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RESEARCH ARTICLE

Optimization of integrated sources of nutrients and foliar application of micronutrients on growth, flowering and yield of marigold (*Tagetes erecta* L) cv. Pusa Narangi Gainda

Devanshu Shukla[1], Mukesh Kumar[1*], Chetan Chauhan[1], Krishna Kaushik[1], Rohan Tomar[1], Ujjwal Sirohi[2], Mahima Sharma[1], Rishubh Motla[1] & Manoj Kumar Singh[3]

[1]Department of Floriculture and Landscaping Architecture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut 250 110, India
[2]Department of Agricultural Biotechnology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut 250 110, India
[3]Department of Vegetable Science, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut 250 110, India

*Correspondence email - k.mukesh123@yahoo.com

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Abstract

The study was conducted to evaluate the impact of foliar application of micronutrient and integrated nutrient sources on the "growth, flowering and yield" of Marigold cv. Pusa Narangi Gainda in year 2021-2022 in randomised block design (RBD) with three replications. Among the treatments, the highest plant height and spread were observed in plants treated with T2 (100% RDF with foliar spray of 0.5% ZnSO4). The greatest number of branches per plant and maximum total dry matter were recorded under T6 (75% RDF with foliar spray of 0.5% ZnSO4 + 0.5% FeSO4). For flowering parameters, T6 also resulted in the minimum days to first flowering, longest flowering duration, highest number of flowers per plant, maximum flower weight and maximum petal weight, while the largest flower diameter was found in T2. Regarding yield, the highest flower yield per plant, flower yield per hectare and seed yield per flower were observed under T6 with the foliar spray of 0.5% ZnSO4 + 0.5% FeSO4. It was concluded that from an economic perspective, treatment T6 was determined to be the most efficient

Keywords: ferrous sulphate; integrated nutrient management; marigold; zinc sulphate

Introduction

Marigold, originally native to Central and South America, particularly Mexico, includes two prominent species: *Tagetes erecta* L., known as the African marigold and *Tagetes patula* L., referred to as the French marigold. The genus *Tagetes* comprises 33 species. The African marigold (*Tagetes erecta*) was introduced to Europe in 1596, while the French marigold (*Tagetes patula*) made a similar journey from Mexico to Africa in 1573 (1). *Tagetes erecta* is one of the most widely cultivated loose flowers in India and belongs to the Asteraceae family. It is widely used for social and religious objectives in a number of ways (2). It is planted in landscape herbaceous gardening, as a pot plant and as an attractive crop. Furthermore, it may be grown in well -drained sandy loam soil with a pH of 7.0 to 7.5. It needs an ideal environment for growth and flowering, temperature between 15°C and 27°C is ideal. Marigold can be commercially cultivated from seeds three times a year, during the summer, winter and rainy

There are certain therapeutic benefits to the floral extract, which is created from flowers mixed with other ingredients. The material produced during the extraction process is used to cure eye ulcers (3). It is a good source of xanthophyll, the pigment that gives egg yolks their yellow hue and accentuates the color of chicken skin, which is used in poultry feed (1). The human body is unable to produce lutein; it must be obtained from natural sources. The most crucial raw material for the synthesis of lutein is now marigold (4- 6). To guarantee that egg yolks and broiler skins are properly colored, lutein is also added to chicken feed and utilized as a food coloring (7).

Nutrients have an important impact on crop growth and production potential. However, the use of chemical fertilisers changes the fertility of the soil, which leads to contamination of the soil and water bodies (8). Additionally, nutrients significantly affect the growth and development of plants (9). The ecosystem is disturbed by the overuse of inorganic fertilizers (10-12). Moreover, these fertilizers have harmful effects on the environment, soil, water and horticulture crop quality (11, 12). Consequently, integrated nutrient management, which improves crop productivity and soil quality, is one of the potential solutions to this problem (10-13). However, the widespread adoption of INM faces several challenges, including soil fertility management, availability and cost of inputs, ensuring balanced nutrient supply, inadequate infrastructure and limited awareness of Integrated Nutrient Management (INM) practices (14). INMs' guiding philosophy is to achieve high crop yield while reducing N losses and their detrimental environmental effects (15). In order to increase agricultural productivity and resource efficiency, INM aims to optimize biological potential through the rhizosphere and root zone. In order to collect nutrients from the soil, plant roots employ the rhizosphere, a little region of the soil that is directly influenced by root development, root secretions and associated soil bacteria (16). Organic manures, biostimulants and fertilizers are only a few examples of the many various sources of nutrients. Vermi-compost treatment increased soil dehydrogenase activity, microbial biomass and other compounds that affect plant growth (17). In marigold, an application of vermicompost and reduced recommended NPK increased flower output and floral diameter per plant compared to plants that did not get fertilizer or vermicompost alone (18).

Micronutrients play a major role in yield qualities and flower production in addition to integrated nutrient management (19). Micronutrients are also crucial for the development and blooming of ornamental plants. Zinc is one of the micronutrients that participate in a variety of physiological processes and activates a number of enzymes (20). In addition to being an essential element, zinc activates the enzymes peptidase, proteinase and dehydrogenase (21). Iron, however, affects the many flowering features through the production of several proteins and amino acids. Similar to this, iron plays a role in the transport of electrons and is a necessary component of enzymes. Many photosynthetic components, such as the Fe-S protein ferredoxin (Fd), which is involved in significant oxidoreductive processes in chloroplasts, experience decreased function as a result of iron deprivation (22). Therefore, treatments of iron and zinc are crucial for plant blossoming. Particularly in flowers, iron and zinc may be beneficial in facilitating the passage of water, minerals, amino acids and carbohydrates from the site of biosynthesis to the storage tissue, increasing the number, size and weight of flowers (20). The goal of the current study was to identify the most suitable Integrated Nutrient Management (INM) treatment for maximizing growth, flowering and yield of marigold under the specific agro-climatic conditions of the Meerut region in Western Uttar Pradesh, India.

Materials and Methods

Marigold cv Pusa Narangi Gainda is widely cultivated across India, primarily due to its notable characteristics, including tall plant stature, extensive branching and high yield potential. Given its broad adaptability and superior performance, this variety has been selected for the present study. The effects of foliar micronutrient spray and integrated nutrition sources on marigold cv. Pusa Narangi Gainda growth, flowering and yield were assessed in this study. Using a randomised block design (RBD) with three replications and twelve treatments, the study was carried out at the Horticulture Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut (U.P.). The cultivar's seeds came from the College of Horticulture, Department of Floriculture and Landscape Architecture, SVPUT, Modipuram. Following the treatment combinations, one-month-old seedlings with two to three pairs of leaves were transplanted with a 45-cm gap between rows and a 30-cm gap between plants with net plot size 1.80m×1.35m. At 15, 30 and 45 days following transplantation, foliar sprays of ferrous and zinc sulphate were administered. The data were recorded as per treatment-wise and statistically analyzed as suggested by the meth The data were recorded as per treatment-wise and statistically analyzed as suggested by the Gomez Nand Gomez method (23).

Results and Discussion

Impact of micronutrients and INM on marigold growth characteristics

The application of zinc sulphate @ 0.5% with 100% RDF (T2) produced the highest plant height and plant spread, whereas the (T1) control produced the lowest plant height and plant spread, as Table 1 and Fig. 1 makes clear. The incorporation of vermicompost showed effective plant height due to increased soil enzyme activities such as urease, phosphomonoesterase, phosphodiesterase and any sulfatase acting as growth promoters and protectors for plants (13). Moreover, the differential response of zinc sulfate with respect to plant height and plant spread might be due to the fact that it aids in the production of vital plant hormones and amino acids as well as the activation of a number of enzymes, including tryptophan synthetase, peroxidase, catalase, alcohol dehydrogenase, etc., transportation of carbohydrates, oxidation-reduction regulation and several photosynthetic activities of plants (24). (25) showed similar outcomes in Marigold v. Pusa Basanti Gainda. Furthermore, maximum number of branches per plant (16.33) and total dry matter (36.03 g) were recorded under the treatment T_6 (75% RDF with 25% FYM and VC with foliar application of @ 0.5% zinc sulfate and ferrous sulfate), whereas minimum number of branches per plant (7.00) and total dry matter (22.23 g) were noted under T_1 control (25). Plant development and growth may be greatly aided by a regular supply of N, P and K from RDF supplemented with extra dosages of vermicompost, leading to greater growth qualities (26). In a similar way, (13) also reported similar results in Marigold. Furthermore, vermicompost has been demonstrated to enhance plant dry weight when added as an integrated form, making it a potential slow-release, naturally occurring source of plant nutrients (27). The use of

Table 1. Effect of integrated sources of nutrients and foliar application of micronutrients on growth characters of marigold

S.No.	Treatments	Plant height (cm)	Plant spread diameter (cm)	Number of branches per plant	Total dry matter (gm)
T_1	Control	50.90	28.83	7.00	22.23
T_2	100% RDF (NPK @150,100,100 kg/ha) +F.S. of @ 0.5% $ZnSO_4$	64.33	41.77	14.60	34.03
T_3	100% RDF + F.S. of @ 0.5% FeSo4	63.37	39.33	13.40	33.13
T_4	75% RDF + FYM + F.S. of @ 0.5% $ZnSO_4$	59.80	35.83	13.00	32.23
T_5	75% RDF + 25% VC + F.S. of @ 0.5% $FeSO_4$	61.23	36.03	13.17	32.53
T_6	75% RDF + 25% (FYM + VC) + F.S. of @ 0.5% $ZnSO_4$+ @0.5% $FeSO_4$	62.23	37.27	16.33	36.03
T_7	50% RDF + 50% FYM + F.S. of @ 0.5% $ZnSO_4$	58.37	34.00	13.00	32.60
T_8	50% RDF + 50% VC + F.S. of @ 0.5% $FeSO_4$	58.47	34.13	12.80	32.97
T_9	50% RDF + 50% (FYM + VC) + F.S. of @ 0.5% $ZnSO_4$+ @0.5% $FeSO_4$	59.23	35.10	13.10	33.03
T_{10}	25% RDF + 75%VC + F.S. of @ F.S. of @ 0.5% $ZnSO_4$+@ 0.5% $FeSO_4$	58.70	34.50	12.87	32.77
T_{11}	25% RDF + 75% FYM + F.S. of @ 0.5% $ZnSO_4$	56.90	32.83	11.87	30.17
T_{12}	25 %RDF +75% (FYM + VC) + F.S. of @ 0.5% $ZnSO_4$+@ 0.5% $FeSO_4$	57.93	33.20	11.93	31.90
C.D.		1.53	1.28	1.16	1.66
C.V.		1.52	2.14	5.33	3.04

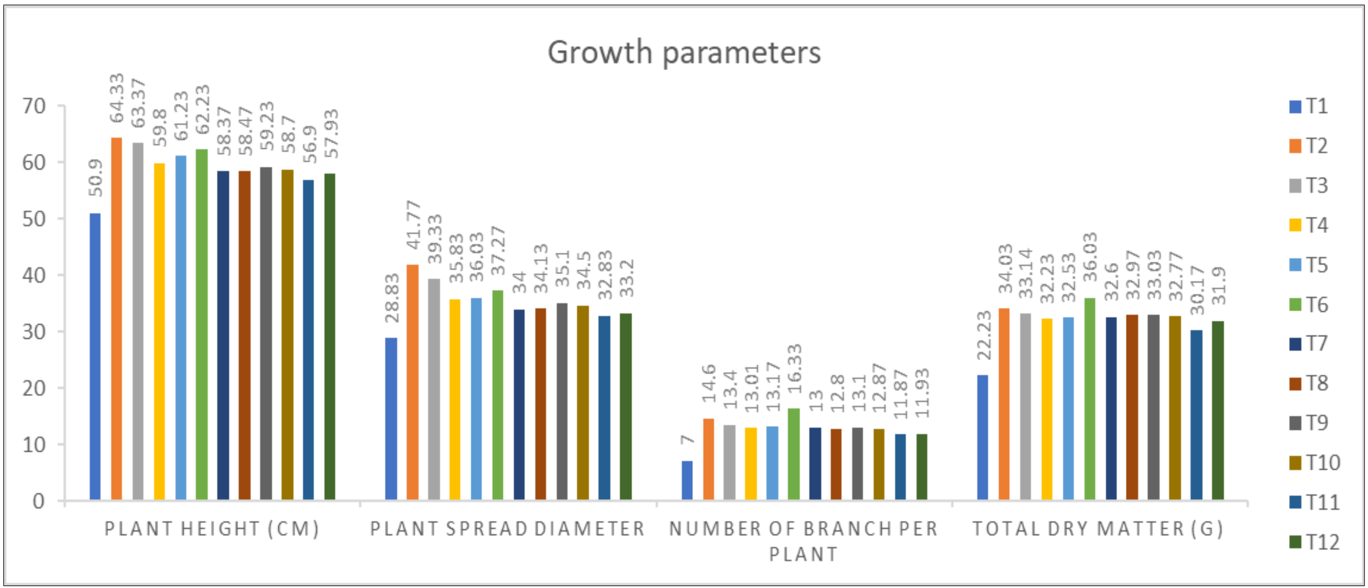

Fig.1. Effect of integrated sources of nutrients and foliar application of micronutrients on growth characters of marigold

iron and zinc, which helps move minerals, water, amino acids and carbohydrates from the production site to robust tissue, may be the cause of the maximum number of branches and total dry matter. Similar results have been recorded by the application of organic manure by Shyala et al., in hybrid marigold cv. Maxima Yellow (28). This result is also supported by Singh et al. in Marigold cv. Pusa Narangi Gainda (29).

Effect of INM and micronutrients on flowering characters of marigold

Table 2 and Fig. 2 clearly shows that early flowering, maximum duration of flowering, number of flowers per plant, weight of flowers per plant and petal weight were recorded under (T1) control, whereas late bud initiation, minimum duration of flowering, number of flowers per plant, weight of flowers per plant and petal weight were recorded under (T_1) control. It might be due to the incorporation of vermicompost and inorganic fertilizers, which showed an effective number of flowers per plant and petal weight due to increased soil enzyme activities such as urease, phosphomonoesterase, phosphodiesterase and any sulfatases acting as a flowering promoter and protector for the plant and tending to increase the essential soil microorganisms, promoting the microbial population, aiding in better aeration of plant roots, increasing the availability of macro- and micronutrients and thus improving the uptake of nutrients by plants, resulting in better growth and flowering (13). In addition, zinc sulfate and ferrous sulfate together may have an impact on flowering characteristics, where iron sulfate is an essential component of several dehydrogenases, proteases and peptidases and promotes growth hormones and is closely associated with growth (28). Although zinc sulphate influences numerous biological processes and functions as a co-factor for numerous enzymes (24). Singh et al. found similar outcomes in Marigold (28,29). Also, in the case of weight of flower per plant, particularly Marigold CV Pusa Narangi Gainda it was noted that zinc application alleviated chlorosis and created healthy green leaves, resulting in assimilation synthesis and partitioning of floral development, which may improve flower weight (28). The maximum flower diameter (6.97) was recorded with (T_2) 100% RDF with 0.5% ZnSO4, while the minimum diameter of the flower (3.10 cm) was shown in control. Flower diameter is affected and has shown a beneficial effect on flower size and weight, which might be due to an increment in protein synthesis, thus promoting the development of the primordial flower and obtaining more flowers (29). Similar outcomes were noted in Marigold cv. Pusa Narangi Gainda, where zinc sulfate increases the synthesis of iron and mobilizes more water in the flowers, both of which increase the diameter of the blooms (30).

Table 2. Effect of integrated sources of nutrients and foliar application of micronutrients on flowering characters of marigold

S. No.	Treatments	Days of first flowering (g)	Duration of flowering (Days)	Flower diameter (cm)	Number of flowers per plant	Weight of flower per plant (g)	Petal weight (g)
T_1	Control	70.23	36.20	3.10	9.30	22.20	1.93
T_2	100% RDF (NPK @150,100,100 kg/ha) +F.S. of @ 0.5% $ZnSO_4$	57.27	61.33	6.97	19.87	39.00	3.60
T_3	100% RDF + F.S. of @ 0.5% FeSo4	58.87	60.33	6.77	18.27	38.51	3.50
T_4	75% RDF + 25% FYM + F.S. of @ 0.5% $ZnSO_4$	60.13	58.53	6.00	17.17	36.18	3.10
T_5	75% RDF + 25% VC + F.S. of @ 0.5% $FeSO_4$	59.27	59.87	6.53	17.67	38.18	3.40
T_6	75% RDF + 25% (FYM + VC) + F.S. of @ 0.5% $ZnSO_4$+ @0.5% $FeSO_4$	56.93	62.03	6.60	20.27	41.13	3.83
T_7	50% RDF + 50% FYM + F.S. of @ 0.5% $ZnSO_4$	59.93	56.00	6.30	16.53	36.45	3.03
T_8	50% RDF + 50% VC + F.S. of @ 0.5% $FeSO_4$	60.27	58.87	5.97	16.93	35.33	3.10
T_9	50% RDF + 50% (FYM + VC) + F.S. of @ 0.5% $ZnSO_4$+ @0.5% $FeSO_4$	59.63	58.77	6.17	17.00	37.93	3.23
T_{10}	25% RDF + 75%VC + F.S. of @ F.S. of @ 0.5% $ZnSO_4$+@ 0.5% $FeSO_4$	60.70	56.10	5.17	16.43	34.73	2.97
T_{11}	25% RDF + 75% FYM + F.S. of @ 0.5% $ZnSO_4$	62.00	53.50	5.27	15.63	32.29	2.20
T_{12}	25 %RDF +75% (FYM + VC) + F.S. of @ 0.5% $ZnSO_4$+@ 0.5% $FeSO_4$	61.20	54.70	5.63	16.60	33.70	2.57
C.D.		1.71	2.20	0.18	0.78	1.11	0.23
C.V.		1.66	2.29	1.75	2.73	1.83	4.35

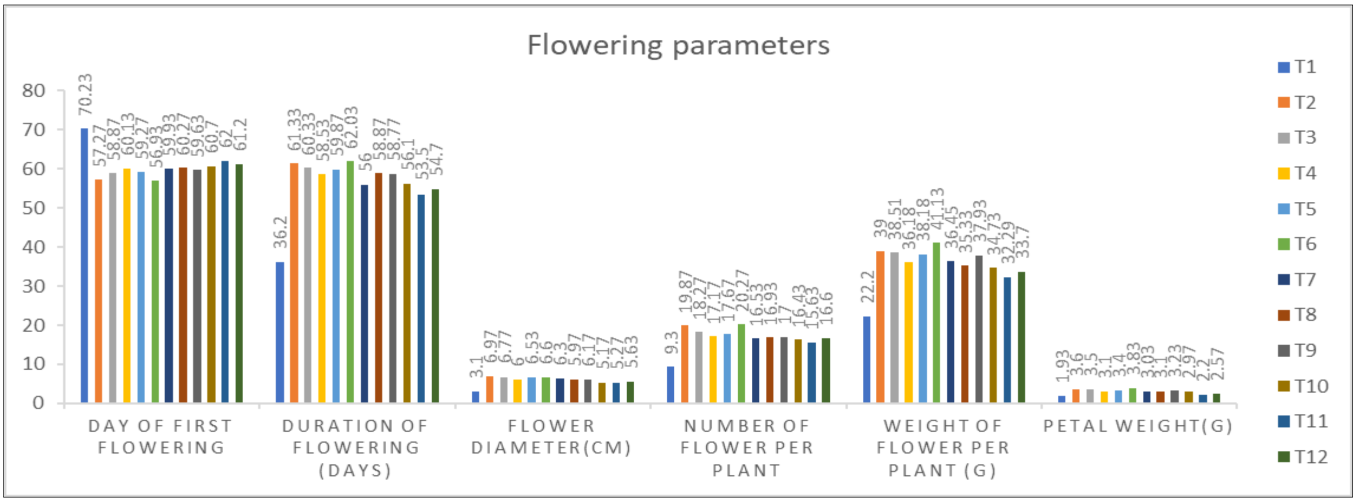

Fig.2. Effect of integrated sources of nutrients and foliar application of micronutrients on flowering characters of marigold

Effect of INM and micronutrients on yield characters of marigold

As Table 3 and Fig. 3 makes clear that maximum yield of flower per plant, flower yield per ha and seed yield were obtained by (T_6) 75% RDF with 25% FYM and VC with foliar applications of @ 0.5% zinc sulfate and ferrous sulfate, while minimum flower per plant, flower yield per ha and seed yield were observed in control (T1). The beneficial outcomes of nitrogen and phosphate fertilizers on floral size and weight may be attributable to a rise in protein synthesis. This prompted flower buds to expand, resulting in the highest yield per plant. However, vermicompost and FYM improved the soil conditions for healthy plant growth and development, increasing the yield of flowers per plant (31). Also, vermicompost and FYM provides the best soil conditions for the healthy growth and development of plants, increasing floral yield per hectare. Although iron and zinc help in accelerating the synthesis of chlorophyll and the transportation of amino acids, minerals and water from plant synthesis sites, boost the physiological activity of floral cells. Our findings closely align with those of Marigold (28). Moreover, vermicompost is also an excellent source of micronutrients and various enzymes. In addition, $ZnSO_4$ and $FeSO_4$ encourage the development of the marigold's flowers while also speeding up the photosynthetic rate and increasing the seed yield. The results are comparable to those of Singh et al. in Marigold (31).

Table 3. Effect of integrated sources of nutrients and foliar application of micronutrients on yield characters of marigold

S. No.	Treatments	Yield of flower per plant (g)	Yield of flower per/ ha (t/ha)	Seed yield per flower (g)
T_1	Control	262.67	8.93	40.46
T_2	100% RDF (NPK @150,100,100 kg/ha) +F.S. of @ 0.5% $ZnSO_4$	388.73	19.13	64.03
T_3	100% RDF + F.S. of @ 0.5% FeSo4	383.87	18.72	63.40
T_4	75% RDF + 25% FYM + F.S. of @ 0.5% $ZnSO_4$	378.67	18.20	61.07
T_5	75% RDF + 25% VC + F.S. of @ 0.5% $FeSO_4$	380.47	18.41	62.80
T_6	75% RDF + 25% (FYM + VC) + F.S. of @ 0.5% $ZnSO_4$+ @0.5% $FeSO_4$	408.07	20.10	66.50
T_7	50% RDF + 50% FYM + F.S. of @ 0.5% $ZnSO_4$	342.93	16.97	60.00
T_8	50% RDF + 50% VC + F.S. of @ 0.5% $FeSO_4$	347.53	15.67	60.70
T_9	50% RDF + 50% (FYM + VC) + F.S. of @ 0.5% $ZnSO_4$+ @0.5% $FeSO_4$	353.67	17.57	61.62
T_{10}	25% RDF + 75%VC + F.S. of @ F.S. of @ 0.5% $ZnSO_4$+@ 0.5% $FeSO_4$	339.27	13.23	59.90
T_{11}	25% RDF + 75% FYM + F.S. of @ 0.5% $ZnSO_4$	320.47	12.73	56.94
T_{12}	25 %RDF +75% (FYM + VC) + F.S. of @ 0.5% $ZnSO_4$+@ 0.5% $FeSO_4$	334.33	13.23	58.93
C.D.		17.49	0.9	2.69
C.V.		2.90	3.60	2.64

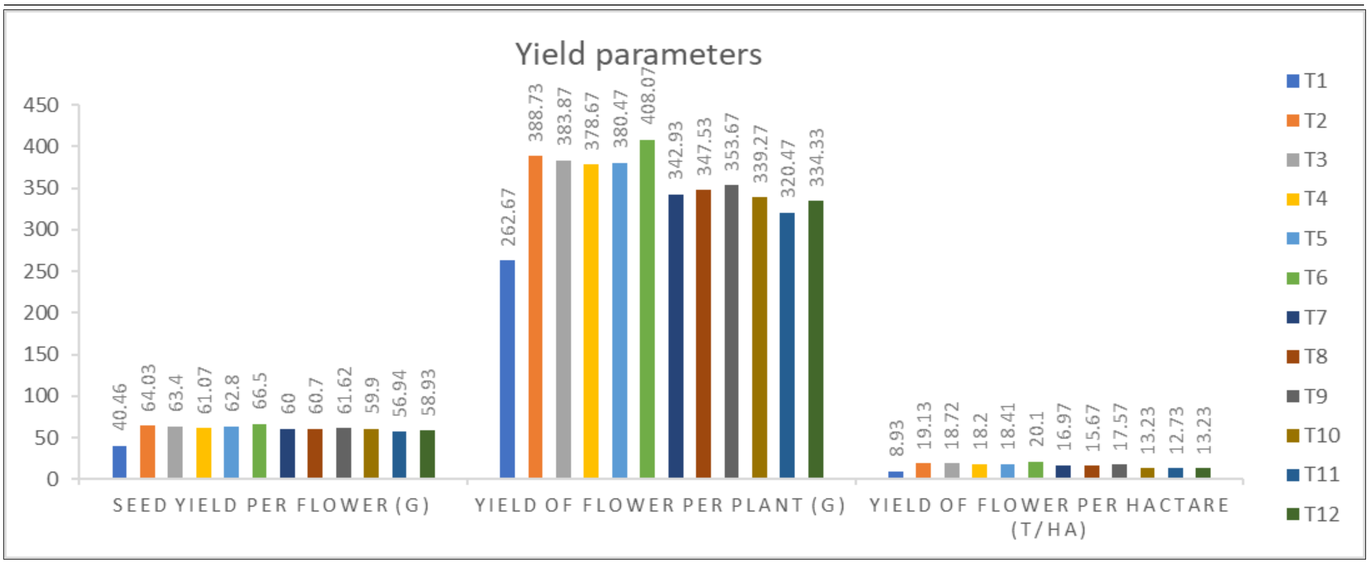

Fig.3. Effect of integrated sources of nutrients and foliar application of micronutrients on yield characters of marigold

Conclusion

According to the current study, it can be concluded that the treatment T_2 (100% RDF (NPK @ 150, 100, 100 kg/ha) + foliar spray of 0.5% ZnSO4) was optimized for growth parameters of marigold. However, in terms of flowering and yield attributes, the best results were observed in treatment T_6 (75% RDF (NPK @ 112, 75, 75 kg/ha) + FYM (4 t/ha) + VC (1.5 t/ha) + foliar spray of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$. Thus, we can conclude that marigold crops do best when grown in open field conditions with 25% less inorganic nutrients, which are supplemented with an integrated supply of nutrients (FYM and VC) and micronutrients (0.5% $ZnSO_4$ + 0.5% $FeSO_4$) in terms of growth, flowering and yield characters.

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Authors' contributions

MK and DS developed the idea and designed the experiment. DS, CC and KK collected the literature sources and conducted the field experiments. The CC, RT and US did data analysis. CC, MS and DS wrote the MS. RM and MKS helped to edit the manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest

Ethical issues: None

References

1. Kaur H, Singh J, Singh B. Importance and prospects of marigold. *Just Agric.* 2021;2:1-5.
2. Idan RO, Prasad VM, Saravanan S. Effect of organic manures on flower yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. *Int J Agric Sci Res.* 2014;4(1):39-50.
3. Choudhary M, Beniwal BS, Kumar A. Evaluation of marigold genotypes under semi-arid conditions of Haryana. *Ann Hortic.* 2014;7(1):30-5.
4. Rajput N, Naeem M, Ali S, Zhang JF, Zhang L, Wang T. The effect of dietary supplementation with the natural carotenoids curcumin and lutein on broiler pigmentation and immunity. *Poult Sci.* 2013;92(5):1177-85. https://doi.org/10.3382/ps.2012-02853
5. Berman J, Zorrilla-López U, Farré G, Zhu C, Sandmann G, Twyman RM, Christou P. Nutritionally important carotenoids as consumer products. *Phytochem Rev.* 2015;14:727-43. https://doi.org/10.1007/s11101-014-9373-1
6. Cheng X, Chen D, Luo C, Liu H, Huang C. Comparative transcriptome analysis of Ts (resistant genotype) and Ma (susceptible genotype) marigold (*Tagetes erecta* L.) leaves in response to *Alternaria tagetica*. *Hortic Plant J.* 2023;9(2):321-34. https://doi.org/10.1016/j.hpj.2022.04.005
7. Bhattacharyya S, Datta S, Mallick B, Dhar P, Ghosh S. Lutein content and *in vitro* antioxidant activity of different cultivars of Indian marigold flower (*Tagetes patula* L.) extracts. *J Agric Food Chem.* 2010;58(14):8259-64. https://doi.org/10.1021/jf101262e
8. Kaushik H, Singh JP. Impact of integrated nutrient management (INM) on plant growth and flower yield of African marigold (*Tagetes erecta* L.). *J Pharmacogn Phytochem.* 2020;9(4):1481-4.
9. Pandey N. Role of plant nutrients in plant growth and physiology. In: *Plant nutrients and abiotic stress tolerance.* 2018;51-93. https://doi.org/10.1007/978-981-10-9044-8_2
10. Wu W, Ma B. Integrated nutrient management (INM) for sustaining crop productivity and reducing environmental impact: a review. *Sci Total Environ.* 2015;512:415-27. https://doi.org/10.1016/j.scitotenv.2014.12.101
11. Kumar M, Chaudhary V. Effect of integrated sources of nutrients on growth, flowering, yield and soil quality of floricultural crops: a review. *Int J Curr Microbiol Appl Sci.* 2018;7(3):2373-404. https://doi.org/10.20546/ijcmas.2018.703.278
12. Kumar M, Chaudhary V, Naresh RK, Maurya OP, Pal SL. Does integrated sources of nutrients enhance growth, yield, quality and soil fertility of vegetable crops. *Int J Curr Microbiol Appl Sci.* 2018;7(6):125-55. https://doi.org/10.20546/ijcmas.2018.706.017
13. Tiwari H, Kumar M, Naresh RK, Singh MK, Malik S, Singh SP, Chaudhary V. Effect of organic and inorganic fertilizers with foliar application of gibberellic acid on productivity, profitability and soil health of marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. *Int J Agric Stat Sci.* 2018;14(2):575-85.
14. Gupta A, Dwivedi A, Shukla A, Agnihotri G. Integrated nutrient management for sustainable mungbean production: a review of the opportunities and challenges. *Int J Adv Biochem Res.* 2024;8(12):1156-62.
15. Gruhn P, Goletti F, Yudelman M. Integrated nutrient management, soil fertility and sustainable agriculture: current issues and future challenges. *Int Food Policy Res Inst.* 2000.
16. Zhang F, Cui Z, Fan M, Zhang W, Chen X, Jiang R. Integrated soil-crop system management: reducing environmental risk while increasing crop productivity and improving nutrient use efficiency in China. *J Environ Qual.* 2011;40(4):1051-7. https://doi.org/10.2134/jeq2010.0292
17. Arancon NQ, Edwards CA, Bierman P, Welch C, Metzger JD. Influences of vermicomposts on field strawberries. 1. Effects on growth and yields. *Bioresour Technol.* 2004;93(2):145-53. https://doi.org/10.1016/j.biortech.2003.10.014
18. Mashaldi A. Effect of organic and inorganic fertilizers on growth, yield and post-harvest life of marigold (*Tagetes erecta* L.) cv. Double Orange [MSc thesis]. Univ Agric Sci Bangalore; 2004.
19. Khader JBM, Chezhiyan M, Ponnuswami V, Thamburaaj S, Rangaswami P. Studies on the effect of micronutrients on crossandra. *South Indian Hort.* 1985;33:143-4.
20. Balakrishnan V, Jawaharlal M, Kumar TS, Ganga M. Response of micro-nutrients on flowering, yield and xanthophyll content in African marigold (*Tagetes erecta* Linn.). *J Ornam Hortic.* 2007;10(3):153-6.
21. Singh AK, Sisodia A, Sisodia V, Kirti A. Effect of foliar application of boron and zinc on growth and flowering characters in African marigold cv. Pusa Narangi Gainda. *J Ornam Hortic.* 2018;21(1-2):1-6.
22. Tognetti VB, Zurbriggen MD, Morandi EN, Fillat MF, Valle EM, Hajirezaei MR, Carrillo N. Enhanced plant tolerance to iron starvation by functional substitution of chloroplast ferredoxin with a bacterial flavodoxin. *Proc Natl Acad Sci USA.* 2007;104:11495-500. https://doi.org/10.1073/pnas.0704553104
23. Gomez KA, Gomez AA. *Statistical procedures for agricultural research.* New York: John Wiley & Sons; 1984.
24. Choudhary A, Mishra A, Nagar KK, Meena R. Foliar application of zinc and salicylic acid on African marigold. *J Crop Weed.* 2016;12(3):107-11.
25. Singh P, Prakash S, Kumar M, Malik S, Singh MK, Kumar A. Effect of integrated nutrient management (INM) on growth, flowering and yield in marigold (*Tagetes erecta* L.) cv. Pusa Basanti. *Ann Hortic.* 2015;8(1):73-80.
26. Sharma G, Singh P. Response of NPK on vegetative growth,

flowering and corm production in gladiolus under mango orchard. *J Ornam Hortic.* 2007;10(2):52-4.

27. Edwards CA. Historical overview of vermicomposting. *Biocycle.* 1995;36:56-8.
28. Shyala MR, Dhanasekaran D, Rameshkumar S. Effect of foliar application of micronutrients and potassium humate on growth and flower yield of African marigold (*Tagetes erecta* L.). *Ann Plant Soil Res.* 2019;21(2):101-7.
29. Singh L, Gurjar PKS, Barholia AK, Haldar A, Shrivastava A. Effect of organic manures and inorganic fertilizers on growth and flower yield of marigold (*Tagetes erecta* L.) var. Pusa Narangi Gainda. *Plant Arch.* 2015;15(2):779-83.
30. Thirumalmurugan V, Manivannan K, Nanthakumar S. Influence of micronutrients on growth, flowering and yield of African marigold (*Tagetes erecta* L.). *J Pharmacogn Phytochem.* 2021;10(3):461-3.
31. Singh AK, Singh SV, Sisodia A, Hembrom R. Effect of pinching and nitrogen on growth, flowering and seed yield in African marigold cv. Pusa Narangi Gainda. *Environ Ecol.* 2015;33(4B):1876-9.

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