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B Sahithi
M.Sc. Scholar, Department of Floriculture and Landscape Architecture, Sri Konda Laxman Telangana State Horticultural University, College of Horticulture, Mojerla, Wanaparthy, Telangana, India

Dr. K Kaladhar Babu
Assistant Professor (Hort.) (Selection Grade), Department of Floriculture and Landscape Architecture, SKLTSHU University, College of Horticulture, Rajendranagar, Hyderabad, Telangana, India

Dr. P Prasanth
Associate Dean, Department of Floriculture and Landscape Architecture, SKLTSHU-University, College of Horticulture Rajendranagar, Hyderabad, Telangana, India

Dr. D Lakshminarayana
Principal Scientist (Hort.) and Head, Department of Floriculture and Landscape Architecture, SKLTSHU University, College of Horticulture, Rajendranagar, Hyderabad, Telangana, India

Dr. P Gouthami
Assistant Professor, Department of Crop Physiology, SKLTSHU University, College of Horticulture, Mojerla, Wanaparthy, Telangana, India

Corresponding Author:
B Sahithi
M.Sc. Scholar, Department of Floriculture and Landscape Architecture, Sri Konda Laxman Telangana State Horticultural University, College of Horticulture, Mojerla, Wanaparthy, Telangana, India

Studies on effect of nano urea and nano dap alone and in combination with different levels of nitrogen and phosphorus on growth and yield of marigold (*Tagetes erecta* L.) Cv. superball

B Sahithi, Dr. K Kaladhar Babu, Dr. P Prasanth, Dr. D Lakshminarayana and Dr. P Gouthami

Abstract
The experiment entitled "Studies on effect of nano urea and nano DAP alone and in combination with different levels of nitrogen and phosphorus on growth and yield of marigold (*Tagetes erecta* L.) Cv. Super ball" was carried out during the *rabi* season of the year 2022-2023 at PG Research block. College of Horticulture, Mojerla, Sri Konda Laxman Telangana State Horticultural University. Among the treatments, the treatment T_6 (50% N + 50% P_2O_5 + Nano Urea @ 3ml/l + Nano DAP @ 5ml /l (2 sprays at 30 DAT, 45 DAT) recorded maximum plant height (69.34cm), plant spread in East-West direction (50.72cm), plant spread in North -South direction (47.96 cm), number of branches per plant (10.0), leaf area (13.40 cm^2), number of flowers $plant^{-1}$ (32.13), flower diameter (6.82cm), flower fresh weight (12.23g), flower yield $plant^{-1}$ (230.67g), flower yield $plot^{-1}$ (4.61kg), flower yield $hectare^{-1}$ (11.46 t). whereas minimum number of days to first flower bud initiation (32.20 days), 50% flowering (44.60 days), number of days to full bloom (51.20 days) and, highest leaf chlorophyll content (54.21) recorded in T_1 (100% RDF). However T_2 -75% N + Nano Urea @ 2ml/l (2 sprays at 30 DAT and 45 DAT), recorded minimum in all the parameters.

Keywords: Nano urea, nano DAP, marigold. Super ball

Introduction
African marigold is an important commercial flower crop of India that belongs to the family Asteraceae. Marigold is a native of Central and South America especially Mexico. It is also called as 'Gainda' in the Hindi language. The genus Tagetes contain around 33 species of African marigold (*Tagetes erecta* L., 2n = 24) and French marigold (*Tagetes patula* L., 2n = 48) (Rydberg, 1915) [15].

Marigold is commonly used for garlands, avenue beautification, pigment and oil extraction, and therapeutic purposes. Aside from these uses, it is perfect for adding color and filling gaps in beds, herbaceous borders, and newly planted shrubberies. (Yadav *et al*., 2015) [23].

Marigold has long been regarded for its multipurpose properties, such as flower extract, which is thought to be a blood purifier and a remedy for bleeding piles and ulcers. It is also used effectively in dye fabrics, where its ethanol-based floral extracts produce a variety of colors on clothes. (Vankar *et al*., 2009) [20].

The 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 helping to reduce global warming, it is cheaper than conventional urea and reduces input cost to farmers, leading to an increase in farmer's income. (Baboo 2021) [5]

Nitrogen (8.0% N w/v) and Phosphorus (16.0% P_2O_5 w/v) are incorporated in the Nano DAP formulation, making it a high-quality source of bioavailable nitrogen (N) and phosphorus (P_2O_5) for all crops. Nano DAP (Liquid) has a greater surface area to volume ratio since its particle size is fewer than 100 nanometres (nm). Because of this uncommon feature, it has easy access to the seed surface as well as stomata and other plant openings. Biopolymers and other excipients are used to functionalize the nano nitrogen and phosphorus clusters in Nano DAP. Better Nano DAP dispersion and assimilation within the plant system results in higher seed vigour, chlorophyll content, photosynthetic efficiency, and seed quality. (https://www.iffco.in/en/nano-dap-liquid) [9].

Materials and Methods

The current investigation is titled "Studies on effect of nano urea and nano DAP alone and in combination with different levels of nitrogen and phosphorus on growth and yield of marigold (*Tagetes erecta* L.) Cv. Super ball" was carried out during the rabi season of the year 2022-2023 at PG Research block. College of Horticulture, Mojerla, Sri Konda Laxman Telangana State Horticultural University. After one month, healthy seedlings were transplanted into the main field at a 40 cm x 30 cm spacing. The design used was a Randomized Block Design with seven treatments reproduced three times. Treatments included T_1 - 100% RDF, T_2 -75% N + Nano Urea @ 2ml/l (2 sprays at 30 DAT and 45 DAT), T_3 - 50% N + Nano Urea @ 3ml/l (2 sprays at 30 DAT, 45 DAT), T_4 -75% N +75%P_2O_5 + Nano DAP @ 2ml/l (2 sprays at 30 DAT and 45 DAT), T_5 -75% N + 50% P_2O_5+ Nano DAP @ 5ml /l (2sprays at 30 DAT, 45 DAT), T_6 - 50% N + 50% P_2O_5 + Nano Urea @ 3ml/l + Nano DAP @ 5ml /l (2sprays at 30 DAT, 45 DAT), T_7 - Nano Urea @3ml/l + Nano DAP @5ml/l (3 sprays at 30 DAT, 45 DAT, 60 DAT). Nano urea and Nano DAP sprayed on the foliage at 3 intervals i.e., @ 30, 45 and 60 Days After Transplanting (DAT) and the observations recorded were plant height (cm), plant spread E-W (cm), plant spread N-S (cm), number of branches plant^{1} and leaf area (cm^2), Leaf chlorophyll content at 40, 55 and 70 days after transplanting, number of days taken to first flower bud initiation, number of days taken to 50% flowering (days),number of days taken to full bloom (days), number of flowers plant^{-1} flower fresh weight (g), flower diameter (cm), 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

Tables 1 to 6 show the effect of nano urea and nano DAP alone and in combination with different levels of nitrogen and phosphorus on the growth of marigold (*Tagetes erecta* L.) Cv. Super ball.

Plant height (cm)

In terms of plant height in marigold, treatment T_6 50% N+50% P_2O_5 +Nano urea @3ml/l + Nano DAP @5ml/l (2 sprays at 30 DAT and 45 DAT) achieved maximum plant heights of 46.50 cm, 58.76 cm, and 69.34 cm at 40, 55 and 70 days after transplanting, respectively. T_2 75% N + Nano Urea @ 2ml/l (2 sprays at 30 DAT and 45 DAT) achieved minimum plant heights of 31.12 cm, 45.92 cm, and 54.82 cm at 40, 55 and 70 days after transplanting, respectively. The application of Nano urea may result in increased enzymatic activity, which may lead to the synthesis and transportation of photosynthetic material, resulting in an increase in plant height. (Midde *et al.*, 2021) [11]. Phosphorus also contributes significantly to a number of other biological functions, such as the upkeep of membrane structures, the production of high-energy molecules through biomolecule synthesis, cell division, the activation and inactivation of enzymes, and the metabolism of carbohydrates, which promotes plant growth. (Razaq *et al*. 2017) [14]. Comparable outcomes were seen with those of Dutta *et al*. (2022) [7] in potato and Sahu (2023) [16] in rice and wheat.

Plant spread East-West direction (cm)

Among the treatments, T6 50% N+50% P_2O_5+Nano urea @ 3 ml/l + Nano DAP @ 5 ml/l (2 sprays at 30 DAT and 45 DAT) measured maximum plant spreads of 31.42 cm, 48.26 cm, and 50.72 cm after 40, 55 and 70 days following transplanting, respectively. However, minimal plant spreads of 23.34 cm, 37.62 cm, and 39.80 cm were obtained at 40, 55 and 70 days after transplanting, respectively, under T_2 75% N + Nano Urea @ 2ml/l (2 sprays at 30 DAT and 45 DAT).

Plant spread north-south direction (cm)

The treatment T_6 50% N+50% P_2O_5+Nano urea @3ml/l + Nano DAP @ 5 ml/l (2 sprays at 30 DAT and 45 DAT) recorded maximum plant spread 27.34 cm, 46.15 cm, 47.96 cm at 40,55 and 70 days after transplanting respectively. On the other hand, T_2 75% N + Nano Urea @ 2 ml/l (2 sprays at 30 DAT and 45 DAT) had the lowest plant spreads of 21.02 cm, 36.47 cm, and 37.74 cm at 40, 55 and 70 days following transplanting, respectively.

was caused by nitrogen's involvement in protoplasmic synthesis, particularly in the synthesis of amino acids, and by nitrogen fertilization's increased activation of auxin. The plant grows more as a result of the nano urea nitrogen's assistance in protein synthesis, higher cell division, and enlarged cells. Additionally, phosphorus accelerates the growth of early shoots and healthy roots, as well as ground cover, to prevent erosion. The findings closely align with the results obtained from Rathod *et al*. (2022) [13] in French basil and Ahirwar *et al*. (2012) [1] in marigold.

Number of branches plant $^{-1}$

T_6 50% N+50% P_2O_5+Nano urea @3ml/l + Nano DAP @ 5 ml/l (2 sprays at 30 DAT and 45 DAT) recorded maximum number of branches plant^{-1} 6.26, 8.46, 10.0 at 40, 55 and 70 days after transplanting respectively. Whereas T_2 75% N + Nano Urea @ 2 ml/l (2 sprays at 30 DAT and 45 DAT) recorded in minimum number of branches plant $^{-1}$ 4.26, 5.20, 6.06 at 40, 55 and 70 days after transplanting respectively. may be attributed due to the higher levels of cytokinin in plants resulted by the application of nitrogen and nano form, and encouraged the lateral buds to sprout, generating a bigger number of branches. In addition Nano DAP increases leaf chlorophyll content, photosynthetic rate, root biomass, and the quantity of skilled tillers and branches. The outcomes were in line with the findings of Kumar *et al*. (2023) [10] in cauliflower and tomato.

Leaf area (cm^2)

The treatment T_6 50% N+50% P_2O_5+Nano urea @3ml/l + Nano DAP @ 5 ml/l (2 sprays at 30 DAT and 45 DAT) recorded maximum leaf area ($cm^{2)}$ 7.03 cm^2, 9.34 cm^2, 13.40 cm^2 at 40,55 and 70 days after transplanting respectively. While the T_2 75% N + Nano Urea @ 2ml/l (2 sprays at 30 DAT and 45 DAT) recorded in minimum leaf area (cm^2) 5.16 cm^2, 7.34 cm^2, 9.75 cm^2at 40, 55 and 70 days after transplanting respectively. When applied topically to leaves, nano urea readily penetrates via stomata and other apertures, promoting the growth and elongation of the leaf by controlling the rate of cell division or size. (Venkatesh *et al*. 2022) [22]. through the processes of cell division and enlargement, phosphorus affects plant growth from the

cellular to the whole plant level, increasing leaf area. (Assuero *et al*. 2004) [4]. The results were consistent with Shawa *et al*. (2022) [8] in philodendron and Juthery *et al*. (2020) [3] in wheat.

Leaf chlorophyll content (SPAD meter reading)

Among the treatments T_1 (100% RDF) recorded maximum leaf chlorophyll content 35.63, 47.92, 54.21 at 40, 55 and 70 days after transplanting respectively. Whereas T_7 (Nano Urea @ 3 ml/l + Nano DAP @ 5 ml/l (3 Sprays at 30, 45, and 60 DAT) had the lowest leaf chlorophyll content, which was measured at 24.52, 37.89, and 43.21 at 40, 55 and 70 days following transplanting, respectively. Because nitrogen is a crucial component of the chlorophyll molecule, the concentration of nitrate available to a plant directly effects chlorophyll biosynthesis and chloroplast development. The results are in close affirmative with the findings of Juthery *et al*. (2020) [23] in potato.

Table 1: Effect of Nano urea and Nano DAP alone and in combination with different levels of nitrogen and phosphorus on plant height (cm) in marigold Cv. Super ball.

Treatments	Plant height (cm)		
	40 DAT	55 DAT	70 DAT
T_1: Control 100% RDF (90 kg N -75 kg P_2O_5 -75 kg K_2O ha^{-1})	44.57^{ab}	56.89^{ab}	65.86^{b}
T_2: 75% N+ Nano Urea @ 2 ml/l (2 Sprays)	31.12^{c}	45.92^{c}	54.82^{e}
T_3: 50% N+ Nano Urea @ 3 ml/l (2 Sprays)	32.32^{bc}	47.94^{bc}	57.70^{de}
T_4: 75% N+ 75% P_2O_5 + Nano DAP @ 2 ml/l (2 Sprays)	34.39^{bc}	49.84^{b}	58.83^{d}
T_5: 75% N+ 75% P_2O_5 + Nano DAP @ 5 ml/l (2 Sprays)	38.08^{b}	55.02^{ab}	62.84^{c}
T_6: 50% N+ 50% P_2O_5 + Nano Urea @ 3 ml/l + Nano DAP @ 5ml/l (2Sprays)	46.50^{a}	58.76^{a}	69.34^{a}
T_7: Nano Urea @ 3 ml/l + Nano DAP @ 5ml/ l (3 Sprays)	44.21^{ab}	57.16^{ab}	68.20^{ab}
SE m±	1.36	0.82	0.41
CD @ 5%	4.24	2.57	1.30

Table 2: Effect of Nano urea and Nano DAP alone and in combination with different levels of nitrogen and phosphorus on plant spread East – West (cm) in marigold Cv. Super ball.

Treatments	Plant spread E-W (cm)		
	40 DAT	55 DAT	70 DAT
T_1: Control 100% RDF (90 kg N -75 kg P_2O_5 -75 kg K_2O ha^{-1}	30.48^{ab}	46.86^{ab}	48.08^{bc}
T_2: 75% N+ Nano Urea @ 2 ml/l (2 Sprays)	23.34^{e}	37.62^{b}	39.80^{d}
T_3: 50% N+ Nano Urea @ 3 ml/l (2 Sprays)	24.28^{d}	38.52^{ab}	43.49^{c}
T_4: 75% N+ 75% P_2O_5 + Nano DAP @ 2 ml/l (2 Sprays)	27.66^{cd}	42.21^{ab}	47.20^{bc}
T_5: 75% N+ 75% P_2O_5 + Nano DAP @ 5 ml/l (2 Sprays)	28.04^{c}	45.81^{ab}	47.62^{bc}
T_6: 50% N+ 50% P_2O_5 + Nano Urea @ 3 ml/l + Nano DAP @ 5ml/l (2Sprays)	31.42^{a}	48.26^{a}	50.72^{a}
T_7: Nano Urea @ 3 ml/l + Nano DAP @ 5ml/ l (3 Sprays)	29.30^{b}	47.04^{ab}	48.80^{b}
SE m±	0.34	1.24	0.37
CD @ 5%	1.07	3.86	1.15

Table 3: Effect of Nano urea and Nano DAP alone and in combination with different levels of nitrogen and phosphorus on plant spread North - South (cm) in marigold Cv. Super ball.

Treatments	Plant spread N-S (cm)		
	40 DAT	55 DAT	70 DAT
T_1: Control 100% RDF (90 kg N -75 kg P_2O_5 -75 kg K_2O ha^{-1}	26.80^{ab}	43.23^{c}	45.77^{bc}
T_2: 75% N+ Nano Urea @ 2 ml/l (2 Sprays)	21.02^{c}	36.47^{f}	37.74^{e}
T_3: 50% N+ Nano Urea @ 3 ml/l (2 Sprays)	22.25^{b}	38.79^{e}	41.28^{d}
T_4: 75% N+ 75% P_2O_5 + Nano DAP @ 2 ml/l (2 Sprays)	25.79^{ab}	41.71^{d}	43.88^{c}
T_5: 75% N+ 75% P_2O_5 + Nano DAP @ 5 ml/l (2 Sprays)	26.08^{ab}	43.01^{cd}	45.54^{bc}
T_6: 50% N+ 50% P_2O_5 + Nano Urea @ 3 ml/l + Nano DAP @ 5ml/l (2Sprays)	27.34^{a}	46.15^{a}	47.96^{a}
T_7: Nano Urea @ 3 ml/l + Nano DAP @ 5ml/ l (3 Sprays)	26.23^{ab}	44.40^{b}	46.35^{b}
SE m±	0.44	0.34	0.38
CD @ 5%	1.37	1.08	1.20

Table 4: Effect of Nano urea and Nano DAP alone and in combination with different levels of nitrogen and phosphorus on number of branches $plant^{-1}$ in marigold Cv. Super ball.

Treatments	Number of branches $plant^{-1}$		
	40 DAT	55 DAT	70 DAT
T_1: Control 100% RDF (90 kg N -75 kg P_2O_5 -75 kg K_2O ha^{-1}	5.20^{bc}	6.66^{bc}	8.13^{c}
T_2: 75% N+ Nano Urea @ 2 ml/l (2 Sprays)	4.26^{d}	5.20^{d}	6.06^{e}
T_3: 50% N+ Nano Urea @ 3 ml/l (2 Sprays)	4.53^{c}	5.93^{c}	6.86^{d}
T_4: 75% N+ 75% P_2O_5 + Nano DAP @ 2 ml/l (2 Sprays)	5.13^{bc}	6.53^{bc}	7.73^{cd}
T_5: 75% N+ 75% P_2O_5 + Nano DAP @ 5 ml/l (2 Sprays)	5.53^{b}	7.06^{b}	8.80^{bc}
T_6: 50% N+ 50% P_2O_5 + Nano Urea @ 3 ml/l + Nano DAP @ 5ml/l (2Sprays)	6.26^{a}	8.46^{a}	10.0^{a}
T_7: Nano Urea @ 3 ml/l + Nano DAP @ 5ml/ l (3 Sprays)	6.13^{ab}	8.13^{ab}	9.20^{b}
SE m±	0.15	0.22	0.21
CD @ 5%	0.48	0.68	0.66

Table 5: Effect of Nano urea and Nano DAP alone and in combination with different levels of nitrogen and phosphorus on leaf area (cm^2) marigold Cv. Super ball.

Treatments	Leaf area (cm^2)		
	40 DAT	55 DAT	70 DAT
T_1: Control 100% RDF (90 kg N -75 kg P_2O_5 -75 kg K_2O ha^{-1}	6.45^b	8.12^b	11.96^b
T_2: 75% N+ Nano Urea @ 2 ml/l (2 Sprays)	5.16^c	7.34^c	9.75^d
T_3: 50% N+ Nano Urea @ 3 ml/l (2 Sprays)	5.54^{bc}	7.98^{bc}	10.33^c
T_4: 75% N+ 75% P_2O_5 + Nano DAP @ 2 ml/l (2 Sprays)	6.94^{ab}	9.03^{ab}	12.89^{ab}
T_5: 75% N+ 75% P_2O_5 + Nano DAP @ 5 ml/l (2 Sprays)	6.24^{bc}	8.00^{bc}	11.56^{bc}
T_6: 50% N+ 50% P_2O_5 + Nano Urea @ 3 ml/l + Nano DAP @ 5ml/l (2Sprays)	7.03^a	9.34^a	13.40^a
T_7: Nano Urea @ 3 ml/l + Nano DAP @ 5ml/ l (3 Sprays)	6.99^{ab}	9.15^{ab}	12.93^{ab}
SE m±	0.10	0.13	0.15
CD @ 5%	0.33	0.42	0.48

Table 6: Effect of Nano urea and Nano DAP alone and in combination with different levels of nitrogen and phosphorus on leaf chlorophyll content (SPAD meter reading) marigold Cv. Super ball.

Treatments	Leaf chlorophyll content (SPAD meter reading)		
	40 DAT	55 DAT	70 DAT
T_1: Control 100% RDF (90 kg N -75 kg P_2O_5 -75 kg K_2O ha^{-1}	35.63^a	47.92^a	54.21^a
T_2: 75% N+ Nano Urea @ 2 ml/l (2 Sprays)	33.56^{ab}	46.18^{ab}	52.92^{ab}
T_3: 50% N+ Nano Urea @ 3 ml/l (2 Sprays)	27.94^b	41.71^{bc}	47.34^c
T_4: 75% N+ 75% P_2O_5 + Nano DAP @ 2 ml/l (2 Sprays)	31.06^{ab}	42.98^{bc}	49.80^{bc}
T_5: 75% N+ 75% P_2O_5 + Nano DAP @ 5 ml/l (2 Sprays)	26.52^{bc}	39.70^c	45.66^{cd}
T_6: 50% N+ 50% P_2O_5 + Nano Urea @ 3 ml/l + Nano DAP @ 5ml/l (2Sprays)	32.23^{ab}	43.77^b	50.81^b
T_7: Nano Urea @ 3 ml/l + Nano DAP @ 5ml/ l (3 Sprays)	24.52^c	37.89^d	43.21^d
SE m±	0.96	0.61	0.65
CD @ 5%	3.01	1.90	2.0

Yield parameters

Table 7 shows the effect of nano urea and nano DAP alone and in combination with different levels of nitrogen and phosphorus on marigold (*Tagetes erecta* L.) Cv. Super ball yield and experiment results.

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

Minimum number of days to first flower bud initiation (32.20 days) was recorded in T_1 (100% RDF). Whereas T_7 (Nano Urea @ 3 ml/l + Nano DAP @ 5 ml/l) (3 sprays at 30, 45 and 60 DAT) had the highest number of days to first flower bud initiation (35.83 days). The early blooming period could be explained by the simple intake of nutrients and the concurrent delivery of growth-promoting agents, such as cytokinins, to the axillary buds, which breaks apical dominance. ultimately produced a superior sink for the quicker mobilization of photosynthates and the early transition of plant parts from the vegetative to the reproductive phases. (Chaitra *et al*., 2018) [6]. These findings agree with those of Venkatesh *et al*. (2022) [21] in marigold.

Number of days taken to 50% of flowering (days)

Minimum number of days to 50% of flowering (44.60 days) was recorded in T_1 (100% RDF). Whereas T_4 (75% N +75% P_2O_5 + Nano DAP @ 2 ml/l) (2 sprays at 30 DAT and 45 DAT) recorded significantly maximum number of days to 50% of flowering (55.16 days). The present findings are comparable with Venkatesh *et al*. (2022) [21] in marigold.

Number of days taken to full bloom (days)

T_1 (100% RDF) reported the minimum number of days required to reach full bloom, which was 51.20 days. T_4 (75% N + 75% P_2O + Nano DAP @ 2ml/l) (2 sprays at 30 DAT and 45 DAT) recorded a considerably maximum number of days to full bloom (61.06 days) with two sprays at 30 DAT and 45 DAT**.** may be the result of nitrogen promoting growth, which delays the start of blooming. The present findings are comparable with Venkatesh *et al*. (2022) [21] in marigold.

Number of flowers plant $^{-1}$

T_6 (50% N+50% P_2O_5+Nano urea @ 3ml/l + Nano DAP @ 5 ml/l) (2 sprays at 30 DAT and 45 DAT) recorded highest number of flowers $plant^{-1}$ (32.13). While significantly lowest number of flowers $plant^{-1}$ was recorded in T_2 (75% N + Nano Urea @ 2 ml/l) (2 sprays at 30 DAT and 45 DAT) (22.60). may be due to superior vegetative development from the earliest stages of the growth period due to better nitrogen and phosphorus absorption, which may have led to higher photosynthetic activity and a greater number of blooms $plant^{-1}$. The similar observation was also noted by Solanki and Ganie (2009) [18] in marigold.

Flower diameter (cm)

The treatment T_6 (50% N+50% P_2O_5+Nano urea @3ml/l + Nano DAP @ 5 ml/l) (2 sprays at 30 DAT and 45 DAT) recorded maximum flower diameter (6.82 cm). Whereas the minimum flower diameter was recorded in T_2 (75% N + Nano Urea @ 2 ml/l) (2 sprays at 30 DAT and 45 DAT) (5.28 cm). Because of nitrogen and phosphorus application, photosynthetic activity may have been accelerated by increasing leaf size, providing flowers with more photosynthates, which may have resulted in increased cell division and cell expansion, resulting in increased flower size in terms of flower diameter. Similar findings were obtained by Kumar *et al*. (2023) [10] in cauliflower and tomato.

Flower fresh weight (g)

T_6 (50% N+50%P_2O_5 +Nano urea @3ml/l + Nano DAP @ 5 ml/l) (2 sprays at 30 DAT and 45 DAT) had the highest individual flower weight (12.23 g) among the treatments. T_2 (75% N + Nano Urea @ 2 ml/l) (2 sprays at 30 and 45 DAT) had the lowest individual flower weight (8.05 g). It is possible

that the shift of food reserves from vegetative to reproductive sections increases carbohydrate reserves in the flower component, resulting in an increase in bloom size and, as a result, the weight of the flower. Kumar *et al.* (2023) [10] obtained comparable results in cauliflower and tomato.

Flower yield plant^{-1} (g)

T_6 (50% N+50% P_2O_5 +Nano urea @3ml/l + Nano DAP @5 ml/l) (2 sprays at 30 DAT and 45 DAT) produced the maximum Flower yield plant^{-1} (230.67 g). had the lowest Flower yield plant^{-1} (145.96 g) in T_2 (75% N + Nano Urea @ 2ml/l) (2 sprays at 30 DAT and 45 DAT). The increase in flower production may be due to an increase in the number of branches, plant spread, and the application of nitrogen and phosphorus, which play an important role in cell division and protein synthesis, which ultimately enhances the vegetative growth, which was then the driving force behind the life processes that led to increased flower production (Ahmed *et al.*, 2017) [2]. The current findings in calendula are analogous to those of Samoon *et al.* (2018) [17].

Flower yield plot^{-1} (kg)

Among the treatments, T_6 (50% N+50% P_2O_5+Nano urea @ 3ml/l + Nano DAP @ 5 ml/l) (2 sprays at 30 DAT and 45 DAT) recorded significantly highest flower yield plot^{-1} (4.61 kg). Whereas significantly lowest flower yield plot^{-1} was recorded in T_2 (75% N + Nano Urea @ 2 ml/l) (2 sprays at 30 DAT and 45 DAT) (2.91 kg). An adequate supply of nitrogen and phosphorus at higher levels may have accelerated plant photosynthetic activities, making more assimilates available to the flowers, resulting in increased flower weight plant^{-1} as well as enhanced flower yield plot^{-1}. Similar results were also recorded by Subramani *et al.* (2023) [19] in okra.

Flower yield hectare^{-1} (t)

The highest flower yield hectare^{-1} was recorded significantly in T_6 (50% N+50% P_2O_5+Nano urea @3 ml/l + Nano DAP @ 5 ml/l) (2 sprays at 30 DAT and 45 DAT) (11.46 t). On the other hand, the minimum flower yield hectare^{-1} was recorded significantly in T_2 (75% N + Nano Urea @ 2 ml/l) (2 sprays at 30 DAT and 45 DAT) (7.23 t). The quantity of flowers, the weight of the blooms per plant, or the weight of the flowers in plot^{-1}. Perhaps because there is an abundance of nitrogen and phosphorus available, plants' photosynthetic activity is increased, which in turn increases the assimilation of carbohydrates and accelerates the production of flowers. In marigold, the current results are equivalent to those of Naik *et al.* (2015) [12].

Table 7: Effect of Nano urea and Nano DAP alone and in combination with different levels of nitrogen and phosphorus on yield parameters of marigold Cv. Super ball.

Treatments	Days taken to first flower bud initiation	days taken to 50% flowering	days taken to full bloom	Number of flowers Plant^{-1}	Flower diameter (cm)	Flower fresh weight (g)	Flower Yield plant^{-1}	Flower yield plot^{-1}	Flower yield ha^{-1}
T_1: Control 100% RDF (90 kg N -75 kg P_2O_5 -75 kg K_2O ha^{-1}	32.20^{a}	44.60^{a}	51.20^{a}	28.20^{c}	5.65^{bc}	8.39 ^{c}	208.20^{c}	4.15^{c}	10.36^{c}
T_2: 75% N+ Nano Urea @ 2 ml/l (2 Sprays)	33.86^{bc}	52.86^{d}	59.53^{d}	22.60^{d}	5.28^{c}	8.05^{d}	145.96^{g}	2.91^{g}	7.23^{g}
T_3: 50% N+ Nano Urea @ 3 ml/l (2 Sprays)	33.60^{bc}	51.06^{cd}	57.74^{cd}	25.73^{cd}	5.88^{bc}	8.09^{cd}	177.69^{f}	3.55^{f}	8.86^{f}
T_4: 75% N+ 75% P_2O_5 + Nano DAP @ 2 ml/l (2 Sprays)	34.53^{c}	55.16^{e}	61.06^{e}	26.86^{cd}	6.04^{bc}	9.26^{bc}	185.40^{e}	3.70^{e}	9.20^{e}
T_5: 75% N+ 75% P_2O_5 + Nano DAP @ 5 ml/l (2 Sprays)	32.46^{ab}	47.20^{bc}	57.40^{c}	27.80^{cd}	6.16^{bc}	9.80^{bc}	190.87^{d}	3.81^{d}	9.50^{d}
T_6: 50% N+ 50% P_2O_5 + Nano Urea @ 3 ml/l + Nano DAP @ 5ml/l (2Sprays)	33.40^{b}	46.60^{b}	54.60^{b}	32.13^{a}	6.82^{a}	12.23^{a}	230.67^{a}	4.61^{a}	11.46^{a}
T_7: Nano Urea @ 3 ml/l + Nano DAP @ 5ml/ l (3 Sprays)	35.83^{d}	49.46^{c}	55.13^{bc}	30.13^{b}	6.22^{b}	9.95^{b}	218.19^{b}	4.35^{b}	10.86^{b}
SE m±	0.15	0.52	0.54	0.43	0.09	0.20	1.59	0.03	0.08
CD @ 5%	0.46	1.61	1.69	1.35	0.27	0.63	4.9	0.10	0.27

Conclusion

The current study suggests that nano urea and nano DAP have a substantial influence on the growth and yield of marigold Cv. Super Ball.

In comparison to other treatments, the T_6 treatment (50% N +50% P_2O_5 + Nano urea @ 3 ml/l + Nano DAP @ 5 ml/l) (2 Sprays at 30 and 45 DAT) had a positive influence on growth and yield parameters.

Future Scope

The following lines of work could be carried out in the future.

1. Effect of nano urea and nano DAP in combination with nano micronutrients may be studied.
2. The combined effect of nano urea and nano DAP on hybrids of marigold may be studied.
3. The combined effect of nano urea and nano DAP on different cultivars of marigold may be evaluated.

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