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INFLUENCE OF DIFFERENT ORGANIC NUTRIENT SOURCES ON GROWTH AND YIELD OF MARIGOLD CV. PUSA ARPITA

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ABSTRACT

Marigold (*Tagetes patula* L.) is a commercially significant ornamental flower in India due to its ease of cultivation, adaptability, prolonged flowering period and excellent shelf life. Organic manures, such as farmyard manure (FYM) and vermicompost, improve soil structure and microbial activity, while bio-fertilizers like Azotobacter enhance nutrient availability. Integrating organic and inorganic fertilizers promotes sustainable agriculture, reducing environmental pollution and fertilizer costs while maintaining soil health. A field experiment was conducted at the Horticulture Research Field, Department of Horticulture, C.C.R. P.G. College, Muzaffarnagar, from September 2021 to April 2022, using the 'Pusa Arpita' variety. The study followed a Randomized Block Design (RBD) with 11 treatments and three replications. Treatment T_{11} (½ RDF + ½ PSB + ½ Vermicompost) exhibited the highest growth parameters, including plant height (57.47 cm at 85 DAT), stem diameter (18.21 mm) and plant spread (41.17 cm). Additionally, T_{11} recorded the maximum number of leaves per plant (143.89) and the highest number of primary branches. Moreover, T_{11} resulted in the earliest flowering (41.39 days) and the highest flower yield per plant (38.56 flowers). It also significantly enhanced quantitative yield per plant (133.58 g), per plot (5.98 kg) and per hectare (402.09 q). The findings suggest that combining organic and inorganic fertilizers enhances growth, yield and sustainability in marigold cultivation. Adopting eco-friendly practices can improve productivity while ensuring long-term soil health, making it a viable approach for commercial marigold production.

Key words : Marigold, Organic manure, Bio fertilizers, Growth, Yield.

Introduction

Marigold (*Tagetes patula* L.) is widely cultivated in India for its loose flowers due to its ease of cultivation, adaptability to diverse soil and climatic conditions, prolonged flowering period and excellent shelf life. It is a dominant species in ornamental horticulture and one of the most commercially significant flowers in India.

Marigold belongs to the family Asteraceae (formerly Compositae). The *Tagetes* genus comprises 33 species with *Tagetes erecta*, *T. patula*, *T. tenuifolia*, *T. lucida* (sweet-scented marigold), *T. lacera*, *T. lemmonii*, *T. minuta* and *T. filifolia* being the most notable. Native to Central and South America, particularly Mexico (Datta *et al*., 2008), marigold was introduced to the world from Mexico in the early 16th century. The Portuguese introduced it to India between 1502 and 1550 A.D.

In India, the two commercially significant species are *Tagetes erecta* (African marigold) and *Tagetes patula* (French marigold), valued for their adaptability to a wide range of agro-climatic conditions. Marigold cultivation is expanding rapidly in states such as Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Delhi, West

Bengal and Rajasthan.

Marigold flowers are widely used in religious and social functions, including temple decorations, weddings, and festivals. They are extensively grown for landscaping and ornamental gardening, serving as bedding plants, potted plants, and components of hanging baskets and window boxes. Marigold flowers are also commercially used as cut flowers for bouquets and garlands. Additionally, they have significant industrial applications, particularly in the extraction of essential oils and pigments.

Marigold is known by different names in various regions worldwide. In the United States, it is called the "Friendship Flower," while in Germany, it is referred to as the "Student Flower." In Latin America, it is known as the "Dead Flower," and in Nepal, it is called "Shayapatri."

Marigold thrives in diverse climatic conditions and can be cultivated throughout the year. The primary growing season in the plains is winter, from August to January. However, it is also grown in other seasons such as spring (November to April), summer (February to July) and the rainy season (May to October).

A natural yellow dye extracted from marigold flowers is used to color sheep wool. In cosmetics, marigold-based ointments are effective for treating minor skin damage, sunburn, and broken capillaries. Marigold also has medicinal benefits, enhancing eyesight and improving mood. Traditionally, marigold leaves have been used to treat piles, kidney ailments, muscle pain, ulcers, and wounds. The leaf paste is applied externally to boils and carbuncles, while the flower extract is considered a blood purifier and a remedy for fever, epilepsy, liver disorders, and eye infections (Bose and Yadav, 1993).

Excessive use of chemical fertilizers has led to soil degradation, nutrient imbalance, soil acidity and groundwater contamination (Savci, 2012; Song *et al.*, 2017). To maintain soil fertility and crop productivity, a balanced nutrient management approach is essential. Integrated Nutrient Management (INM) combines organic manures, bio-fertilizers, and judicious use of chemical fertilizers to improve soil quality and enhance agricultural sustainability.

Organic manures such as farmyard manure (FYM) and vermicompost improve soil structure and microbial activity. Bio-fertilizers, such as Azotobacter, a nitrogen-fixing bacterium, play a crucial role in making essential nutrients like nitrogen, phosphorus, potassium, and sulfur available to plants. The combination of organic and inorganic fertilizers enhances nutrient availability while reducing environmental pollution.

Marigold is beneficial for controlling soil nematodes, particularly Meloidogyne spp., due to its nematicidal properties (Husain *et al.*, 2020). It also possesses antibacterial and antimicrobial properties, with the flavonoid patulitrin playing a significant role in combating microbial infections (Rhama and Madhawan, 2011). Additionally, marigold cultivation improves soil health by increasing microbial populations and enhancing nutrient availability, making it an eco-friendly agricultural practice.

The integration of organic manures, bio-fertilizers, and balanced chemical fertilizers promotes sustainable agriculture. Several industries in Andhra Pradesh, Karnataka, and Maharashtra export marigold powder, highlighting its commercial significance. The adoption of eco-friendly farming practices reduces fertilizer costs while maintaining soil health, ensuring profitable and sustainable marigold cultivation.

By incorporating integrated nutrient management strategies, farmers can enhance the quality and yield of marigold while preserving soil fertility and promoting environmental sustainability.

Materials and Methods

The experiment was laid out at the Horticulture research field, Department of Horticulture at C.C.R. P.G. College, Muzaffarnagar from September 2021 to April 2022. 'Pusa Arpita' variety of marigold (*Tagetes patuala* L.) was used in the experiment. The experiment design was laid out in Randomized Block Design (RBD) with 11 treatments and 3 replications. Treatment details are as follows:

S. no.	Notation	Treatment Combination
1.	T_1	Control
2.	T_2	RDF@ 150:60:60 kg/ha (N:P:K)
3.	T_3	FYM @ 30t/ha
4.	T_4	Vermicompost @10 q/ha
5.	T_5	*Azotobacter* @700 ml/ha
6.	T_6	PSB @ 500 ml/ha
7.	T_7	½ RDF + ½ FYM
8.	T_8	½ RDF + ½ Vermicompost
9.	T_9	½ RDF + ½ *Azotobacter*
10.	T_{10}	½ RDF + ½ PSB
11.	T_{11}	½ RDF + ½ PSB + ½ Vermicompost

Observations Recorded

Growth parameters

Height of plant (cm): The height of plant was measured in centimeters at 15 days interval (*i.e.*, 40, 55, 70 and 85 DAT) with the help of meter scale.

Diameter of main stem (mm) : The diameter of

main stem was measured in (mm) with the help of Vernier callipers at the neck of the plant.

Number of primary branches per plant : The branches arising from the main stem were counted at 15 days intervals (*i.e.*, 40, 55, 70 and 85 DAT) and averages were determined.

Total number of leaves per plant : Number of leaves were counted from each tagged plant at 15 days intervals (*i.e.*, 40, 55, 70 and 85 DAT) and averages were determined.

Spread of the plant (cm) : Plant spread was measured separately from North-South and East-West directions in centimeters at 15 days intervals (*i.e.*, 40, 55, 70, and 85 DAT).

Days taken to first flowering (number of days): Days to first flower initiation was recorded from the transplanting to date when the first flower of plant fully opened.

Number of flowers per plant: Total number of flowers produced per plant was counted then noted and average of flowers per plant was calculated.

Yield parameters

Yield of flowers per plant (g) : The flowers collected from each tagged plant were weight after each picking till the flowers from selected plant harvested. The total yield consolidated by summed up all the fractional yields and average was calculated.

Yield of flowers per plot (kg) : The flowers collected from each plots and weight after each picking till the flowers from all plants harvested. The total yield consolidated at the end by summed the entire fractional yield and averages were calculated.

Yield of flowers (q/h) : After calculating the yield of flowers per plot then yield of flower per hectare for each treatment was calculated with the help of per plot yield and total area.

Results and Discussion

Growth parameters: the data recorded in relevance to effect of different nutrient sources on growth of marigold cv. Pusa Arpita is presented in Tables 1 and 2 and discussed below.

During all the active growth stages—40, 55, 70, and 85 days after transplanting (DAT)—Treatment T_{11} (½ Recommended Dose of Fertilizer (RDF) + ½ Phosphate-Solubilizing Bacteria (PSB) + ½ Vermicompost) demonstrated superior performance in terms of plant growth.

Among the treatments, T_{11} recorded the highest plant height, with measurements of 29.47 cm, 38.52 cm, 50.55 cm, and 57.47 cm at 40, 55, 70, and 85 DAT, respectively. Similarly, it exhibited the greatest stem diameter, reaching 6.94 mm, 9.83 mm, 14.90 mm, and 18.21 mm at the corresponding time intervals. Additionally, the number of primary branches per plant was also highest in T_{11}, increasing progressively to 10.52, 15.72, 18.33 and 21.96 at 40, 55, 70 and 85 DAT, respectively.

These findings indicate that the integrated application of organic and bio-fertilizers in Treatment T11 significantly enhanced vegetative growth parameters compared to other treatments, potentially contributing to improved overall plant vigor and productivity. These findings are

Table 1 : Influence of organic nutrient sources on plant height, stem diameter and number of primary branches of Marigold cv. Pusa Arpita.

Treatment	Plant height (cm)				Diameter of stem (mm)				Number of primary branches			
	40 DAT	55 DAT	70 DAT	85 DAT	40 DAT	55 DAT	70 DAT	85 DAT	40 DAT	55 DAT	70 DAT	85 DAT
T_1	17.25	22.54	35.14	40.62	3.47	5.32	8.19	12.15	6.10	8.31	12.41	16.23
T_2	21.39	25.36	38.79	44.26	4.52	5.82	9.68	13.98	8.05	10.46	14.23	17.86
T_3	23.45	26.26	41.94	43.96	4.64	5.72	9.76	13.22	8.39	10.32	14.46	17.36
T_4	23.57	28.33	42.65	45.04	4.80	5.44	10.77	13.43	8.49	11.36	15.51	18.23
T_5	24.49	29.60	42.45	47.10	5.16	5.42	10.83	13.32	9.10	11.41	15.52	18.24
T_6	25.71	32.28	44.40	47.81	5.53	6.58	11.81	14.24	9.25	12.42	16.53	19.33
T_7	26.51	33.32	45.61	51.07	5.68	7.61	11.98	14.62	9.32	12.63	16.37	19.64
T_8	26.50	34.40	46.45	52.76	5.88	7.50	12.91	15.58	9.37	13.54	16.42	19.66
T_9	28.39	35.33	48.39	53.13	6.55	8.57	12.87	15.63	10.03	13.70	17.39	20.67
T_{10}	28.41	36.50	49.53	55.41	6.89	8.62	12.80	16.66	10.29	14.65	17.17	20.26
T_{11}	29.47	38.52	50.55	57.47	6.94	9.83	14.90	18.21	10.52	15.72	18.33	21.96
S.E.(m)±	0.56	0.46	0.54	0.35	0.32	0.50	0.48	0.39	0.34	0.34	0.46	0.36
C. D. at 5%	1.68	1.37	1.61	1.06	0.95	1.49	1.44	1.18	6.10	8.31	12.41	16.23

Table 2 : Influence of organic nutrient sources on Number of leaves per plant, spread of the plant, Days taken for first flowering and number of flowers per plant of Marigold cv. Pusa Arpita.

Treatment	Number of leaves per plant				Spread of the plant (Cm)				Days taken for first flowering	Number of flowers per plant
	40 DAT	55 DAT	70 DAT	85 DAT	40 DAT	55 DAT	70 DAT	85 DAT		
T_1	19.20	28.64	45.61	66.48	10.33	18.51	22.88	24.51	59.70	14.69
T_2	25.25	34.33	69.07	88.56	12.14	20.17	24.77	26.26	57.53	24.58
T_3	28.29	42.00	83.47	88.37	12.91	20.85	24.73	28.48	54.40	22.76
T_4	29.89	49.60	93.37	124.20	13.33	21.88	25.73	29.37	51.40	25.79
T_5	31.77	52.62	102.37	120.39	13.41	22.75	24.95	30.47	50.32	32.72
T_6	29.88	53.34	97.63	137.39	13.66	23.39	26.70	31.43	48.62	31.63
T_7	33.33	57.88	104.54	124.10	14.41	25.71	26.82	33.31	47.43	29.62
T_8	30.40	52.66	105.98	131.02	15.10	26.18	29.63	35.81	46.72	31.65
T_9	29.45	58.56	109.10	123.03	16.18	26.32	31.62	38.79	43.76	32.62
T_{10}	28.33	47.50	96.44	127.02	16.34	28.07	33.73	39.63	43.76	35.56
T_{11}	34.02	62.39	110.46	143.89	18.35	31.75	37.50	41.17	41.39	38.56
S.E.(m)±	0.28	0.52	0.40	0.44	0.33	0.34	0.46	0.45	0.62	0.52
C. D. at 5%	0.84	1.56	1.20	1.32	0.99	1.02	1.39	1.33	1.85	1.56

Table 3 : Effect of different organic manures and bio fertilizers on yield of Marigold cv. Pusa Arpita.

Treatment	Treatment combination	Yield of flowers per plant (g)	Yield of flowers per plot (kg)	Yield of flower per ha (q)
T_1	Control	80.59	1.20	151.41
T_2	RDF@ 150:60:60 kg/ha (N:P:K)	86.42	1.76	208.35
T_3	FYM @ 30t/ha	94.30	2.80	292.47
T_4	Vermicompost @10 q/ha	108.59	2.47	181.32
T_5	Azotobacter @700 ml/ha	115.05	3.80	248.28
T_6	PSB @ 500 ml/ha	116.79	3.65	222.48
T_7	½ RDF + ½ FYM	108.50	4.47	327.87
T_8	½ RDF + ½ Vermicompost	127.60	4.12	340.61
T_9	½ RDF + ½ Azotobacter	120.54	4.54	352.76
T_{10}	½ RDF + ½ PSB	128.22	5.56	385.41
T_{11}	½ RDF + ½ PSB + ½ Vermicompost	133.58	5.98	402.09
S.E.(m) ±		0.49	0.39	0.57
C. D. at 5%		1.47	1.17	1.71

conformity with Singh and Rao (2005) and Chadha *et al*. (2002) in marigold.

The data related to growth traits, as presented in Table 2, indicate that across all observed growth stages i.e., 40, 55, 70, and 85 days after transplanting (DAT)—Treatment T_{11} (½ Recommended Dose of Fertilizer (RDF) + ½ Phosphate-Solubilizing Bacteria (PSB) + ½ Vermicompost) exhibited superior performance in key growth parameters.

In Treatment T_{11}, the number of leaves per plant was recorded as the highest, progressively increasing to 34.02, 62.39, 110.46 and 143.89 at 40, 55, 70, and 85 DAT, respectively. Additionally, this treatment also resulted in the widest plant spread, measuring 18.35 cm, 31.75 cm, 37.50 cm and 41.17 cm at the respective growth stages.

Moreover, treatment T_{11} demonstrated earliest flowering, with the shortest duration to first flowering (41.39 days), indicating an accelerated reproductive phase. Furthermore, this treatment recorded the highest number of flowers per plant (38.56), suggesting a potential improvement in reproductive efficiency and yield.

These findings highlight the effectiveness of integrating organic and bio-fertilizers in enhancing vegetative growth, promoting early flowering, and increasing the overall floral output, which could contribute to improved productivity and crop performance. These findings are the close confirm with Chadha *et al*. (2002)

and Garge *et al.* (2020) in marigold.

Yield parameters : The yield parameters recorded in relevance to the study are yield of flowers per plant (g), yield of flowers per plot (Kg) and yield of flowers per hectare (q). The data pertaining to these parameters are presented in Table 3 and discussed below.

The treatment T_{11} (½ RDF + ½ PSB + ½ Vermicompost) significantly exhibited the superiority in yield. The same treatment recorded highest quantitative yield per plant (133.58 g), per plot (5.98 kg) and per hectare (402.09 q).

The results clearly indicate that the combined application of chemical fertilizers, bio-fertilizers, and organic amendments in treatment T_{11} effectively enhanced yield potential. This improvement may be attributed to better nutrient availability, improved soil health, and enhanced plant vigor, ultimately leading to higher productivity. The results obtained were similar to finding of Shashikanth (2005) and Garge *et al.* (2020) in marigold.

Conclusion

The study demonstrated that integrating organic and inorganic fertilizers significantly enhances the growth, flowering, and yield of marigold (*Tagetes patula* L.). Among the treatments, T_{11} (½ RDF + ½ PSB + ½ Vermicompost) proved to be the most effective, resulting in the highest plant height, stem diameter, number of leaves, plant spread, and number of flowers per plant. Additionally, this treatment led to the earliest flowering and the highest quantitative yield per plant, per plot, and per hectare.

These findings highlight the benefits of combining organic and bio-fertilizers with chemical fertilizers to improve nutrient availability while maintaining soil health. The approach promotes sustainable and eco-friendly marigold cultivation, reducing dependency on synthetic fertilizers and minimizing environmental impact. Given its superior performance, the T_{11} treatment can be recommended for optimizing marigold production and ensuring profitability for growers.

Competing interests

"Authors have declared that no competing interests exist."

Authors contributions

Mahima Sharma - designed and conducted the study, Data collection, analysis and interpretation of results.

Prof. Vijai Kumar - facilitated the resources required and provided technical guidance.

Karthik, D. R. - wrote the manuscript and sourced the journal for publication.

Harshit Vimal - Assisted in conduct of experiment.

Atul Kumar Mishra - Assisted in conduct of experiment.

All authors read and approved the final manuscript.

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