshnaik *et al.*, 2024).

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MATERIALS AND METHODS

Experiment Site

The field experiment was conducted during *Rabi* season of 2021 on research plot of Udai Pratap (Autonomous) College, Varanasi (U.P.) adjoining the Department of Agricultural Chemistry and Soil Science. The soils of Varanasi formed on alluvial, deposited by river Ganga have predominance of illite, quartz and feldspars. Illite minerals are partly inherited from micas which are predominant in the clay and silt fraction.

Experimental Design and Treatment Details

The experiment was conducted under randomized block design (RBD) with six treatments. Treatments were replicated thrice making the total of 18 plots. Treatments were T_1= Control (RDF),T_2 =T_1 + N @ 120 kg ha^1(50% basal) + 30 kg ha^{-1}at CRI+ 30 kg ha^{-1} at PI stage T_3= T_1 + N @ 140 kg ha^{-1} (50% basal) + 35 kg ha^{-1} at CRI+ 35 kg ha^{-1} at PI stage,T_4= T_1 + N @ 120 kg ha^{-1} (50% basal) + 4 ml/L FS at CRI+ 4 ml/L FS at PI Stage,T_5 = T_1 + N @ 120 kg ha^{-1}(50%basal)+ 30k gha^{-1}at CRI+ 4ml/L FS at PI Stage, T_6= T_1+ N @ 140 kg ha^{-1}(50% basal)+35 kg ha^{-1} at CRI+ ml/L FS at PI Stage.

(*RDF= Recommended dose of fertilizer (60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1}).FS = Foliar spray of Nano urea, CRI = Crown root initiation, PI = Panicle Initiation.)

Determination of Soil Properties

Soil pH and EC were determined using soil water suspension (Chopra and Kanwar, 2008). Organic carbon was analysed by Walkely and Blacks' rapid titration method (Walkley and Black, 1934). Available nitrogen, phosphorus, potassium and sulphur were determined by the methods as described by Subbiah and Asija (1956), Olsen (1954), Jackson (1973) and Chesnin and Yien (1950) respectively.

Determination of Nutrients in Plant

Total nitrogen, phosphorus, potassium and sulphur content in plan were determined by using di acid digestion following standard methods.

RESULTS AND DISCUSSION

Growth Attributes

Plant Height

The data presented in table 4 and figure 2 indicates that plant height at 60DAS under various treatments ranged from 49.74 to 74.69 cm. The integrated use of nano and non-nano fertilizers had significantly increased the plant height when compared with without nitrogen application in T_1. Minimum plant height was recorded with T_1 whereas maximum with T_4 (N @ 120 kg ha^{-1} (50% basal) + 4ml/L FS of N.U. at CRI + 4ml/L, FS of N.U. at P.I.). T_4 registered maximum plant height (74.69 cm) at this stage and was found to be significantly superior over all the treatments.

Plant Tillers

It is apparent from the table 5 that the number of tillers under various treatments ranged from 5.33 to 6.32 at 60 DAS. Results clearly indicated that urea as basal application and nano urea applied in the form of foliar spray at different growth stages significantly increased the number of tillers. Maximum increase was registered with T_4 (N@120 kg ha^{-1} (50% basal) +4ml/L FS of N.U.at CRI+4ml/L, FS of N.U. at P.I.) and had significantly higher plant tiller overall the treatments and recorded maximum number of tillers per plant. As indicated by Bahmaniar and Sooaee Mashaee (2010) nitrogen positively affects the plant height. Cells growth increase under nitrogen might be a reason for plant height rise. Several studies indicated that exogenous application of some nano particles can significantly improve plant growth (Mandeh *et al.*, 2012).

Table1: Initial soil properties of experimental soil

S. N.	Parameters	Value
1.	pH	7.40
2.	Electrical conductivity (dS m^{-1})	0.24
3.	Organic carbon (%)	0.40
4.	Available nitrogen (kg ha^{-1})	280
5.	Available phosphorus(kg ha^{-1})	15.33
6.	Available potassium (kg ha^{-1})	175
7.	Available Sulfur (kg ha^1)	10

Nutrients (N, P, K, S) Content and Uptake

Nutrients (N, P, K, S) Content

The effect of various treatments on nitrogen content could be arranged in order of T_4> T_6> T_5> T_3> T_2 and T_1. Among the treatments, the content of N in straw and grain varied from 0.31 to 0.42 % and 0.58% to 1.88 % respectively. It was also noted that effect of T_4 (N @ 120 kg ha^{-1} (50% basal) + 4ml/L FS of N.U.at CRI + 4ml/L, FS of N.U. at P.I.) was found to be significantly superior over all the other treatments.

Maximum phosphorus content in straw was found with the treatment T_4 followed by T_6, T_5, T_3, T_2, and T_1. Similar trend was also recorded in case of phosphorus content in grain was found to be significantly superior over other all the treatments. The content ranged from 0.12% to 0.29 % in straw and grain 0.38 to 0.64%.

The potassium content in straw and grain varied from 0.51to 0.94% and 0.81 to 1.10 % respectively. The effect of various treatments on potassium content in grain and straw could be arranged in order of T_4>T_6> T_5> T_3> T_2 and T_1. . The content of sulphur ranged from 0.13 to 0.18% in straw and grain 0.08 to 1.11%. Maximum sulphur content in straw was found with the treatment T_4.

Table 2: Effect of treatments on plant height at various stages of growth

Treatment	Plant height (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
T_1	19.28	35.87	41.37	49.74
T_2	19.51	36.39	47.68	69.51
T_3	19.79	37.19	48.05	70.71
T_4	29.29	38.01	50.52	74.69
T_5	19.87	37.83	50.17	71.08
T_6	20.04	37.95	50.25	71.22
SEm±	0.167	0.337	0.562	0.804
CD(P=0.05)	0.527	1.064	1.773	2.533

DAS=Days after Sowing

Table 3: Effect of treatments on plant tillers at various stages of growth

Treatment	Number of tillers			
	15 DAS	30 DAS	45 DAS	60 DAS
T_1	2.45	3.42	5.33	2.45
T_2	2.75	3.70	5.99	2.75
T_3	2.80	3.99	6.05	2.80
T_4	3.75	4.32	6.32	3.75
T_5	2.88	4.17	6.17	2.88
T_6	3.18	4.23	6.23	3.18
SEm±	0.072	0.170	0.121	0.072
CD(P=0.05)	0.228	0.548	0.383	0.228

DAS=Days after Sowing

Nutrients (N, P, K and S) Uptake

The effect of various treatments on nitrogen uptake (straw and yield) was found in the order of T_4>T_6> T_5> T_3> T_2 and T_1. Among various treatments, the uptake of N by straw and grain varied from 4.08to 17.48 kg ha^{-1} and 21.10 to 64.54 kg ha^{-1}respectively. The effect of T_4 (N @ 120 kg ha^{-1} (50% basal) + 4ml/L water, FS of N.U. at CRI + 4ml/L, FS of N.U. at P.I. stage) was found to be significant over all the other treatments.

The effect of various treatments on phosphorus uptake could be arranged in the order of T_4>T_6>T_5>T_3>T_2 and T_1. The effect of T_4 was found to be significantly superior over all other treatments. The data ranged from 1.58 to 9.75 kg $ha^{-1}$for straw and from 5.07 to 25.40 kg ha^{-1} for grain. The effect of various treatments on potassium uptake by straw and grain was found in the order of T_4>T_6> T_5> T_3> T_2 and T_1. Among various treatments, the uptake of K by straw and grain varied from 6.75to 34.40 kg ha^{-1} and 10.82 to 38.86 kg ha^{-1}respectively.

Among various treatments, the uptake of sulphur by straw and grain varied from 1.75 to 8.12 kg ha^{-1} and 1.18 to 4.33 kg ha^{-1} respectively. The effect of T_4 was found to be significant over all the other treatments.

Nano-fertilizers are easily absorbed by the epidermis of leaves translocated to stems which facilitated the uptake of active molecules (Abdel-Aziz *et al.*, 2018). Nano fertilizer have large surface area and particle size less than the pore size of leaves of the plant which can increase penetration into the plant tissues from applied surface and improve uptake and nutrient use efficiency and uptake of the nutrients. (Dimkpa *et al.*, 2015 and Qureshi *et al.*, 2018). The foliar application is rapid uptake of nutrients during the fast growing period of crop especially if the soil was deficient in available of soil nutrients (Wojtkowiak *et al.*, 2014 and Al-Juthery and Saadoun, 2018).

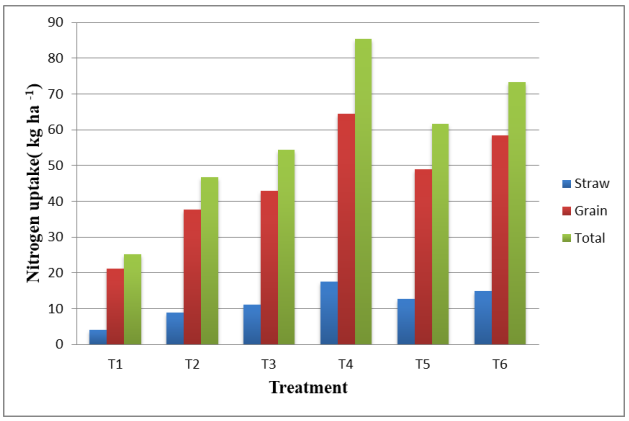

Figure 1: Effect of treatments on N uptake by plant

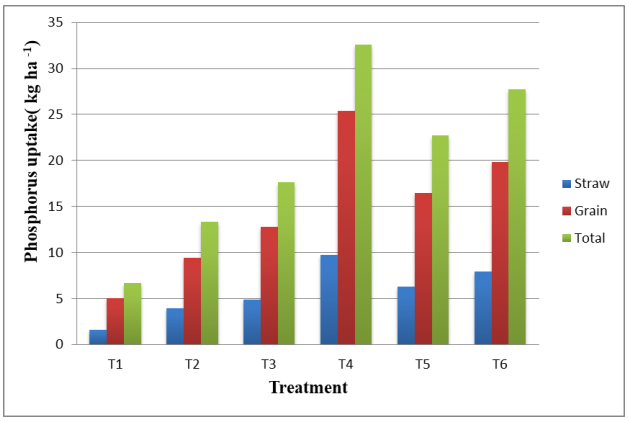

Figure 2: Effect of treatments on P uptake by plant

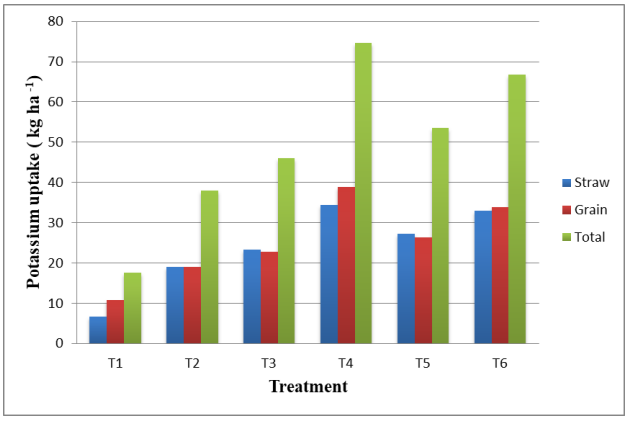

Figure 3: Effect of treatments on K uptake by plant

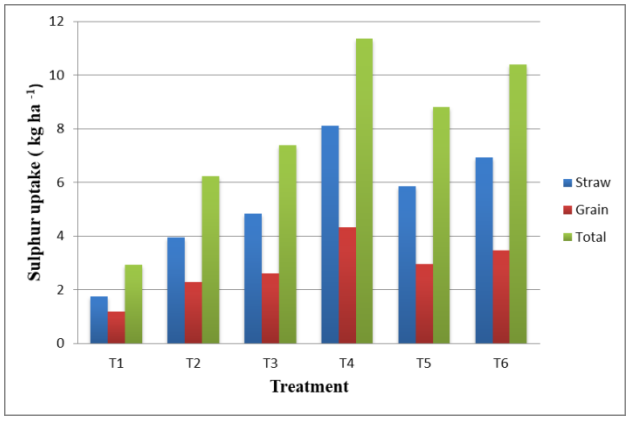

Figure 4: Effect of treatments on S uptake by plant

Table 4: Effect of treatments on nutrients content (%)

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur	
	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain
T_1	0.31	0.58	0.12	0.38	0.51	0.81	0.13	0.08
T_2	0.32	1.64	0.14	0.41	0.68	0.83	0.14	0.10
T_3	0.35	1.72	0.15	0.51	0.74	0.91	0.15	0.105
T_4	0.42	1.88	0.29	0.64	0.94	1.10	0.18	0.112
T_5	0.36	1.78	0.18	0.59	0.78	0.94	0.16	0.107
T_6	0.38	1.83	0.20	0.62	0.84	1.06	0.15	0.108
SEm±	0.010	0.021	0.002	0.004	0.033	0.009	0.003	0.0017
CD (P=0.05)	0.033	0.066	0.008	0.013	0.104	0.030	0.010	0.0052

Table 5: Dry matter yield as affected by different treatments

Treatment	Straw Yield (q ha^{-1})	Grain Yield (q ha^{-1})
T_1	13.36	13.17
T_2	22.99	27.87
T_3	25.02	31.50
T_4	36.09	43.86
T_5	27.88	34.94
T_6	31.84	39.10
SEm ±	1.485	1.453
CD (P=0.05)	4.681	4.581

Dry Matter Yield

Grain Yield

Results clearly indicate that application of nitrogen through urea and nano urea significantly and positively affected the grain yield when compared with no nitrogen. Combined application of urea and nano urea was found significantly superior over only urea application.T_4 (N@120 kg ha^{-1} (50% basal) + 4ml/L FS of N.U. at CRI +4ml/L, FS of N.U. at P.I.) was found to be significantly superior over all the treatments.

Straw Yield

Maximum yield was recorded with T_4 when nano urea was applied at crown root initiation stage and panicle initiation stages @ 4ml/L through foliar spray application combined with urea application as basal. Result of the present study clearly showed that application of nano urea significantly enhanced the dry matter yield (straw + grain) of the wheat crop.

Several studies proved the significance of nano-fertilizers. For instance, gained higher grain yield in rice via applying nano-fertilizer. This is in agreement with the findings of Liu *et al.* (2009) reporting that nano-fertilizer application increased crop yield by 20% - 40%. Benzon *et al.*, (2015) reported synergistic effect of the nano-fertilizers on the efficacy of conventional fertilizer for better nutrient absorption by plant cells resulting to optimal growth plant parts and metabolic process such as

photosynthesis leads to higher photosynthates accumulation and translocation to the economic parts of the plant, thus resulting in high yield which may be attributed to increased source (leaves) and sink (economic part) strength (Taiz and Zeiger, 2006).

CONCLUSION

On the basis of above findings it is concluded that, application of nitrogen through urea and nano urea significantly and positively affected the growth, yield and quality of wheat crop. Soil application of nitrogen @120 kg ha^{-1}(50% as basal) with two foliar sprays at CRI and PI stages of Nano Urea @4ml/L recorded maximum grain, straw yield, nutrient content and uptake. Considering higher recovery of added Nano urea foliar application, this should be promoted among farmers for better results.

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