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M Venkatesh
Department of Floriculture and Landscape Architecture, College of Horticulture, SKLTSHU, Telangana, India

K Kaladhar Babu
Assistant Professor, Selection Grade, College of Horticulture, SKLTSHU, Telangana, India

P Prasanth
Senior Scientist (Hort.) and Head of Floricultural Research Station, ARI, SKLTSHU, Telangana, India

D Lakshminarayana
Associate Dean, College of Horticulture, SKLTSHU, Telangana, India

S Praneeth Kumar
Scientist, Floricultural Research Station, ARI, SKLTSHU, Telangana, India

Corresponding Author:
M Venkatesh
Department of Floriculture and Landscape Architecture, College of Horticulture, SKLTSHU, Telangana, India

Study on effect of different levels of nitrogen in combination with nano urea on growth and yield of marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda

M Venkatesh, K Kaladhar Babu, P Prasanth, D Lakshminarayana and S Praneeth Kumar

Abstract
The experiment entitled "Study on effect of different levels of nitrogen in combination with nano urea on growth and yield of marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda" was conducted during the *Rabi* season of the year 2021-2022 at College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University. Among the treatments, the treatment T4 (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded maximum plant height (71.33 cm), plant spread in North- South direction (49.67 cm), plant spread in East-West direction (50.67 cm), number of branches plant-1 (9.26), leaf area (14.80 cm2), individual flower weight (9.17 g), flower diameter (5.69 cm), number of flowers plant-1 (29.01), flower yield plant-1 (220 g), flower yield plot-1 (4.42 kg) flower yield hectare-1 (11.05 t), whereas minimum number of days taken to first flower bud initiation (32.8 days), number of days taken to 50 percent flowering (46.73 days), number of days taken to full bloom (49.73 days) and maximum duration of flowering (45.74 days) was recorded by T1 treatment (100% RDF). However, T6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT, 75 DAT) recorded minimum in all the parameters.

Keywords: Nano urea, marigold, Pusa Narangi Gainda

Introduction
Marigold (*Tagetes erecta* L.) is an important commercial annual flower belonging to the family Asteraceae. It is a native of Central and South America especially Mexico. The genus *Tagetes* comprises about 33 species, of which the commonly cultivated species are *Tagetes erecta, Tagetes patula* and *Tagetes minuta.* Amongst these, *Tagetes erecta* is commonly grown by the farmers on large scale for commercial purpose.

Marigold gained popularity amongst gardeners and flower dealers on account of its easy culture and wide spectrum of attractive colours, shape, size and good keeping quality (Chandrikapure *et al*., 1999) [2].

The uses of marigold are many folds, often referred to as the 'versatile crop with golden harvest'. Marigold is extensively used for making garlands, beautification of avenues and other purposes *i.e*., pigment and oil extraction and therapeutic uses. Roots of marigold plants are known to suppress nematode population and hence used as a trap crop in nematode infested fields. Apart from these uses, it is highly suitable for bedding purpose, herbaceous border and newly planted shrubberies to provide colour and fill the space (Yadav *et al.*, 2015) [10].

Nano urea has manifold benefits over conventional urea, reduces the requirement of conventional urea by 50 percent or more, required less and produces more: efficacy of one bottle of nano urea (500 ml) is equivalent to one bag of urea, environment friendly produce, improve soil, air and water quality thus, helps in reducing the global warming, it is cheaper than conventional urea and reduce input cost to farmers, leads to increase in farmer's income. (Prem Babu, 2021) [6]

Materials and Methods
The present investigation entitled "Study on effect of different levels of nitrogen in combination with nano urea on growth and yield of marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda" was carried out during the *Rabi* season of the year 2021-2022 at College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University. Healthy seed was planted on the raised bed and transplanted in main field at a spacing of 40 cm x 30 cm after one month.

The design adopted was Randomized Block Design with seven treatments replicated thrice. Treatments included T_1- Control 100% RDF (90:75:75 kg NPK ha^{-1}), T_2- 75% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT), T_3- 75% N + Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT), T_4- 50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT), T_5- 50% N + Nano Urea @ 2ml /l (3 sprays at 25 DAT, 50 DAT and 75 DAT), T_6- Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) and T_7- Nano Urea
@ 4 ml/l (3 sprays at 25 DAT, 50 DAT, 75 DAT). Nano urea sprayed on the foliage at 3 intervals *i.e*., @ 25, 50 and 75 Days After Transplanting (DAT) and the observations recorded were plant height (cm), plant spread N-S (cm), plant spread E-W (cm), number of branches plant-1 and leaf area (cm2) at 40, 65 and 90 days after transplanting, number of days taken to first flower bud initiation, number of days taken to 50 percent flowering (days), flower weight (g), flower diameter (cm), days taken to full bloom (days), number of flowers $plant^{-1}$, duration of flowering, flower yield $plant^{-1}$ (g), flower yield $plot^{-1}$ (Kg) and flower yield $hectare^{-1}$ (t) were recorded and the data was statistically analysed.

Results and Discussion Growth parameters

The effect of different levels of nitrogen in combination with nano urea on growth of marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda and the results of the experiment were presented in Table 1 to 4.

Plant height (cm)

With respect to plant height in marigold, treatment T4 (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded maximum plant height 46.37 cm, 60.40 cm and 71.33 cm at 40, 65 and 90 days after transplanting respectively. Whereas T6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT, 75 DAT) recorded minimum plant height 30.40 cm, 50.97 cm and 56.17 cm at 40, 65 and 90 days after transplanting respectively. It is might be due to nitrogen which acts as an essential part in the biosynthesis of nucleic acids hence, it plays a vital role in promoting the plant growth. The increase in vegetative growth was due to greater uptake of nitrogen due to the application of nano urea which was finally involved in the cell division, cell elongation as well as protein synthesis which ultimately enhanced the stem length and vegetative growth. The results were comparable with findings of Karavadia and Dhaduk (2002) [3] in annual chrysanthemum, Shinde *et al*. (2014) [7] in marigold.

Plant spread North – South (cm)

Among the treatments, T_4 (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded highest plant spread in North – South direction 27.60 cm, 46.93 cm and 49.67 cm at 40, 65 and 90 days after transplanting respectively. Whereas T_6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT, 75 DAT) recorded lowest plant spread in North – South direction 23.93 cm, 35.60 cm and 37.00 cm at 40, 65 and 90 days after transplanting respectively.

Plant spread East – West (cm)

Among the treatments, T4 (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded highest plant spread in North – South direction 31.10 cm, 49.10 cm and 50.67 cm at 40, 65 and 90 days after transplanting respectively. Whereas T_6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT, 75 DAT) recorded lowest plant spread in North – South direction
24.00 cm, 35.47 cm and 38.00 cm at 40, 65 and 90 days after transplanting respectively. According to the findings reported by Mishra (2012) [5], Maheta (2015) [4] in china aster and Abhipsa (2018) [1] in marigold. The increase in plant spread may be attributed due to association of nitrogen in the synthesis of protoplasm and primarily in the formation of amino acids and increase in auxin activities due to nitrogen fertilization. Through nano urea nitrogen helps in synthesis of proteins and increases the cell division and cell enlargement which results in the increased growth of plant.

Number of branches per plant

The treatment T4 (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded highest number of branches plant-1 (9.26). Whereas T6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT, 75 DAT) recorded lowest number of branches $plant^{-1}$ (5.90). The increase in the number of branches may be due to the significant quality of nitrogen supplied which have resulted in stimulation of the production and export of cytokinin to the shoots (Wagner and Michael, 1971) [9].

Leaf area (cm2)

Among the treatments, T4 (50% N + Nano Urea @ 2 ml/l (2 sprays 25 DAT and 50 DAT) recorded significantly highest leaf area (14.80 cm2), whereas lowest leaf area was recorded in T6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT, 75 DAT) (9.92 cm^2). When nano urea sprayed on leaves, it easily enters through stomata and other openings. Nitrogen supply promotes leaf elongation and expansion growth by regulating the rate of cell division or cell size. The findings were in line with Vos *et al*. (2005) [8] in Maize.

Table 1: Effect of different levels of nitrogen in combination with nano urea on different growth stages of plant height (cm) of marigold Cv. Pusa Narangi Gainda

Treatments	40 DAT	65 DAT	90 DAT
T_1: Control 100% RDF (90 kg N -75 kg P2O5-75 kg K2O ha-1)	38.27b	58.97ab	69.00a
T_2: 75% N + Nano Urea @ 2 ml/l (2 sprays)	36.93b	55.90b	62.30c
T_3: 75% N + Nano Urea @ 2 ml/l (3 sprays)	38.52b	56.53ab	62.33bc
T_4: 50% N + Nano Urea @ 2 ml/l (2 sprays)	46.37a	60.40a	71.33a
T_5: 50% N + Nano Urea @ 2 ml/l (3 sprays)	37.07b	56.30b	65.67b
T_6: Nano Urea @ 2 ml/l (3 sprays)	30.40c	50.97c	56.17d
T_7: Nano Urea @ 4 ml/l (3 sprays)	33.20b	52.47c	57.33d
SE m±	2.54	0.91	1.01
CD @ 5%	7.84	2.82	3.26

Table 2: Effect of different levels of nitrogen in combination with nano urea on different growth stages of plant spread in North- South (cm) of marigold Cv. Pusa Narangi Gainda

Treatments	40 DAT	65 DAT	90 DAT
T_1: Control 100% RDF (90 kg N -75 kg P2O5-75 kg K2O ha-1)	27.20	45.60b	49.33a
T_2: 75% N + Nano Urea @ 2 ml/l (2 sprays)	26.67	43.07cd	46.67b
T_3: 75% N + Nano Urea @ 2 ml/l (3 sprays)	25.87	45.27b	49.00a
T_4: 50% N + Nano Urea @ 2 ml/l (2 sprays)	27.60	46.93a	49.67a
T_5: 50% N + Nano Urea @ 2 ml/l (3 sprays)	27.13	44.00c	48.33a
T_6: Nano Urea @ 2 ml/l (3 sprays)	23.93	35.60e	37.00d
T_7: Nano Urea @ 4 ml/l (3 sprays)	25.67	42.53d	45.33c
SE m±	1.38	0.35	2.25
CD @ 5%	NS	1.19	6.94

Table 3: Effect of different levels of nitrogen in combination with nano urea on different growth stages of plant spread in East –West (cm) of marigold Cv. Pusa Narangi Gainda

Treatments	40 DAT	65 DAT	90 DAT
T_1: Control 100% RDF (90 kg N -75 kg P2O5-75 kg K2O ha-1)	29.97ab	48.53a	49.31ab
T_2: 75% N + Nano Urea @ 2 ml/l (2 sprays)	27.40ab	44.13c	45.67b
T_3: 75% N + Nano Urea @ 2 ml/l (3 sprays)	28.33ab	45.13bc	47.00ab
T_4: 50% N + Nano Urea @ 2 ml/l (2 sprays)	31.10a	49.10a	50.67a
T_5: 50% N + Nano Urea @ 2 ml/l (3 sprays)	28.00ab	46.27b	49.33ab
T_6: Nano Urea @ 2 ml/l (3 sprays)	24.00b	35.47d	38.00c
T_7: Nano Urea @ 4 ml/l (3 sprays)	26.73b	44.07c	44.67b
SE m±	1.29	2.47	1.27
CD @ 5%	3.97	7.62	3.92

Table 4: Effect of different levels of nitrogen in combination with nano urea on number of branches plant-1 and leaf area (cm2) of marigold Cv. Pusa Narangi Gainda

Treatments	Number of Branches per Plant	Leaf area (cm2)
T_1: Control 100% RDF (90 kg N -75 kg P2O5-75 kg K2O ha-1)	8.67b	12.06d
T_2: 75% N + Nano Urea @ 2 ml/l (2 sprays)	7.24e	12.87b
T_3: 75% N + Nano Urea @ 2 ml/l (3 sprays)	7.53d	12.50c
T_4: 50% N + Nano Urea @ 2 ml/l (2 sprays)	9.26a	14.80a
T_5: 50% N + Nano Urea @ 2 ml/l (3 sprays)	8.12c	12.20cd
T_6: Nano Urea @ 2 ml/l (3 sprays)	5.90g	9.92e
T_7: Nano Urea @ 4 ml/l (3 sprays)	6.43f	10.03e
SE m±	1.82	0.74
CD @ 5%	0.59	0.30

Yield parameters

The effect of different levels of nitrogen in combination with nano urea on yield of marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda and the results of the experiment were presented in Table 5.

Number of days taken to first flower bud initiation (days)

Minimum number of days taken to first flower bud initiation (32.8 days) was recorded in T_1 (100% RDF). Whereas T_7 (Nano Urea @ 4 ml/l (3 sprays at 25 DAT, 50 DAT, 75 DAT) recorded significantly maximum number of days taken to first flower bud initiation (35.73 days). The early flower bud appearance can be attributed to the reason that subtle increase in nutrition dose for better plant growth resulting in early supply of photosynthates facilitates early opening of bud.

Number of days taken to 50 percent flowering (days)

T_1 (100% RDF) recorded minimum number of days taken to 50 percent flowering (46.73 days). Whereas the maximum number of days taken to 50 percent flowering was recorded in T_7 (Nano Urea @ 4 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) (58.67 days). The variation might be due to better translocation of photosynthates from source to sink. The present findings are comparable with Maheta (2015) [4] in China aster, Abhipsa (2018) [1] in marigold and Mali (2013) [11] in chrysanthemum.

Flower weight (g)

Among the treatments, T4 treatment (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded significantly highest individual flower weight (9.17 g). While T_1 (100% RDF) recorded significantly lowest individual flower weight (6.96 g). The increase in flower weight might be due to translocation of food reserves from vegetative parts to reproductive parts.

Flower diameter (cm)

The treatment T_4 (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded significantly maximum flower diameter (5.69 cm), whereas the minimum flower diameter was recorded in T_6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) (4.78 cm). The increase in flower diameter due to the nitrogen level might have accelerated photosynthetic activity by increasing the size, thereby providing flowers with more photosynthates, which might have resulted in increased cell division and cell expansion thereby increased flower size in terms of flower diameter. The present findings of flower diameter are in close

affirmative with observations recorded by Tosar (1989) [12], Patil (2001) [13], Sharma (2002) [14] in gaillardia.

Number of days taken to full bloom (days)
Among all the treatments, T_1 (100% RDF) recorded significantly minimum number of days taken to full bloom (49.73 days). While the significantly maximum number of days taken to full bloom was recorded in T_7 (Nano Urea @ 4 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) (62.33 days). Minimum number of days taken to full bloom might be due to the fact that, nitrogen stimulates growth and thereby delayed initiation of flowering.

Number of flowers plant-1
Among the treatments, T_4 treatment (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded maximum number of flowers plant^{-1} (29.01). While the significantly minimum number of flowers plant^{-1} was recorded in T_6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) (20.47). Maximum number of flowers plant^{-1} was due to the fact that the crop plants in these treatments experienced good vegetative growth right from early stages of growth period due to higher absorption of nitrogen which might have resulted in higher photosynthetic activity and higher number of flowers plant^{-1}. Similar kind of observation reported by Shalini and Patil (2006) [15] in gerbera and Kori and Patil (2003) [16] in gladiolus.

Duration of flowering (days)
It was observed that, T_1 treatment (100% RDF) recorded maximum duration of flowering (45.74 days), While the minimum duration of flowering was recorded significantly in T_7 (Nano Urea @ 4 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) (33.68 days).

Flower yield plant-1(g)
Among the treatments, T_4 treatment (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded significantly highest flower yield plant^{-1} (220 g), While significantly lowest flower yield plant^{-1} was recorded in T_6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) (141.15 g). Maximum flower yield plant^{-1} might be due to increased number of branches, spread of plant, and environmental conditions.

Flower yield plot-1(Kg)
It was noticed that, T4 treatment (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) recorded significantly highest flower yield plot^{-1} (4.42 kg). Whereas, significantly lowest flower yield plot^{-1} was recorded in T6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) (2.82 kg). The maximum flower yield plot^{-1} might be due to the increase in photosynthate rate.

Flower yield hectare-1(t)
The highest flower yield hectare^{-1} was recorded significantly in T4 treatment (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT) (11.05 t). On the other hand, the minimum flower yield hectare-1 was recorded significantly in T6 (Nano Urea @ 2 ml/l (3 sprays at 25 DAT, 50 DAT and 75 DAT) (7.05 t). The significant variation in the yield of flowers hectare^{-1} found in treatments might be due to the number of flowers, weight of the flowers plant^{-1}, weight of the flowers plot^{-1}. Thus, abundant supply of nitrogen enhanced the photosynthetic activity of plants; ultimately increasing the carbohydrates assimilates which leads to acceleration in flower yield. The present findings are close affirmative with Hugar and Nalawadi (1998) [17], Patil *et al*. (2001) [13] and Sharma (2002) [14] in gaillardia and Shafiullah *et al*. (2018) [18] in marigold.

Table 5: Effect of different levels of nitrogen in combination with nano urea on yield parameters of marigold Cv. Pusa Narangi Gainda

Treatments	Days taken to bud initiation	days taken to 50% flowering	Flower weight	Flower diameter	days taken to full bloom	Number of flowers Plant-1	Duration of flowering	Flower yield plant-1	Flower yield plot-1	Flower yield ha-1
T1: Control 100% RDF (90 kg N -75 kg P2O5-75 kg K2O ha-1)	32.80a	46.73a	6.96e	5.16bc	49.73a	28.98a	45.74a	214.00b	4.28b	10.70b
T2: 75% N + Nano Urea @ 2 ml/l (2 sprays)	33.47b	50.27b	7.05de	4.98c	51.80b	26.67b	43.82a	172.41d	3.44e	8.60c
T3: 75% N + Nano Urea @ 2 ml/l (3 sprays)	33.27b	53.13c	7.25d	5.06bc	53.20c	27.10b	34.67b	182.92c	3.65d	9.12c
T4: 50% N + Nano Urea @ 2 ml/l (2 sprays)	34.47c	47.40a	9.17a	5.69a	51.13b	29.01a	44.50a	220.00a	4.42a	11.05a
T5: 50% N + Nano Urea @ 2 ml/l (3 sprays)	34.67c	51.20b	8.06b	5.11bc	57.60d	28.60a	34.50b	210.00b	4.20c	10.51b
T6: Nano Urea @ 2 ml/l (3 sprays)	34.87c	57.27d	7.51cd	4.78c	60.00e	20.47d	34.20b	141.15e	2.82g	7.05d
T7: Nano Urea @ 4 ml/l (3 sprays)	35.73d	58.67d	7.55cd	4.93c	62.33f	23.73c	33.68b	168.21d	3.36f	8.40c
SE m±	0.35	0.60	0.53	0.42	0.28	4.52	0.84	1.48	0.01	0.34
CD @ 5%	0.40	1.85	0.17	0.14	0.87	1.46	2.61	4.46	0.02	1.02

Conclusion
From the present study it can be concluded that nano urea significantly influences the growth, yield and quality of marigold Cv. Pusa Narangi Gainda.
The treatment T4 (50% N + Nano Urea @ 2 ml/l (2 sprays 25 DAT and 50 DAT) showed positive effect on growth, yield and quality parameters as compared to other treatments.

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.

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Conflict of interest: None

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