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Effect of nano urea and spacing on growth and yield of maize article type

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Abstract
A maize field experiment was carried out at Crop Research Farm, Department of Agronomy, during the 2023 *kharif* season. The treatment consisted of 3 levels of N i.e. 120 kg N through urea, 30 kg of N through urea along with 4 ml/lit 2 sprays of Nano urea and 60 kg of N through along with 4 ml/lit 3 sprays of Nano urea and 3 methods of spacing (30x15 cm2, 30x20 cm^2 and 30x45 cm^2) along with recommended control (120-60-40 N-P-K kg/ha). The soil of the field, which is part of the central gangetic alluvium, is neutral and deep. The experimental field's soil had a sandy loam texture, was virtually neutral in soil reaction (pH - 7.7), contained 0.57% organic carbon, available N (171.48 kg/ha), available P (27.0 kg/ha), and available K (291.2 kg/ha). The experiment was laid out in a Randomized Block Design, with 10 treatments, and replicated three times. 60 kg of N through urea along with 4 ml/lit 3 sprays of Nano urea + Spacing- 30x20 cm2 (treatment 8) recorded maximum highest plant height (185.27 cm), plant dry weight (90.53 g), Number of cobs per plant (2.20), Number of grains per cob(434.13), Cob length (19.43 cm), Grain yield (4.20 t/ha), Stover yield (6.91 t/ha). The aforesaid treatment also recorded maximum gross returns (1,01,574.00 INR/ha), net returns (65,646.84 INR/ha) and B:C ratio (1.83).

Keywords: Growth, *kharif*, maize, nano urea, spacing, yield

Introduction
Maize is renowned as the "Queen of cereals" because it has the highest genetic production potential of all cereals. It comes in third place among cereals in India, after wheat and rice. Corn is defined as "to sustain life" and offers nutrients to humans and animals all around the planet. It is planted throughout the year in all seasons and grown all over the world. (*Zea mays* L.), or maize, is the scientific name for the most frequently grown food crop in the world. It supplies enough calories and protein to feed one billion plus people worldwide. The nutritional value of maize is high as it contains 72% starch, 10% protein, 8.5% fiber, 4.8% oil, 3.0% sugar and 1.7% ash. Comparatively maize gives more yield than the other cereals such as rice, wheat etc. India uses it as a fodder crop and as one of its staple foods. Maize is also used to extract gluten, starch, and cooking oil. In addition to being fermented and distilled to create grain alcohol, the starch in maize can also be hydrolysed and subjected to enzymatic treatment to create syrups, especially high fructose corn syrup and used as a sweetener. Rathore *et al*. 2022 [11].
Nano urea is environmentally friendly and has a high nitrogen use efficiency. This fertilizer is sometimes referred to as "smart fertilizer" since it lowers emissions of nitrous oxide, which is mostly to blame for contaminating soil, air, and water bodies. It also contributes to a decrease in global warming. At the present time, the greatest substitute for urea fertilizer is liquid nano fertilizer. A bag of urea fertilizer (45 kg) is equal to one bottle of nano urea (500 ml), which is 10% less than a bag of traditional urea. It has the potential to reduce fertilizer imports of urea. An individual nano urea liquid particle has a diameter of 30 nanometres and a surface area to volume ratio 10,000 times greater than that of a typical granular urea particle. Compared to conventional urea, foliar application of nano urea liquid at crucial crop growth phases of a plant effectively satisfies its nitrogen requirement and results in improved crop productivity and quality. Sahu *et al*. 2022 [12].

Therefore, there is potential to increase maize productivity using a variety of agronomic techniques. The traditional basis for spacing is the anticipated growth of a particular crop in a particular agroclimatic condition and the identification of factors that govern the crop's growth, development, and yield. Agronomic practices, particularly the spacing between rows, have a major impact on yield since they are ultimately linked to plant population, root formation, growth, and fruiting Devi *et al.* 1995 [2]. There is a complex link between yield and spacing. Maintaining an optimal plant population is essential to maximizing the use of natural resources including nutrients, sunlight, and soil moisture as well as to guarantee maximum economic grain yield for each area used for production. It has a significant impact on maize output and growth, which results in the timely initiation of vegetative and reproductive development. The way that maize reacts to plant density varies. Luque *et al.* 2006 [8].

Materials and Methods

At the Department of Agronomy, Crop Research Farm, SHUATS, Prayagraj (U.P.), the experiment was carried out in the *kharif* season of 2023. Deep and neutral soil makes up the field that is a portion of the central gangetic alluvium. Almost neutral in soil response (pH - 7.7), with organic carbon (0.57%), available N (171.48 kg/ha), available P (27.0 kg/ha), and available K (291.2 kg/ha), the soil in the experimental field had a sandy loam texture. The treatment consists of T_1: 120 kg N through urea + Spacing- 30x15 cm2, T_2:120 kg N through urea + Spacing- 30x20 cm2, T_3: 120 kg N through urea + Spacing- 30x45 cm2, T_4: 30 kg of N through urea along with 4 ml/lit 2 sprays of nano urea + Spacing- 30x15 cm2, T_5: 30 kg of N through urea along with 4 ml/lit 2 sprays of nano urea + Spacing- 30x20 cm2, T_6: 30 kg of N through urea along with 4 ml/lit 2 sprays of nano urea + Spacing- 30x45 cm2, T_7: 60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + Spacing- 30x15 cm2, T_8: 60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + Spacing- 30x20 cm2, T_9: 60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + Spacing- 30x45 cm2, T_{10}: Control (RDF 120-60- 40 NPK kg/ha) With three replications of each treatment, the experiment was set up using a randomized block design. Plant height (cm) and plant dry weight (g) were the physical measurements that were recorded. No. ofcorns per plant, Corn yield (t/ha). Hybrid maize was sown manually at about 5 cm depthin furrow with the spacing according to the treatments with seed rate of 20-25 kg/ha. Sowing is done on 12th August, 2023. Maize, variety (Hybrid maize) were selected for sowing.

Seeds are sowed with spacing as per treatment along with recommended spacing i.e. 60x20 cm2. The basal application of urea is done at the time of sowing where as the foliar application of nano urea is done at 30, 45, 60 Days after sowing respectively. Nano urea formulations are often developed to improve nutrient uptake efficiency. By enhancing the availability and uptake of nutrients, including nitrogen, nano urea has the potential to promote plant growth reported by Kumar *et al.* (2022) [12]. The analysis of variance method was used to examine data on many aspects of the crop, such as growth, yield attributes, and yield. Statistical analysis was done by Gomez and Gomez (1976) [3].

Result and discussion growth parameters

The data revealed that significantly higher plant height (185.27 cm) was recorded with application of 60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + spacing 30x20 cm2. However, treatment (T9) and treatment (T8) were found to be statistically at par with the highest. Application of Nano urea (4 ml/l) resulted in significantly higher plant height; this could be because increasing the dose of Nano urea increases cell division, cell metabolism, and cell growth. Similar result was reported by Singh *et al.* (2019).

Significantly highest plant dry weight (90.53 g) was recorded with application of 60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + spacing 30x20 cm2. However, treatment (T9) was found to be statistically at par with highest. Nano urea has been suggested to enhance various physiological processes in plants, such as photosynthesis, nutrient uptake, and enzymatic activities. These improvements in plant physiology can contribute to better growth and development, potentially leading to increased plant height Srivastava *et al*. (2023) [14].

Yield parameters

Treatment-8 (60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + spacing30x20 cm2) was recorded significantly higher number of cobs per plant (2.20). But it was discovered that, statistically speaking, treatment T9 was comparable to the best. Nano urea has the potential to enhance photosynthetic efficiency in plants. Improved photosynthesis can lead to increased carbohydrate production, which is essential for reproductive development and the formation of cobs Raliya *et al.* (2017) [10].

Treatment-8 (60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + spacing 30x20 cm2) was recorded significantly higher number of grains per cob (434.13). However, treatment T7 and T9 was found to be statistically at par with the highest. Nitrogen availability influences the allocation of carbohydrates within the plant. Adequate nitrogen supply ensures an optimal supply of assimilates to developing grains. Nitrogen deficiency can lead to resource limitations and reduced carbohydrate availability for grain filling.

In contrast, optimal nitrogen levels facilitate carbohydrate transport and accumulation in developing grains, promoting the formation of a higher number of grains per cob reported by Worku *et al.* (2000) [15].

Treatment-8 (60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + spacing 30x20 cm2) was recorded significantly higher cob length (19.43 cm). However, treatment T7 and T9 was found to be statistically at par with the highest. The increased yield qualities resulting from higher amounts of nitrogen and more irrigations may be the reason of an increase in cob length. Similar findings were reported by Mukhtar *et al.* (2012) [9].

Treatment-8 (60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + spacing 30x20 cm2) grain yield (4.20 t/ha) was noted to be significantly higher. However, treatment T9 (4.12 t/ha) and T7 (4.01 t/ha) was found to be statistically at par with the highest. Theincrease in grain yield might be due to the favourable influence of nitrogen in increasingthe source size and establishing an appropriated source to sink relationship, respectively. Similar findings were observed by Srivastava *et al.* (2023) [14].

Treatment-8 (60 kg of N through urea along with 4 ml/lit 3 sprays of nano urea + spacing 30x20 cm2) was recorded significantly higher stover yield (6.91 t/ha). However, treatment T9 and T7 was found to be statistically at par with the highest. Nano urea formulations are often developed to improve nutrient uptake efficiency. Through improving the accessibility and assimilation of nutrients, including nitrogen, nano urea has the potential to promote plant growth, including stover biomass production reported by Kumar *et al.* (2022) [12].

Table 1: Influence of nano urea and spacing on growth attributes maize at 80 DAS.

	Treatment Combinations	Plant height (cm)	Plant dry weight (g)
1.	120 kg N through urea + Spacing- 30x15 cm2	171.57	77.74
2.	120 kg N through urea + Spacing- 30x20 cm2	176.70	74.63
3.	120 kg N through urea + Spacing- 30x45 cm2	175.03	81.65
4.	30 kg of N through urea, 4 ml/lit 2 sprays of nano urea + Spacing- 30x15 cm2	174.27	83.14
5.	30 kg of N through urea, 4 ml/lit 2 sprays of nano urea + Spacing- 30x20 cm2	176.73	82.31
6.	30 kg of N through urea, 4 ml/lit 2 sprays of nano urea + Spacing- 30x45 cm2	178.17	82.74
7.	60 kg of N through urea, 4 ml/lit 3 sprays of nano urea + Spacing- 30x15 cm2	181.43	86.40
8.	60 kg of N through urea, 4 ml/lit 3 sprays of nano urea + Spacing- 30x20 cm2	185.27	90.53
9.	60 kg of N through urea, 4 ml/lit 3 sprays of nano urea + Spacing- 30x45 cm2	181.90	88.10
10.	Control (RDF)	157.17	72.50
	S.Em(±)	4.60	2.49
	CD (p=0.05)	13.67	7.41

Table 2: Influence of nano urea and spacing on yield attributes at harvest of maize.

	Treatment Combinations	No. of cobs /plant	No. of grains/ cob	Cob length (cm)	Grain yield (t/ha)	Stover yield (t/ha)
1.	120 kg N through urea + Spacing- 30x15 cm2	1.80	324.40	17.20	3.40	5.93
2.	120 kg N through urea + Spacing- 30x20 cm2	1.80	321.87	17.03	3.48	5.91
3.	120 kg N through urea + Spacing- 30x45 cm2	1.53	329.86	17.06	3.55	6.18
4.	30 kg of N through urea, 4 ml/lit 2 sprays of nano urea + Spacing- 30x15 cm2	1.47	335.93	16.80	3.73	6.47
5.	30 kg of N through urea, 4 ml/lit 2 sprays of nano urea + Spacing- 30x20 cm2	1.67	338.53	16.80	3.82	6.41
6.	30 kg of N through urea, 4 ml/lit 2 sprays of nano urea + Spacing- 30x45 cm2	1.47	372.27	18.06	3.92	6.59
7.	60 kg of N through urea, 4 ml/lit 3 sprays of nano urea + Spacing- 30x15 cm2	1.73	420.13	19.07	4.01	6.61
8.	60 kg of N through urea, 4 ml/lit 3 sprays of nano urea + Spacing- 30x20 cm2	2.20	434.13	19.43	4.20	6.91
9.	60 kg of N through urea, 4 ml/lit 3 sprays of nano urea + Spacing- 30x45 cm2	1.83	417.80	18.53	4.12	6.78
10.	Control (RDF)	1.73	301.33	15.17	3.11	5.55
	S.Em(±)	0.13	10.98	0.63	0.13	0.12
	CD (p=0.05)	0.40	32.63	1.87	0.38	0.36

Conclusion

It can be concluded that application of 60 kg of N through urea along with 4 ml/lit at 3 intervals of spray through nano urea along with Spacing- 30x20 cm2 as performed better in growth and yield attributes.

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