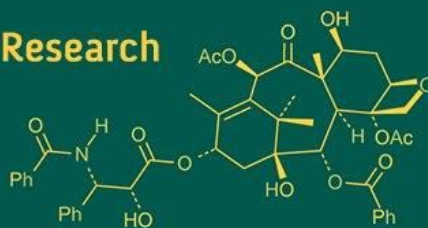


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Effect of nano-urea application on yield, nutrient uptake and quality of *kharif* maize (*Zea mays* L.)

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Abstract

An experiment on "Effect of nano-urea application on yield, nutrient uptake and quality of *kharif* Maize (*Zea mays* L.)" was conducted during *kharif* 2023 at Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule (Maharashtra). Seed of maize hybrid variety NK 6540 was used. The crop was sown at spacing 75 cm × 20 cm on 12 July 2023. The gross and net plot sizes were 7.00 m × 6.00 m 6.20 m × 4.50 m, respectively. The experiment had three replications with eleven treatments was set up in a randomized block design. The grain (66.74 q ha⁻¹) and stover yield (86.66 q ha⁻¹) were significantly more in application of 100% N through urea (T₃) which was statistically at par with application of 75% N through urea+ 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS (T₅) and application of 75% N through urea + 25% N through two foliar sprays of nano urea at 20 and 40 DAS (T₄). The values of N, P and K uptake in grain (105.64 kg ha⁻¹, 23.36 kg ha⁻¹, 54.07 kg ha⁻¹, respectively) and stover (53.18 kg ha⁻¹, 11.86 kg ha⁻¹, 70.29 kg ha⁻¹, respectively) is higher in application of 100% N through urea (T₃) which was statistically at par with application of 75% N through urea+ 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS (T₅) and application of 75% N through urea + 25% N through two foliar sprays of nano urea at 20 and 40 DAS (T₄).

Among the different nutrient management treatments application of 100% N through urea with 60 kg ha⁻¹ P₂O₅ and 40 kg ha⁻¹ K₂O or 75% N through urea+ 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS 60 kg ha⁻¹ P₂O₅ and 40 kg ha⁻¹ K₂O or 75% N through urea + 25% N through two foliar sprays of nano urea at 20 and 40 DAS 60 kg ha⁻¹ P₂O₅ and 40 kg ha⁻¹ K₂O to maize crop exhibited higher grain yield (q ha⁻¹), stover yield (q ha⁻¹), nutrient uptake(kg ha⁻¹) than rest of treatments.

Keywords: Nano-urea, maize, foliar spray, DAS

Introduction

Maize scientifically known as *Zea mays* L., belongs to the Gramineae family (2n=20) and the tribe maydeae, maize is often referred to as a "miracle crop" and the "queen of grains" due to its remarkable productivity holds third position among cereals in India, following wheat and rice. The term "corn" signifies its role in sustaining life, providing essential nutrients for both humans and animals globally. Maize cultivation occurs year-round in all seasons and is practiced worldwide. Its nutritional composition is notable, with approximately 72% starch, 10% protein, 8.5% fiber, 4.8% oil, 3.0% sugar, and 1.7% ash (Elamin and Elagib, 2001) [5]. Maize is an exhaustible crop that demands high nutrition for their growth and development. The productivity of crop depends on nutrient management system. Inorganic fertilizers are most widely used all over world as it gives higher yield and end result is also much appreciable. Efficient use of nitrogen is important for maize production as it increases yield and maximizes economic return and minimizes NO₃ leaching to ground.

Nitrogen (N) occupies a conspicuous place in plant metabolic system. Nitrogen being a major part of plants, and it is an essential constituent of protein and chlorophyll present in many major portions of the plant body. Urea is the most extensively used commercial nitrogen fertilizer for enhancing crop output. Urea accounts for around 82% of overall fertilizer usage in India and approximately 55% of total nitrogen fertilizer consumption worldwide. Plants use around 30- 40% of the nitrogen from urea. The remainder is lost owing to rapid chemical alteration as a result of leaching, volatilization, denitrification, and

run off, resulting in low usage efficiency and also adding to environmental degradation and entering aquatic systems and leading to eutrophication (Navya *et al.*, 2022) [12].

Whereas nano urea has high nitrogen use efficiency and also it is environment friendly. This fertilizer is popularly known as “smart fertilizer” because it cuts down the emission of nitrous oxide which is the prime pollutant of soil and air and also helps in reduction of global warming. These properties make it a promising alternative over conventional urea. (Kanno *et al.*, 2022) [7]. What makes nano urea effective is its tiny size that provides greater surface to mass ratio and hence helps in its targeted delivery of nutrients.

In order to improve the nitrogen-use efficiency by crops, several strategies have been suggested in the past few decades. Nanotechnology denotes to study of particles on the atomic scale for their use and control (Khavesh *et al.*, 2015) [8]. Nanotechnology focuses on creating new compounds by modifying the material. These “nano fertilizers” have high surface area, sorption capacity, and controlled-release kinetics to targeted sites making them an efficient distribution system (Kumar *et al.*, 2021^a) [9].

The greatest alternative to urea fertilizer presently is liquid nano urea. One bottle of nano urea (500 ml) equals one bag of urea (45 kg), which is about 10% less expensive than a bag of regular urea. It has the potential to reduce urea fertilizer imports. One liquid nano urea particle is 30 nanometer in diameter and has 10,000 times the surface area to volume size of regular granular urea (Sahu *et al.*, 2022) [14]. Urea raises soil pH by hydrolysis, resulting in large ammonia volatilization losses. Many fertilizer companies in India developed nanotechnology-based Nano Urea (Liquid) fertilizer to address the imbalanced and excessive use of conventional piled urea (Arya *et al.*, 2022) [1]. Present day's nano fertilizers are emerging as an alternative to conventional fertilizers (Veronica *et al.*, 2014) [16].

Nanotechnology is one possibility for reaching these aims in a long-term and precise manner, and scientists are now researching nano particles for use in plant science and agriculture. In various plants, a range of inorganic, organic, and composite nano materials have been researched to identify their potential effect on plant growth, development, and production. The effect of nano particles on plants is highly reliant on both their intrinsic properties (size, shape, surface area, surface charge, and so on) and their extrinsic nano bio-interactions. (Kumar *et al.*, 2021^b) [10]. In order to solve higher fertilizer requirement during crop growth, and to address environmental issues and also taking economic aspects under consideration, the use of nitrogen nano fertilizer is essential (Sharma *et al.*, 2022) [15].

Materials and Methods

The field experiment was conducted during the *Kharif* season of 2023 at the Agronomic Farm, Agronomy Section, College of Agriculture, Dhule, M.S. (India) during *Kharif* 2023. The Post Graduate Research Farm is located in Northern Maharashtra's Agro-climatic Zone-6, often known as the scarcity zone. It is located at 20.4 °N latitude and 74 °E longitude. The elevation is 258 meters above mean sea level. Climatologically, this area falls in the sub-tropical region at the North. The rainfall is mostly received in 34 to

40 rainy days in a year. The total rainfall of 1041.8 mm was received in 47 days during the experimentation, which was 87.25 per cent of annual rainfall. The experiment had eleven treatment and three replications was set up in a randomized block design. The Eleven treatments included T₁-Absolute control (no fertilizer), T₂-Water spray at 20, 40 and 60 DAS, T₃-100% N through urea, T₄-75% N through urea + 25% N through two foliar sprays of nano urea at 20 and 40 DAS, T₅-75% N through urea+ 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS, T₆-50% N through urea+ 50% N through two foliar sprays of nano urea at 20 and 40 DAS, T₇-50% N through urea+ 50% N through three foliar sprays of nano urea at 20, 40 and 60 DAS, T₈-75% N through urea+ 25% N through three foliar sprays of 2% urea at 20, 40 and 60 DAS, T₉-50% N through urea+ 50% N through three foliar sprays of 2% urea at 20, 40 and 60 DAS, T₁₀-75% N through urea+ 25% N through three foliar sprays of 2 ml/ L nano urea at 20, 40 and 60 DAS, T₁₁-50% N through urea+ 50% N through three foliar sprays of 4 ml/ L nano urea at 20, 40 and 60 DAS. Whereas recommended dose of Phosphorous and Potassium is common to all treatment except T₁. The recommended dose of fertilizer in the form of urea, SSP and MOP were applied as per treatment with recommended of fertilizer dose of 120:60:40 N: P₂O₅: K₂O kg ha⁻¹. The IFFCO nano urea (4% W/V) liquid was used for foliar spray. The crop of hybrid variety NK-6045 was sown at spacing 75 cm x 20 cm.

The topography of the experimental field was uniformly levelled and well drained. The soil of experimental field was clayey in nature. Composite soil sample was collected and analysed for physical and chemical properties. The data of soil analysis revealed that the soil was clay in texture, low in available nitrogen, medium in available phosphorus and very high in available potassium content and moderately alkaline in reaction. The soil was free from any kind of salinity or sodicity hazards.

Grain yield (q ha⁻¹), after harvest cobs were sun dried, and grains removed with the help of hand maize sheller. grain weight per net plot was recorded and calculated as grain yield per hectare. For stover yield (q ha⁻¹) harvested plant were sun dried till they showed constant weight. The weight of stover per net plot was recorded and calculated as stover yield per hectare.

The uptake of nitrogen, phosphorus and potassium by grain and fodder was calculated by multiplying per cent N, P and K in grain and fodder with their respective yields. Total uptake was recorded by summing up the respective uptake by grain and fodder.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content} \times \text{yield}}{100}$$

Protein content (%) in grains of maize was calculated by multiplying nitrogen percentage in grain with the conversion factor 6.25 (A.O.A.C.,1960) [2]. For protein yield (kg ha⁻¹) of maize was calculated by multiplying protein content (%) in grain of maize with the grain yield (kg ha⁻¹) of maize and for the starch content (%) in grains of maize was determined by using standard procedure of Anthrone method.

Table 1: Treatment details

Tr. No.	Treatment Details
T ₁	Absolute control. (No fertilizer)
T ₂	Water spray at 20, 40 and 60 DAS.
T ₃	100% N through urea.
T ₄	75% N through urea + 25% N through two foliar sprays of nano urea at 20 and 40 DAS.
T ₅	75% N through urea+ 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS.
T ₆	50% N through urea+ 50% N through two foliar sprays of nano urea at 20 and 40 DAS.
T ₇	50% N through urea+ 50% N through three foliar sprays of nano urea at 20, 40 and 60 DAS.
T ₈	75% N through urea+ 25% N through three foliar sprays of 2% urea at 20, 40 and 60 DAS.
T ₉	50% N through urea+ 50% N through three foliar sprays of 2% urea at 20, 40 and 60 DAS.
T ₁₀	75% N through urea+ 25% N through three foliar sprays of 2 ml/ L nano urea at 20, 40 and 60 DAS.
T ₁₁	50% N through urea+ 50% N through three foliar sprays of 4 ml/ L nano urea at 20, 40 and 60 DAS.

Note:

1. 500 ml bottle of liquid nano urea is equivalent to 50 kg urea bag.
2. For T₂ no top dressing with urea is done.
3. 10 tonne ha⁻¹ FYM is common to T₂ to T₁₁.

The data collected and analysis of data was carried out by “Analysis of Variance method” (Panse and Sukhatme, 1967) [13]. When the treatment differences were significant standard error (S.E.±) and critical difference (C.D.) were calculated at 5% probability level and when the treatment differences were not significant, only standard error was worked out.

Results and Discussion

The grain yield (66.74 q ha⁻¹) and stover yield (86.66 q ha⁻¹) where application of 100% nitrogen (N) through urea (T₃) was done to maize crop which was at par with treatment application of 75% N through urea + 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS (T₅) with grain yield (64.18 q ha⁻¹) and stover yield (83.43 q ha⁻¹) and treatment 75% N through urea + 25% N through two foliar spray of nano urea at 20 and 40 DAS (T₄) grain yield (63.13 q ha⁻¹) and stover yield (82.76 q ha⁻¹). The lowest grain yield (30.56 q ha⁻¹) and stover yield (39.72 q ha⁻¹) were observed in treatment absolute control (no fertilizers) (T₁).

Nitrogen is a crucial constituent of amino acids, enzymes, genetic materials (DNA-RNA), photosynthetic pigments (chlorophyll) and energy transfer compounds (ATP- ADP) in a plant. Nitrogen is a crucial element found in all plant structures, forming the basis of amino acids that make up plant proteins. It plays a vital role in the growth and development of essential plant tissues and cells, including cell membranes and chlorophyll. Consequently, plants that receive an adequate nitrogen supply exhibit enhanced rates of photosynthesis and demonstrate robust growth and development.

Increase in stover yield with higher dose of fertilization may be due to vigorous and luxuriant growth of maize. An improvement in stover yield with higher levels of nitrogen obtained may be attributed to higher meristematic activity and thus better growth of the plants, resulting ultimately in higher stover yield.

These are in accordance with those reported by Chavan *et al.*, (2023) [14], Meena *et al.*, (2023) [11], Bhukya *et al.*, (2024) [3].

Table 2: Grain yield (q ha⁻¹) and stover yield (q ha⁻¹) of maize as influenced due to different treatments

Tr. No.	Treatment details	Grain yield (q ha ⁻¹)	Stover yield (q ha ⁻¹)
T ₁	Absolute control (no fertilizer)	30.56	39.72
T ₂	Water spray at 20, 40 and 60 DAS.	42.40	55.12
T ₃	100% N through urea	66.74	86.66
T ₄	75% N through urea + 25% N through two foliar sprays of nano urea at 20 and 40 DAS.	63.13	82.76
T ₅	75% N through urea + 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS.	64.18	83.43
T ₆	50% N through urea+ 50% N through two foliar sprays of nano urea at 20 and 40 DAS.	57.22	74.38
T ₇	50% N through urea+ 50% N through three foliar sprays of nano urea at 20, 40 and 60 DAS.	59.56	77.42
T ₈	75% N through urea+ 25% N through three foliar spray of 2% urea.	60.74	78.96
T ₉	50% N through urea+ 50% N through three foliar spray of 2% urea	56.16	73.00
T ₁₀	75% N through urea+ 25% N through three foliar spray of 2 ml/ L nano urea	61.82	80.36
T ₁₁	50% N through urea+ 50% N through three foliar spray of 4 ml/ L nano urea	58.20	75.66
	General mean	56.43	73.35
	SE(m)±	1.36	1.77
	CD at 5%	4.01	5.21

Nutrient content (%)

The treatment receiving an application of 100% nitrogen through urea (T₃) treatment obtained numerically higher value of nitrogen% in grain 1.58% N, 0.35% P and 0.50% K and in stover 0.61% N, 0.14% P and 0.81% K followed by treatment application of 75% N through urea + 25% N through two foliar sprays of nano urea at 20, 40 and 60 DAS

(T₅) with 1.56% N, 0.34% P and 0.49% K in grain and 0.61% N, 0.13% P and 0.80% K in stover and treatment application of 75% N through urea + 25% N through two foliar sprays of nano urea at 20 and 40 DAS (T₄) with 1.55% N, 0.33% P and 0.48% K in grain and 0.60% N, 0.12% P and 0.79% K in stover. These results agree with those reported by Yogendra *et al.*, (2020), Sahu *et al.*, (2021) [14].

Nutrient uptake (kg ha⁻¹)

The treatment application of 100% nitrogen (N) through urea (T₃) recorded significantly higher nitrogen, phosphorus and potassium uptake by grain 105.64 kg ha⁻¹, 23.36 kg ha⁻¹, 54.07 kg ha⁻¹, respectively and stover 53.18 kg ha⁻¹, 11.86 kg ha⁻¹ and 70.29 kg ha⁻¹, respectively than rest of the treatments which was at par with the treatment application of 75% N through urea + 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS (T₅) with nitrogen, phosphorus and potassium uptake by grain 99.60 kg ha⁻¹,

21.82 kg ha⁻¹, 51.27 kg ha⁻¹, respectively and by stover 50.71 kg ha⁻¹, 10.93 kg ha⁻¹ and 66.65 kg ha⁻¹, respectively and treatment application of 75% N through urea + 25% N through two foliar spray of nano urea at 20 and 40 DAS (T₄) with nitrogen, phosphorus and potassium uptake by grain 98.61 kg ha⁻¹, 20.83 kg ha⁻¹ and 50.09 kg ha⁻¹, respectively and by stover 49.49 kg ha⁻¹, 9.85 kg ha⁻¹, 65.12 kg ha⁻¹, respectively.

These results agree with those reported by Yogendra *et al.*, (2020)^[17], Sahu *et al.*, (2021)^[14].

Table 3: Nutrient content (%) and nutrient uptake (kg ha⁻¹) in grain and stover of maize as influenced due to different treatment

Tr. No.	Nitrogen content (%)		Phosphorous content (%)		Potassium content (%)		Nitrogen uptake (kg ha ⁻¹)		Phosphorous uptake (kg ha ⁻¹)		Potassium uptake (kg ha ⁻¹)	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T ₁	1.38	0.50	0.26	0.09	0.41	0.75	42.24	20.26	7.94	3.72	23.00	29.90
T ₂	1.46	0.53	0.27	0.10	0.42	0.73	62.01	29.21	11.45	5.51	30.95	40.23
T ₃	1.58	0.61	0.35	0.14	0.50	0.81	105.64	53.18	23.36	11.86	54.07	70.29
T ₄	1.55	0.60	0.33	0.12	0.48	0.79	98.61	49.49	20.83	9.85	50.09	65.12
T ₅	1.56	0.61	0.34	0.13	0.49	0.80	99.60	50.71	21.82	10.93	51.27	66.65
T ₆	1.52	0.57	0.31	0.11	0.46	0.76	87.16	42.40	17.79	8.48	43.55	56.61
T ₇	1.52	0.59	0.32	0.11	0.47	0.77	90.68	44.67	19.06	8.83	45.79	59.53
T ₈	1.53	0.58	0.32	0.11	0.47	0.78	92.93	45.24	19.44	9.00	47.44	61.68
T ₉	1.47	0.55	0.30	0.10	0.45	0.76	82.64	40.15	16.85	7.30	42.62	55.41
T ₁₀	1.54	0.58	0.31	0.11	0.47	0.78	95.20	46.45	19.27	8.90	48.35	62.85
T ₁₁	1.49	0.56	0.31	0.11	0.46	0.77	86.71	42.37	18.04	8.28	44.67	58.07
GM	1.51	0.57	0.31	0.11	0.47	0.77	85.77	42.19	17.80	8.42	43.80	56.94
S.E(m) ±	0.04	0.03	0.02	0.01	0.02	0.03	3.49	2.18	1.30	0.61	1.89	2.46
CD at 5%	NS	NS	NS	NS	NS	NS	10.30	6.50	3.83	1.81	5.58	7.25

pH (1:25), EC (dSm⁻¹) and OC (%)

The results regarding the pH (1:25), EC (dSm⁻¹) and OC (%) of maize experimental plot are presented in Table 4. The data clearly demonstrates that pH (1:25), EC (dSm⁻¹) and OC (%) shows the non-significant effect. The data in respect of the average pH (1:25), EC (dSm⁻¹) and OC (%) was 7.73, 0.32 dSm⁻¹ and 0.56%, respectively.

Nutrient status of soil (kg ha⁻¹)

The data in respect of available nitrogen, phosphorus and potassium in the soil after harvest of maize as influenced due to different treatments. The mean available nitrogen, phosphorus and potassium after harvest of experimental maize were 150.25 kg ha⁻¹, 30.44 kg ha⁻¹ and 363.72 kg ha⁻¹, respectively.

Available nitrogen (kg ha⁻¹)

The application of water spray at 20, 40 and 60 DAS (T₂)

recorded the significantly higher available nitrogen (173.98 kg ha⁻¹) in soil after harvest of maize and it was at par with treatment 100% N through urea (T₃) with available nitrogen (167.57 kg ha⁻¹) in soil after harvest of maize. The lowest available nitrogen (128.33 kg ha⁻¹) was recorded with the treatment application of 50% N through urea+ 50% N through three foliar sprays of nano urea at 20, 40 and 60 DAS (T₇) treatment.

Available phosphorus (kg ha⁻¹)

The application of water spray at 20, 40 and 60 DAS treatment (T₂) recorded the highest available phosphorus (39.76 kg ha⁻¹) in soil after harvest of maize. It was highly significant and superior over rest of the treatments. The lowest available phosphorus (21.92 kg ha⁻¹) was recorded with the absolute control (no fertilizer) (T₁).

Table 4: pH (1:25), EC (dSm⁻¹), OC (%), Available Nitrogen (kg ha⁻¹), Available Phosphorus (kg ha⁻¹) and Available Potassium (kg ha⁻¹) from the soil of experimental field as influenced by different treatments

Tr. No.	Available nutrients (kg ha ⁻¹)			pH (1:25)	EC (dSm ⁻¹)	OC (%)
	Nitrogen	Phosphorus	Potassium			
T ₁	145.90	21.92	369.69	7.78	0.36	0.53
T ₂	173.98	39.76	394.24	7.76	0.34	0.55
T ₃	167.57	22.55	347.73	7.65	0.30	0.59
T ₄	149.03	29.58	353.13	7.65	0.27	0.58
T ₅	155.07	29.07	352.32	7.63	0.26	0.6
T ₆	136.68	31.14	369.16	7.79	0.33	0.56
T ₇	128.33	31.53	364.93	7.96	0.33	0.6
T ₈	158.44	33.32	359.31	7.77	0.31	0.57
T ₉	143.29	34.76	366.47	7.66	0.32	0.58
T ₁₀	155.93	29.24	356.43	7.64	0.34	0.51
T ₁₁	138.57	31.99	367.49	7.75	0.35	0.54
GM	150.25	30.44	363.72	7.73	0.32	0.56
S.E(m)±	5.03	1.45	2.85	0.07	0.03	0.02
CD at 5%	14.83	4.27	8.42	NS	NS	NS
Initial available	194.6	17.3	395.8	7.73	0.34	0.56

Quality studies

Protein content (%)

In quality investigations, protein content in grain of maize was significantly attributed to different treatments during experimental trial. The significantly higher protein content in grains was found in treatment (T₃) application of 100%

nitrogen (N) through urea (9.89%) which was followed by treatment (T₅) application of 75% N through urea + 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS (9.75%) and treatment (T₄) application of 75% N through urea + 25% N through two foliar sprays of nano urea at 20 and 40 DAS (9.69%).

Table 5: Protein content (%), protein yield (kg ha⁻¹) and starch content (%) of maize as influenced due to different treatments

Tr. No.	Protein content (%)	Protein yield (kg ha ⁻¹)	Starch content (%)
T ₁	8.64	263.99	63.36
T ₂	9.14	387.58	65.46
T ₃	9.89	660.28	74.75
T ₄	9.69	611.54	73.28
T ₅	9.75	625.72	74.26
T ₆	9.52	544.75	69.58
T ₇	9.52	566.78	70.46
T ₈	9.56	580.79	71.56
T ₉	9.19	516.52	67.39
T ₁₀	9.63	594.99	72.14
T ₁₁	9.29	541.94	68.61
GM	9.44	535.90	70.08
S.E(m)±	0.24	21.82	2.49
CD at 5%	NS	64.38	NS

Protein yield (kg ha⁻¹)

In quality investigations, protein yield of maize was significantly attributed to different treatments during experimental trial. The significantly higher protein yield was found in treatment (T₃) application of 100% nitrogen (N) through urea (660.28 kg ha⁻¹) which was at par with treatment (T₅) application of 75% N through urea + 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS (625.72 kg ha⁻¹) and treatment (T₄) application of 75% N through urea + 25% N through two foliar spray of nano urea at 20 and 40 DAS (611.54 kg ha⁻¹).

Starch content (%)

Starch content in grain of maize was significantly attributed to different treatments during experimental trial. The content in grains was found higher in treatment (T₃) application of 100% nitrogen (N) through urea (74.75%) which was followed by treatment (T₅) application of 75% N through urea + 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS (74.26%) and treatment (T₄) application of 75% N through urea + 25% N through two foliar spray of nano urea at 20 and 40 DAS (73.28%).

These results are accordance with Horvat *et. al.*, (2022) [6], Bhukya *et. al.*, (2024) [3].

Conclusion

Application of 100 per cent N through urea with 60 kg ha⁻¹ P₂O₅ and 40 kg ha⁻¹ K₂O recorded significantly higher value uptake of nutrients N, P and K (kg ha⁻¹) and protein yield (kg ha⁻¹) it was at par with treatment application of 75% N through urea + 25% N through three foliar sprays of nano urea at 20, 40 and 60 DAS with 60 kg ha⁻¹ P₂O₅ and 40 kg ha⁻¹ K₂O and treatment application of 75% N through urea + 25% N through two foliar spray of nano urea at 20 and 40 DAS with 60 kg ha⁻¹ P₂O₅ and 40 kg ha⁻¹ K₂O.

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