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Determining Effect of Different Levels of Nitrogen in Combination with Nano Urea on Quality Parameters, Seed Parameters, Available Nitrogen in Soil and Nitrogen Content in Leaves of Marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda

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Authors' contributions

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

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Original Research Article

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ABSTRACT

An experiment was conducted in the Rabi season of 2021– 2022 at the College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University. T4 (50% N + Nano Urea @ 2ml/l; 2 sprays at 25 DAT and 50 DAT) was the treatment that recorded the maximum shelf life (3.59 days), 100 seed weight (0.34 g), seed yield per flower (0.82 g), and benefit cost ratio (1.95) among the treatments. T3 recorded the minimum shelf life (2.50 days), while T6 (Nano Urea) recorded the minimum 100 seed weight (0.20 g), seed yield per flower (0.43 g), and benefit cost ratio (1.26).

Maximum available nitrogen (286.73 kg ha-1) was found in T1 treatment (100% RDF) and T6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) recorded minimum available nitrogen (218.36 kg ha-1). However, T7 (Nano Urea @ 4 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) recorded highest germination percentage (86.7%) and maximum nitrogen content in leaves (1.81%), while T2 treatment recorded minimum germination percentage (82.6%) and T1 treatment (100% RDF) recorded minimum nitrogen content in leaves (1.55%).

Keywords: Marigold; pusa narangi gainda; nano urea.

1. INTRODUCTION

"One significant annual flower used for commerce is the marigold (*Tagetes erecta* L.), which is a member of the Asteraceae family. It is indigenous to South and Central America, particularly Mexico. The genus Tagetes contains about 33 species; the most often grown species are Tagetes erecta, Tagetes patula and Tagetes minuta. Of these, farmers frequently cultivate *Tagetes erecta* on a big scale for commercial use" [1].

Due to its easy cultivation, vast range of appealing colours, shapes, and sizes, as well as its good keeping quality, marigolds have become more and more popular among gardeners and flower merchants [2].

Often referred to as the "versatile crop with golden harvest," marigold has many uses.

Marigold is commonly used as a colour and to construct garlands and decorate avenues. Marigold's enormous potential for value addition is causing it to attain industrial prominence. Marigold is used to make a wide range of value-added goods, including meals, food colouring, and essential oil pigments [3].

The conventional urea usage causes environmental pollution, eutrophication, leaching and volatilization losses compared to nano urea [4].

Nanotechnology is a recently emerged and intriguing scientific discipline that offers opportunities for advanced study across various domains, including biotechnology and agriculture. Nanotechnology is making it possible to use materials with nanoscale nanostructures such vectors of controlled release or carriers of fertiliser for the construction of so-called "smart fertiliser," a new facility to improve nutrient usage efficiency and lower environmental protection costs [5].

The next frontier of nanotechnology for sustainable agriculture is fertilisers the size of nanoparticles. While drastically reducing the amount of agricultural chemicals that leach into the soil, the nano urea manufacturing process offers a straightforward means of creating nanoscale material for improved crop productivity. The nitrogen particles in nano urea (liquid) are larger than those in 1 mm urea prill, with a surface area of 10,000 times and a particle count of 55,000 above 1 mm urea prill. Moreover, the use of liquid nano urea enhances biomass, yield, soil health, and produce's nutritional value. The advantages of nano urea over traditional urea are numerous. It decreases the need for conventional urea by at least 50%, uses less, and yields more: One 500 ml bottle of nano urea has the same effectiveness.

2. MATERIALS AND METHODS

At Sri Konda Laxman Telangana State Horticultural University's College of Horticulture, Rajendranagar, during the Rabi season of 2021–2022, the current study was carried out. Healthy seed was transferred from the raised bed into the main field after a month, with the plants spaced 40 cm apart from one another.

Every one of the seven treatments was replicated three times using a Randomised Block Design.

3. RESULTS AND DISCUSSION

3.1 Quality Parameters

The results of the experiment and the effects of different nitrogen concentrations in combination with nano urea on the quality of marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda are displayed in Table 1.

3.1.1 Shelf life (days)

The treatment with the longest shelf life (3.59 days) in marigold was T4 (50% N + Nano Urea @ 2 ml/l; 2 sprays at 25 DAT and 50 DAT). The product with the lowest shelf life was T3 (75% N + Nano Urea @ 2 ml/l; 3 sprays at 25 DAT, 50 DAT, and 75 DAT) (2.50 days).

3.1.2 Colour intensity

Using Southern Peony Royal Horticulture Society (RHS) colour matching chart the colour of flowers for all the treatments were observed.

3.2 Seed Parameters

Table 2 presents the experiment's findings and the impact of varying nitrogen levels in conjunction with nano urea on the quality of marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda.

3.2.1 100 seed weight (g)

The maximal 100 seed weight (0.34 g) was recorded by treatment T4 (50% N + Nano Urea @ 2 ml/l) (2 sprays at 25 DAT and 50 DAT). On the other hand, treatment T6 (Nano Urea @ 2ml/l; 3 sprays at 25 DAT, 50 DAT, and 75 DAT) (0.20 g) significantly recorded a minimum of 100 seed weight. Nitrogen may have contributed to the greatest 100 seed weight in treatment T4 (50% N + Nano Urea @ 2ml/l; 2 sprays at 25 DAT and 50 DAT), enhancing protein synthesis and producing bolder, healthier seeds. These findings closely match those of Saman and Kirad [6] in Calendula, Awchar et al. [7] in Calendula and Swaroop et al. (2007) in Marigold.

3.2.2 Seed germination (%)

T7 (Nano Urea @ 4 ml/l (3 sprays at 25 DAT, 50 DAT, and 75 DAT) had the greatest germination rate of all the treatments, at 86.7%. This was similar to T4 (50% N + Nano Urea @ 2 ml/l (2 sprays) at 85.5% and T1 (100% RDF) at 84.6%. The lowest minimum germination, on the other hand, was observed in T2 (75% N + Nano Urea @ 2ml/l; 2 sprays at 25 DAT and 50 DAT) (82.6%). This was similar to T3 (75% N + Nano Urea @ 2ml/l; 3 sprays at 25 DAT, 50 DAT, and 75 DAT) (83.5%), T5 (50% N + Nano Urea @ 2ml/l; 3 sprays at 25 DAT, 50 DAT, and 75 DAT) (84.2%), and T6 (Nano Urea @ 2 ml/l; 3 sprays at 25 DAT, 50 DAT, and 75 DAT) (84.4%).

Table 1. Effect of different levels of nitrogen in combination with nano urea on quality parameters of marigold Cv. Pusa Narangi Gainda

Treatments	Shelf life (days)	Colour intensity
T1: Control 100% RDF (90 kg N -75 kg P2O5-75 kg K2O ha^{-1})	3.36^{b}	Orange group 24 A
T2: 75% N + Nano Urea @ 2ml/l (2 sprays)	2.56^{de}	Orange group 24 B
T3: 75% N + Nano Urea @ 2ml/l (3 sprays)	2.50^{e}	Orange group 25 B
T4: 50% N + Nano Urea @ 2ml/l (2 sprays)	3.59^{a}	Orange group 24 A
T5: 50% N + Nano Urea @ 2ml/l (3 sprays)	3.11^{c}	Orange group 25 A
T6: Nano Urea @ 2 ml/l (3 sprays)	2.51^{de}	Orange group 25 B
T7: Nano Urea @ 4 ml/l (3 sprays)	2.72^{d}	Orange group 24 A
SE m±	0.07	
CD @ 5 %	0.21	

Table 2. Effect of different levels of nitrogen in combination with nano urea on seed parameters of marigold Cv. Pusa Narangi Gainda

Treatments	100 seed weight (g)	Seed germination (%)	Seed yield flower^{-1} (g)
T1: Control 100% RDF (90 kg N -75 kg P2O5-75 kg K2O ha^{-1})	0.27^{b}	84.6^{ab}	0.61^{b}
T2: 75% N + Nano Urea @ 2ml/l (2 sprays)	0.23^{e}	82.6^{b}	0.51^{cd}
T3: 75% N + Nano Urea @ 2ml/l (3 sprays)	0.25^{c}	83.5^{b}	0.52^{c}
T4: 50% N + Nano Urea @ 2ml/l (2 sprays)	0.34^{a}	85.5^{ab}	0.82^{a}
T5: 50% N + Nano Urea @ 2ml/l (3 sprays)	0.24^{d}	84.2^{b}	0.53^{bc}
T6: Nano Urea @ 2 ml/l (3 sprays)	0.20^{g}	84.4^{b}	0.43^{d}
T7: Nano Urea @ 4 ml/l (3 sprays)	0.22^{f}	86.7^{a}	0.47^{cd}
SE m±	0.03	0.68	0.23
CD @ 5 %	0.01	2.12	0.08

3.2.3 Seed yield flower-1 (g)

Treatment T4 (50% N + Nano Urea @ 2ml/l) produced a noticeably higher maximum seed yield flower-1 (0.82 g) after two sprays at 25 and 50 days after the treatment. In contrast, minimum seed yield

T6 (Nano Urea @ 2ml/l; 3 sprays at 25 DAT, 50 DAT, and 75 DAT) produced flower-1, which was 0.43 g. This was comparable to T7 (Nano Urea @ 4ml/l; 3 sprays at 25 DAT, 50 DAT, and 75 DAT) (0.47 g) and T2 (75% N + Nano Urea @ 2ml/l; 2 sprays at 25 DAT and 50 DAT) (0.51 g). Because nano urea has a larger surface area than traditional urea, it can more readily penetrate plant tissues. The findings suggest that the treatment T4 (50% N + Nano Urea @ 2 ml/l; two sprays at 25 DAT and 50 DAT) improved seed yield flower-1. These outcomes were similar to

those of previous studies conducted on African marigold by Shinde et al. [8] and on China aster by Chavan et al. [9].

3.3 Available Nitrogen in Soil (kg ha-1)

Table 3 shows the impact of varying nitrogen levels combined with nano urea on soil nitrogen availability.

Treatment T1 (100% RDF) had the significantly highest nitrogen availability (286.73 kg ha-1) and was judged to be better than all other treatments. Treatment T6 (Nano Urea @ 2 ml/l; 3 sprays at 25 DAT, 50 DAT, and 75 DAT) had the lowest amount of accessible nitrogen (218.36 kg ha-1); treatment T7 (Nano Urea @ 4 ml/l; 3 sprays at 25 DAT, 50 DAT, and 75 DAT) had a similar amount (226.24 kg ha-1). Higher rates of nitrogen input to the soil in the form of urea may be the cause of treatment T1's (100% RDF) higher accessible nitrogen content [10].

3.4 Nitrogen Content in Leaves (%)

Table 3 displays the results of the nitrogen content (%) in leaves.

T7 (Nano Urea @ 4 ml/l (3 sprays at 25 DAT, 50 DAT, and 75 DAT) had the highest nitrogen content (1.81%), which was comparable to T6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT, and 75 DAT) (1.78%). T1 (100% RDF) had a noticeably lower minimum nitrogen concentration (1.55%). The highest nitrogen content ever observed may have resulted from the huge surface area of nano urea and the fact that particles smaller than leaf pores allowed the nano urea to enter the plant and enhance nitrogen uptake.

3.5 Economics

Table 4 displays the information regarding the economics of producing marigold Cv. Pusa Narangi Gainda at varying nitrogen levels in conjunction with nano urea.

The treatment T4 (50% N + Nano Urea @ 2 ml/l; 2 sprays at 25 DAT and 50 DAT) had the highest benefit-to-cost ratio (1.95). Among the three sprays at 25 DAT, 50 DAT, and 75 DAT, T6 (Nano Urea @ 2 ml/l) had the lowest benefit-to-cost ratio (1.26). The T4 therapy (50% N + Nano Urea @ 2 ml/l; 2 sprays at 25 DAT and 50 DAT) provided the highest gross return, as the data unambiguously demonstrates. The treatment's greater floral output per acre than the other treatments could be the source of this.

Table 3. Effect of different levels of nitrogen in combination with nano urea on available nitrogen in soil and nitrogen content in leaves of marigold Cv. Pusa Narangi Gainda

Treatments	Available nitrogen (Kg ha^{-1})	Nitrogen content in leaves (%)
T1: Control 100% RDF (90 kg N -75 kg P2O5-75 kg K2O ha^{-1})	286.73^{a}	1.55^{f}
T2: 75% N + Nano Urea @ 2ml/l (2 sprays)	251.40^{bc}	1.65^{e}
T3: 75% N + Nano Urea @ 2ml/l (3 sprays)	255.27^{b}	1.66^{d}
T4: 50% N + Nano Urea @ 2ml/l (2 sprays)	242.97^{c}	1.70^{c}
T5: 50% N + Nano Urea @ 2ml/l (3 sprays)	246.80^{bc}	1.73^{b}
T6: Nano Urea @ 2 ml/l (3 sprays)	218.36^{d}	1.78^{ab}
T7: Nano Urea @ 4 ml/l (3 sprays)	226.24^{d}	1.81^{a}
SE m±	2.79	0.015
CD @ 5 %	8.61	0.05

Table 4. Effect of different levels of nitrogen in combination with nano urea on economics of cultivation of marigold Cv. Pusa Narangi Gainda

Treatments	Cost of cultivation (₹/ha)	Net income (₹/ha)	B:C Ratio
T1: Control 100% RDF (90 kg N -75 kg P2O5-75 kg K2O ha^{-1})	113013	214000	1.89
T2: 75% N + Nano Urea @ 2ml/l (2 sprays)	113323	172000	1.51
T3: 75% N + Nano Urea @ 2ml/l (3 sprays)	113713	182400	1.60
T4: 50% N + Nano Urea @ 2ml/l (2 sprays)	113173	221000	1.95
T5: 50% N + Nano Urea @ 2ml/l (3 sprays)	113613	210000	1.84
T6: Nano Urea @ 2 ml/l (3 sprays)	111470	141000	1.26
T7: Nano Urea @ 4 ml/l (3 sprays)	112790	168000	1.48

4. CONCLUSION

According to the results of the current study, marigold Cv. Pusa Narangi Gainda's nitrogen content, seed characteristics, and flower quality are significantly impacted by nano urea. The treatment T4 (50% N + Nano Urea @ 2ml/l; 2 sprays, 25 DAT and 50 DAT) shown a positive effect on quality parameters and on metrics related to seed quality when compared to other treatments.

5. FUTURE SCOPE

The future line of work may be carried out in following lines. Effect of nano urea in combination with nano micronutrients, effect of nano urea in combination with nano phosphorous and nano potassium and effect of nano urea on F1 hybrids need to be conducted.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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