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Effect of nano NPK on growth, yield and quality of marigold (*Tagetes erecta* L.) cv. BM 4

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Abstract
The present investigation entitled "Effect of Nano NPK on growth, yield and quality of marigold cv.BM 4" was carried out during *rabi* season of the year 2023-2024 at Floricultural Research Station, Rajendranagar, Hyderabad. The experiment was carried out with ten (10) treatments in Randomized Block Design with three (3) replications. Treatments include combination of three levels of RDF with five levels of nano NPK i.e., 2.5, 5, 7.5, 10 and 12.5 ml was laid out to study the efficacy of nano NPK.T_6 (RDF 50% + 10 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) recorded the maximum plant height (75.6 cm), maximum plant spread in East-West (75.33 cm), in North-South (75.67cm) and maximum number of branches per plant (9 cm).The treatment T_{10} Control (100% RDF) recorded minimum number of days to 50% flowering (37.33 days), minimum number of days to full bloom (46.53 days) and maximum duration of flowering (46.53 days) compared to other treatments. Whereas the treatment T_6 (RDF 50% + 10 ml each of Nano NPK) recorded maximum flower diameter (6.87 g), maximum weight of single flower (15 g), maximum number of maximum number of flowers per plant (35.53), maximum flower yield per plant (245.67 g), maximum flower yield per plot (4.91 kg), and maximum flower yield per hectare (9.4 t). The maximum shelf life (3.95 days), maximum seed yield per flower (1.5 g) and maximum seed yield per plant (5.59 g) and the maximum Benefit: Cost (2.21) compared to other treatments. From the study it can be concluded that the treatment T_6 (RDF 50% + 10 ml each of Nano NPK) recorded significantly maximum growth and flowering parameters compared to other tratments.

Keywords: Marigold, BM 4, Nano NPK

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 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) [4]. Marigold is commonly used for garlands, pigment and oil extraction and therapeutic purposes. Aside from these uses, it is perfect for adding color and filling gaps in flower beds, herbaceous borders and newly planted shrubberies. (Yadav *et al.*, 2015) [26]. 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, 2009) [23]. Marigold is gaining industrial importance due to its huge potential in value addition. A wide array of value-added products are prepared from marigold like pigments, meals, food colorant of essential oils (Swaroop *et al*., 2007) [20]. Marigold is also grown as an ornamental crop for its flowers, which are sold in the market as loose flowers in bulk, as specialty cut flowers or for making garlands. It is also one of the most important natural sources of xanthophylls for use as natural food additive to enhance the yellow colour of egg yolks and poultry skin (Bosma and maness, 2003) [2]. Its flowers are rich in lutein, therefore petals are used in pigments extraction industry specially lutein.

Also flowers are used in drugs and pharmaceutical products, processed food, confectionery and in the poultry industry; one of the most important effects of the plant is their use as very valuable intercrop for controlling plant parasitic nematodes and insecticidal activity (Darwish and Deluca, 1992) [6]. In India, the estimated area under marigold cultivation is about 73.15 thousand ha with a production of 755100 MT (National Horticulture Board, 2021 2022, Govt. of India). In Telangana, marigold is one of the most dominating flowers in the local market with year-round demand. The majority of the trade of marigold is in the form of loose flowers. Commercially, it is cultivated for loose flower production, the estimated area under marigold cultivation is about 945 ha with a production of 14900 MT (Department of Horticulture, Govt. of Telangana 2020-2021). One of important varities of Marigold is 'BM 4' released from Bidhan Chandra Krishi Viswavidyalaya (BCKV), Kalyani. It produces bright orange colored flowers with good flower diameter (6.83 cm). It grows upto a height of 76.33 cm, number of primary branches (8.33), number of secondary branches (37), number of flowers per plant (98.33), flower diameter (6.83) and it yields about 716g per plant.

Utilization of chemical fertilizers has long been condemned because of their harmful impacts on the environment and growing media. Studies have been conducted to boost growth, however exclusively two or three can be seen in the literature involving nano –materials. Nano- materials are defined as the materials with a single unit between one and a hundred nm in size in a minimum of one diameter (Liu and Lal, 2015). Nanotechnology is a new emerging and fascinating field of science, permits advanced research in many areas and applications in the field of biotechnology and agriculture. Nanotechnology is providing feasibility of exploiting nanoscale nanostructure materials as fertilizer carriers or controlled release vectors for building of so called "smart fertilizer" as new facility to enhance nutrient use efficiency and reduce costs of environmental protection (Chinnamuthu and Boopathi, 2009) [5].

Materials and Methods

The experiment was conducted during the year 2023-24 at Floricultural Research Station, ARI, Rajendranagar, Hyderabad, Telangana. The experiment site comes under semi-arid tropical climate located at an altitude of 542.3 m above sea level at latitude of 17.90° N and longitude of 78.23° E with an average rainfall of 614.9 mm. The field experiment was laid out in randomized block design (RBD) and three replication i.e., T_1: RDF 25% + 7.5 ml each of Nano NPK (3 sprays at 30, 60 and 90 DAT), T_2-RDF 25% + 10 ml each of Nano NPK (3 sprays at 30, 60 and 90 DAT), T_3-RDF 25% +12.5 ml each of Nano NPK (3sprays at 30, 60 and 90 DAT), T_4-RDF 50% + 5.0 ml each of Nano NPK (3 sprays at 30, 60 and 90 DAT), T_5-RDF 50% +7.5 ml each of Nano NPK (3 sprays at 30, 60 and 90 DAT), T_6-RDF 50% + 10 ml each of Nano NPK (3 sprays at 30, 60 and 90 DAT), T_7-RDF 75% + 2.5 ml each of Nano NPK (3 sprays at 30, 60 and 90DAT), T_8- RDF 75% + 5.0 ml each of Nano NPK (3 sprays at 30, 60 and 90 DAT) T_9- RDF 75% + 7.5 ml each of Nano NPK (3 sprays at 30, 60 and 90 DAT), T_{10}- Control (100% RDF) (90:90:75 NPK kg/ha^{-1}) and the observations recorded were plant height (cm), plant spread N-S (cm), plant spread E-W (cm), number of branches plant^{-1} at 40, 70 and 100 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

The data on growth parameters *viz*., plant height, plant spread, number of branches plant^{-1} were measured at 40, 70 and100 DAT are depicted from Table 1 to 2, table 3 to 4.

Plant height (cm)

With respect to plant height in marigold, treatment T_6 (RDF 50% + 10 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) recorded maximum plant height 58.80 cm, 68.40 cm and 75.70 cm at 40, 70 and 100 days after transplanting respectively. Whereas T_1 (RDF 25% + 7.5 ml each of 3 sprays at 30, 60 and 90 DAT) recorded minimum plant height 45.33 cm, 52.87 cm and 62.4 cm at 40, 70 and 100 days after transplanting respectively. Increased plant height might be due to application of Nano urea results in enhancement of enzymatic activity that may lead to formation and transportation of photosynthetic material resulting in increase in plant height (Midde *et al*., 2021). In addition phosphorus plays an important role in an array of cellular processes, including maintenance of membrane structures, synthesis of biomolecules formation of high-energy molecules, cell division, enzyme activation/inactivation and carbohydrate metabolism which helps in increasing in plant height. (Razaq *et al*. 2017) [22]. Whereas potassium plays an important role in activation and stabilization of enzymes, proteins and starch synthesis, turgor maintenance, etc. (Shinde *et al*. 2014) [14]. The results were comparable with findings of Shinde *et al*. (2014) [14] in marigold, Sharma *et al*. (2022) [18] in pearl millet, Dutta *et al*. (2022) [7] in potato and Sahu (2023) [23] in rice and wheat.

Plant spread East-West (cm)

Among the treatments, T_6 (RDF 50% + 10 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) recorded highest plant spread in East-West direction 47.67 cm, 63.67 cm and 75.33 cm at 40, 70 and 100 days after transplanting respectively. Whereas T_1(RDF 25% + 7.5 ml each of Nano NPK 3 sprays at 30, 60 and 90DAT) recorded lowest plant spread in East – West direction 34.67cm, 45.67 cm and 53 cm at 40, 70 and 100 days after transplanting respectively.

Plant spread North- South (cm)

Among the treatments, T_6 (RDF 50% + 10 ml each of Nano NPK 3 Sprays at 30, 60 and 90 DAT) recorded highest plant spread in North- South direction 44.67 cm, 55.00 cm and 75.67 cm at 40, 70 and 100 days after transplanting respectively. Whereas T_1 (RDF 25% + 7.5 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) recorded lowest plant spread in North-south direction 32.4 cm, 46.37 cm and 55 cm at 40, 70 and 100days after transplanting respectively. It might be due to 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 vigorously 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. Potassium is not a constituent of any plant tissue or compounds but it is involved in the synthesis of amino acids. It imparts vigor and disease resistance to plants.

The findings closely align with the results obtained from Rathod *et al*. (2022) [21] in French basil and Ahirwar *et al*. (2012) [1] in

marigold.

Number of branches per plant

The treatment T_6 (RDF 50% + 10 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) recorded highest number of branches plant^{-1} (9.8). Whereas T_1 (RDF 25% + 7.5 ml each of Nano NPK 3 sprays at 30,60 and 90 DAT) recorded lowest number of branches plant^{-1} (7.12). This may be attributed to the higher levels of cytokinin in plants resulted by the application of nitrogen in nano form and encouraged the lateral buds to sprout, generating a number of branches.

In addition, phosphorus 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) [9] in cauliflower and tomato.

Yield Parameters

Number of days taken to first flowerbud initation (days)

Minimum number of days taken to first flower bud initiation (28.6 days) was recorded in T10 (100% RDF). Whereas T3 (RDF 25% +12.5 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) recorded significantly maximum number of days taken to first flower bud initiation (35.33 days). The earliness of flowering may be attributed to the easy uptake of nutrients from soil due to congenial condition and simultaneous transport of growth promoting substances like cytokinins to the axillary buds resulting in breakage of apical dominance. Ultimately, resulted in better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. (Chaitra *et al*., 2018) [3]

These results are in agreement with the findings of Sahithi *et al.* **(**2023) [15] in marigold. Showed that minimum number of days to first flower bud initiation (32.20 days) was recorded in T_1 (100% RDF).

Number of days taken to 50% flowering (days)

T_{10} control (100% RDF) recorded minimum number of days taken to 50 percent flowering (37.33 days). Whereas the maximum number of days taken to 50 percent flowering was recorded in T_3 (RDF 25% + 12.5 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) (48 days).The variation might be due to better translocation of photosynthates from source to sink.

The present findings are comparable with Sahithi *et al*. (2023) [15] in marigold Observed that minimum number of days to 50% of flowering (44.60 days) was recorded in T1 (100% RDF).

Number of days taken to full bloom (days)

Among all the treatments, T10 (100% RDF) recorded significantly minimum number of days taken to full bloom (46.53 days). While the significantly maximum number of days taken to full bloom was recorded in T_3 (RDF 25% + 12.5 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) (61.18 days). It might be due to active uptake of nutrients from soil which helps in promoting growth and early start of blooming. However, such earliness may not be advantageous during un season where demand for loose flowers is less. which helps in promoting growth and delays the start of blooming.

The present findings are comparable with sahithi *et al*. (2023) [15] in marigold. Revealed that the minimum number of days required to reach full bloom, recorded in T_1 (100% RDF) which was (51.20 days).

Number of flowers plant^{-1}

Among the treatments, T_6 (RDF 50% + 10 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) recorded maximum number of flowers plant^{-1} (35.53). While the significantly minimum number of flowers plant^{-1} was recorded in T_1 (RDF 25% + 7.5 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) (21.40). Maximum number of flowers plant^{-1} was due to the fact that may be due to the fact that the plants in these treatments experienced good vegetative growth right from early stages of growth period due to higher absorption of nitrogen and potassium which might have resulted in higher photosynthetic activity and resulted in higher number of flowers plant^{-1}. Somewhat delayed flowering in T_6 might have resulted in vigorous vegetative growth and branching resulting in more number of flowers. Similarly early flowering in T_{10} might have promoted more side branches resulting in more number of flowers per plant.

The similar observation was also noted by Vijay *et al.* (2015) [24] in calendula. Reported that maximum number of flowers (35.77) recorded in T_{10} (150 kg N/ ha+80 kg P/ha).

Weight of single flower (g)

Among the treatments, T_6 (RDF 50% + 10 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) recorded significantly highest individual flower weight (15g). While the significantly minimum number of flowers plant^{-1} was recorded in T_1 (RDF 25% + 7.5 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) (8.33g).

The maximum flower weight (g) in T6 (RDF 50% + 10 ml each of Nano NPK) might be due to vigorous vegetative growth and translocation of food reserves from vegetative parts to reproductive parts increasing the carbohydrate reserves in flower portion that led to the increase of flower size there by, the weight of the flower increased.

Similar results were also recorded by Kumar *et al*. (2023) [9] in cauliflower and tomato. Stated that, maximum fresh weight (124.97 and 127.15 g plant^{-1}) at curd initiation was recorded in T8 (50% RDF + 15 t/ha VC + Azotobacter (5 kg/ha) + PSB (5 kg/ha) + Black mulch (2.5 mm).

Flower diameter (cm)

The treatment T_6 (RDF 50% + 10 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) recorded significantly maximum flower diameter (6.93cm), whereas the minimum flower diameter was recorded in T_1 (RDF 25% + 7.5 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) (5.20 cm).It is because of nitrogen, phosphorus and potassium application to soil and foliar 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. The results on flower size, flower weight and plant vigour clearly indicating the relation between vegetative growth and flower yield in terms of size, weight and number. Similar findings were obtained by Kumar et al. (2023) [9] in cauliflower and tomato and sahithi *et.al* (2023) [15] in marigold noted that the treatment T_6 (50% N+50% P2O5+Nano urea @3 ml/l + Nano DAP @ 5 ml/l) (2 sprays at 30 DAT and 45 DAT) recorded maximum flower diameter (6.82 cm).

Duration of flowering (days)

The treatment T_{10} Control (100% RDF) recorded significantly maximum duration of flowering (46.53cm), whereas the minimum duration of flowering was recorded in T_1 (RDF 25% + 7.5 ml each of Nano NPK 3 sprays at 30, 60 and 90 DAT) (39.87 days). Maximum duration of flowering in T_{10} and T_6

could be earlier initiation of flowering in T_{10} and continued flowering, similarly late initiation of flowering and continued flowering due to vigorous growth, but quality parameter were superior in T_6.

The present findings are comparable with Venkatesh *et al.* (2023) in marigold. Reported that T_1 treatment (100% RDF) recorded maximum duration of flowering (45.74 days).

Flower yield plant^{-1}

Among the treatments, T_6(RDF 50% + 10 ml each of Nano NPK) recorded significantly highest flower yield plant^{-1} (532.95 g). While significantly lowest flower yield plant^{-1} was recorded in T_1 (RDF 25% + 7.5 ml each of Nano NPK) (178.26g). It might be due to increased number of branches, plant spread, the increase in flower production with the application of nitrogen and phosphorus plays an important role in cell division and protein synthesis which ultimately enhances the vegetative growth, which were then driving force behind the life processes which led to increased flower production (Ahmed *et al.*, 2017). The present findings are comparable with Samoon *et al.* (2018) in calendula and Venkatesh *et al*. (2022) in marigold. Stated that T_4 treatment (50% N + Nano Urea @ 2 ml/l (2 sprays at 25 DAT and 50 DAT)$_1$

Flower yield plot^{-1}

Among the treatments, T_6(RDF 50% + 10 ml each of Nano NPK) recorded significantly highest flower yield plot^{-1} (10.66 kg). Whereas significantly lowest flower yield plot^{-1} was recorded in T_1 (RDF 25% +7.5 ml each of Nano NPK) (3.57 kg). The maximum flower yield plot^{-1} in the treatment T_6 (RDF 50% + 10 ml each of NPK) may be due to sufficient supply of nutrients an increase in photosynthetic rate, as in crop species such as marigold, the flower alone is considered a yield. The flower acts as a "sink" for assimilates produced by other plant parts (source). An abundant supply of nitrogen, phosphorus and potassium at greater levels may have expedited the photosynthetic activities of plants, 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]. Subramani *et al*. (2023) [23] concluded that the nanospray contributes to the increased okra yield (13-31%) than only NPK addition through chemical fertilizers.

Flower yield ha^{-1}

The highest flower yield hectare^{-1} was recorded significantly in T_6 (RDF 50% + 10 ml each of Nano NPK) (25.1t). On the other hand, the minimum flower yield hectare^{-1} was recorded significantly in T_1(RDF 25% + 7.5 ml each of Nano NPK) (8.4 t). The significant variation in the flower yield hectare^{-1} found in treatments might be due to the number of flowers, weight of the flowers per plant, weight of the flowers plot^{-1} might be due to the abundant supply of nitrogen phosphorus and potassium enhanced the photosynthetic activity of plants ultimately increasing the carbohydrates assimilates which leads to acceleration in flower yield. The present findings are comparable with Naik *et al.* (2015) in marigold and Sahithi *et al.* (2023) [15] in marigold concluded that the highest flower yield hectare^{-1} was recorded in T_6 (50% N+50% P2O5+Nano urea @3 ml/l + Nano DAP @ 5 ml/l) (2 sprays at 30 DAT and 45 DAT) (11.46 t).

Seed parameters

Seed yield flower^{1} (g)

Significantly maximum seed yield flower^{-1}(1.5g) was observed in the treatment T_6 (RDF 50% + 10 ml each of Nano NPK).Whereas minimum seed yield flower^{-1} was recorded in the treatment T_1 (RDF 25% + 7.5 ml each of Nano NPK) (0.74g). This might be due to nitrogen which helped in improving the protein synthesis and resulted in production of bolder and healthy seeds. In addition phosphorus which is an essential part of photosynthesis, it is required for the general health, seed formation and seed development. The similar observation was also noted by Nirgulkar *et al*. (2020) [11] in African marigold.

Seed yield plant^{-1}(g)

Significantly maximum seed yield plant^{-1}(53.3g) was observed in the treatment T_6 (RDF 50% + 10 ml each of Nano NPK). Which is followed by the treatment T_9 (RDF 75% + 7.5 ml each of Nano NPK) (43.86 g).Whereas minimum seed yield plant^{-1} was recorded in the treatment T_1 (RDF 25% + 7.5 ml each of Nano NPK) (15.84 g).The similar observation was also noted by Nirgulkar *et al*. (2020) [11] in African marigold concluded that the application of 10 g/m^2 phosphorus was given maximum seed yield ha-1 in African marigold.

Table 1: Effect of Nano NPK on plant height (cm) at different growth stages of marigold cv. BM 4

Treatments	40 DAT	70 DAT	100 DAT
T_1: RDF 25% + 7.5 ml each of Nano NPK	45.33^{d}	52.87^{c}	62.4^{e}
T_2: RDF 25% + 10 ml each of Nano NPK	47.87^{cd}	55.33^{bc}	66.53^{d}
T_3: RDF 25% + 12.5 ml each of Nano NPK	48.35^{bcd}	56.87^{bc}	67.27^{cd}
T_4: RDF 50% + 5.0 ml each of Nano NPK	48.93^{bcd}	57.87^{bc}	67.33^{cd}
T_5: RDF 50% + 7.5 ml each of Nano NPK	49.27^{bcd}	59.13^{bc}	69.33^{bcd}
T_6: RDF 50% + 10 ml each of Nano NPK	58.80^{a}	68.40^{a}	75.70^{a}
T_7: RDF 75% + 2.5 ml each of Nano NPK	49.80^{bcd}	60.47^{b}	70.22^{bc}
T_8: RDF 75% + 5.0 ml each of Nano NPK	49.93^{bcd}	61.53^{b}	70.53^{bc}
T_9: RDF 75% + 7.5 ml each of Nano NPK	51.33^{bc}	61.60^{b}	71.07^{b}
T_{10}: Control (100% RDF)	53.13^{b}	59.80^{b}	69.87^{bc}
SE m±	1.75	2.23	1.10
CD @ 5%	5.21	6.63	3.28

Table 2: Effect of Nano NPK on plant spread in East-West (cm) in marigold cv. BM 4

Treatments	40 DAT	70 DAT	100 DAT
T_1: RDF 25% + 7.5 ml each of Nano NPK	34.67^{f}	45.67^{f}	53.00^{g}
T_2: RDF 25% + 10 ml each of Nano NPK	37.67^{e}	46.67^{ef}	59.00^{f}
T_3: RDF 25% + 12.5 ml each of Nano NPK	39.00^{e}	48.53^{def}	63.00^{ef}
T_4: RDF 50% + 5.0 ml each of Nano NPK	42.67^{cd}	52.33^{cdef}	67.00^{de}
T_5: RDF 50% + 7.5 ml each of Nano NPK	43.33^{c}	54.33^{bcd}	68.33^{cd}
T_6: RDF 50% + 10 ml each of Nano NPK	47.67^{a}	63.67^{a}	75.33^{a}
T_7: RDF 75% + 2.5 ml each of Nano NPK	44.00^{c}	55.00^{bcd}	71.33^{abcd}
T_8: RDF 75% + 5.0 ml each of Nano NPK	45.67^{b}	56.33^{abc}	72.00^{abc}
T_9: RDF 75% + 7.5 ml each of Nano NPK	46.33^{ab}	61.67^{ab}	74.33^{ab}
T_{10}: Control (100% RDF)	41.33^{d}	54.00^{cd}	70.67^{bcd}
SE m±	1.70	2.51	1.56
CD @ 5%	5.06	7.46	4.64

Table 3: Effect of Nano NPK on plant spread in in North-South (cm) in marigold cv. BM4

Treatments	40 DAT	70 DAT	100 DAT
T_1: RDF 25% + 7.5 ml each of Nano NPK	32.4^{d}	46.37^{h}	55.00^{f}
T_2: RDF 25% + 10 ml each of Nano NPK	35.40^{cd}	46.08^{gh}	59.33^{e}
T_3: RDF 25% + 12.5 ml each of Nano NPK	37.00^{bcd}	48.39^{fg}	61.40^{e}
T_4: RDF 50% + 5.0 ml each of Nano NPK	38.53^{bc}	49.33^{ef}	68.67^{cd}
T_5: RDF 50% + 7.5 ml each of Nano NPK	39.07^{bc}	50.33^{de}	66.33^{d}
T_6: RDF 50% + 10 ml each of Nano NPK	44.67^{a}	55.00^{a}	75.67^{a}
T_7: RDF 75% + 2.5 ml each of Nano NPK	40.27^{abc}	52.67^{bc}	71.33^{bc}
T_8: RDF 75% + 5.0 ml each of Nano NPK	41.40^{ab}	53.67^{ab}	72.33^{b}
T_9: RDF 75% + 7.5 ml each of Nano NPK	42.07^{ab}	54.33^{ab}	74.33^{ab}
T_{10}: Control (100% RDF)	39.60^{abc}	51.67^{cd}	69.00^{cd}
SE m±	1.75	0.80	2.23
CD @ 5%	5.19	2.36	6.64

Table 4: Effect of Nano NPK on number of branches plant^{-1} in marigold cv. BM 4

Treatments	40 DAT	70 DAT	100 DAT
T_1: RDF 25% + 7.5 ml each of Nano NPK	2.40^{f}	4.2^{f}	7.12^{f}
T_2: RDF 25% + 10 ml each of Nano NPK	3.20^{e}	5.2^{e}	7.2^{e}
T_3: RDF 25% + 12.5 ml each of Nano NPK	3.30^{e}	5.3^{e}	7.3^{e}
T_4: RDF 50% + 5.0 ml each of Nano NPK	3.90^{de}	5.6^{de}	7.4^{de}
T_5: RDF 50% + 7.5 ml each of Nano NPK	4.60^{cd}	5.9^{cd}	7.5^{cd}
T_6: RDF 50% + 10 ml each of Nano NPK	5.20^{a}	7.2^{a}	9.8^{a}
T_7: RDF 75% + 2.5 ml each of Nano NPK	4.80^{bc}	6.4^{bc}	7.8^{bc}
T_8: RDF 75% + 5.0 ml each of Nano NPK	4.90^{bc}	6.6^{bc}	8.2^{bc}
T_9: RDF 75% + 7.5 ml each of Nano NPK	5^{ab}	6.8^{ab}	8.62^{ab}
T_{10}: Control (100% RDF)	4.7^{cd}	6.2^{cd}	7.6^{cd}
SE m±	0.05	0.11	0.11
CD @ 5%	0.16	0.33	0.34

Table 5: Effect of Nano NPK on yield parameters in marigold cv. BM 4

Treatments	Days taken to bud initation	Days taken to 50% flowering	Days taken to fullbloom	Number of flowers per plant	Wt of single flower	Flower diameter
T_1: RDF 25% + 7.5 ml each of Nano NPK	33.6^{ab}	46.83^{ab}	55.27^{b}	21.40^{c}	8.33^{e}	5.20^{e}
T_2: RDF 25% + 10 ml each of Nano NPK	34.47^{a}	47.00^{ab}	59^{a}	22.60^{c}	10.67^{d}	5.27^{e}
T_3: RDF 25% +12.5 ml each of Nano NPK	35.33^{ab}	48.00^{a}	61.18^{a}	22.93^{c}	10.80^{d}	5.67^{d}
T_4: RDF 50% + 5.0 ml each of Nano NPK	31.73^{bc}	44.83^{ab}	53.8^{b}	23.60^{c}	11.40^{cd}	5.97^{cd}
T_5: RDF 50% + 7.5 ml each of Nano NPK	32.2^{bc}	45.83^{ab}	54.07^{b}	24.33^{c}	11.73^{cd}	6.00^{cd}
T_6: RDF 50% + 10 ml each of Nano NPK	33^{abc}	46.33^{ab}	55^{b}	35.53^{a}	15.00^{a}	6.93^{a}
T_7: RDF 75% + 2.5 ml each of Nano NPK	29.47^{cd}	43.33^{b}	48.33^{c}	26.60^{bc}	11.80^{cd}	6.20^{bc}
T_8: RDF 75% + 5.0 ml each of Nano NPK	29.6^{de}	43.50^{ab}	49.07^{c}	25.20^{c}	12.80^{bc}	6.27^{bc}
T_9: RDF 75% + 7.5 ml each of Nano NPK	31.47^{de}	44.67^{ab}	52.63^{b}	31.33^{ab}	13.93^{ab}	6.53^{b}
T_{10}: Control (100% RDF)	28.6^{e}	37.33^{c}	46.53^{c}	27.27^{bc}	13.07^{bc}	6.13^{c}
SE m±	0.69	1.55	1.17	1.98	0.64	0.12
CD @ 5%	2.04	4.61	3.48	5.88	1.89	0.35

Table 6: Effect of Nano NPK on yield parameters in marigold cv. BM 4

Treatments	Duration of flowering	Flower yield plant^{-1}	Flower yield plot^{-1}	Flower yield ha^{-1}	Seed yield flower^{-1}	Seed yield plant^{-1}
T_1: RDF 25% + 7.5 ml each of Nano NPK	39.87^{c}	178.26^{h}	3.57^{h}	8.4^{i}	0.74^{g}	15.84^{h}
T_2: RDF 25% + 10 ml each of Nano NPK	40.00^{c}	241.14^{g}	4.83^{g}	11.3^{h}	0.76^{g}	17.18^{gh}
T_3: RDF 25% +12.5 ml each of Nano NPK	28.07^{d}	247.64^{g}	4.95^{g}	11.6^{h}	0.82^{f}	18.80^{g}
T_4: RDF 50% + 5.0 ml each of Nano NPK	40.27^{c}	269.04^{f}	5.38^{f}	12.6^{g}	1.02^{e}	24.07^{f}
T_5: RDF 50% + 7.5 ml each of Nano NPK	40.80^{c}	285.39^{e}	5.71^{e}	13.4^{f}	1.2^{d}	29.20^{e}
T_6: RDF 50% + 10 ml each of Nano NPK	45.53^{a}	532.95^{a}	10.66^{a}	25.1^{a}	1.5^{a}	53.30^{a}
T_7: RDF 75% + 2.5 ml each of Nano NPK	40.87^{c}	313.88^{d}	6.27^{d}	14.7^{e}	1.18^{d}	31.39^{d}
T_8: RDF 75% + 5.0 ml each of Nano NPK	41.60^{bc}	322.56^{d}	6.45^{d}	15.1^{d}	1.28^{c}	32.26^{cd}
T_9: RDF 75% + 7.5 ml each of Nano NPK	43.33^{b}	436.43^{b}	8.73^{b}	20.5^{b}	1.4^{b}	43.86^{b}
T_{10}: Control (100% RDF)	46.53^{a}	356.42^{c}	6.83^{c}	16.7^{c}	1.22^{d}	33.27^{c}
SE m±	0.71	5.07	0.09	0.11	0.02	0.58
CD @ 5%	2.11	15.07	0.27	0.34	0.06	1.72

Conclusion

- From the present study it can be concluded that Nano N, P, K significantly influences the growth, yield and quality of marigold cv.BM 4.
- The Fresh weight of individual flowers had showed best results by applying Nano NPK. By this overall growth and yield had been increased.
- The treatment T_6 (RDF 50% + 10 ml each of Nano NPK) showed positive effect on growth, yield and quality parameters as compared to other treatments and the next best treatment is T_9 (RDF 75% + 7.5 ml each of Nano NPK).
- BM 4 variety responded well to the conditions of soil and climate**.**

Future line of work

The future line of work may be carried out in following lines.

1. The effect of nano NPK in combination with micro nutrients may be studied.
2. The effect of nano NPK in combination with Organic fertilizers may be studied.
3. The effect of nano NPK may be studied in the cut flowers and foliage plants.
4. More studies are to be conducted with combination of Nano fertilizer and Bio stimulant foliar sprays for greater nutrient assimilation.
5. Studies on Nano fertilizer assimilation at tissue level and their mobility within plant.

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