



RESEARCH ARTICLE

# Effect of organic nutrient management on plant growth and flower production of African marigold (*Tagetes erecta* L.) cv. Pusa Narengi Gainda in mid hills of Sikkim

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## Abstract

The present experiment was conducted at College of Horticulture (Central Agricultural University, Imphal), Birmiok, Sikkim during winter season of 2022–2023 to study the effect of organic nutrients on the growth, flowering and yield production of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. The experimental design was laid out in a randomized block design (RBD) with 3 replication and eight treatment combinations, viz. T<sub>1</sub>: Farmyard manure (FYM) (20 t/ha), T<sub>2</sub>: Poultry manure (PM) (6 t/ha), T<sub>3</sub>: Goat manure (GM)(10 t/ha), T<sub>4</sub>: FYM+ PSB (200 g/m<sup>2</sup>), T<sub>5</sub>: FYM + Vesicular–arbuscular mycorrhiza (VAM) (100 g/m<sup>2</sup>), T<sub>6</sub>: FYM + PSB + VAM, T<sub>7</sub>: FYM+ PM +GM with control (T<sub>8</sub>). The experimental results showed that maximum plant height (56.45 cm), plant spread (41.13 cm), stem girth (1.00 cm), number of branches per plant (26.06), days to flower bud initiation (44.50), days to 50 % flowering (70.96), flowering duration (86.00), number of flowers/plant (34.22), flower diameter (7.18 cm), length of flower stalk (6.76 cm), weight of the flower (13.00 g) and flower yield/plant (709.56 g) was observed with T<sub>7</sub> and lowest was observed in control. Hence among all the treatments T<sub>7</sub>: FYM + PM +GM has a positive impact on plant growth, flower and yield attributes of African Marigold cv. Pusa Narangi Gainda.

**Keywords:** farmyard manure; goat manure; organic nutrient management; poultry manure; phosphate solubilizing bacteria; vesicular–arbuscular mycorrhiza

## Introduction

The African marigold (*Tagetes erecta* L.) cv. Pusa Narangi, a member of the Asteraceae family, is one of the most widely planted loose flowers and is used extensively in many forms for religious and social purposes (1). This family has 23000 species and 1600 genera, including climbers, shrubs, herbs and medicinal plants (2). African marigold blooms can be preserved amazingly well when cut and they have an appealing range of colours that last for a very long duration. The entire plant can occasionally be utilised as a decorative element. Marigold is native to Central and South America particularly Mexico. "Tages" is the name of the Etruscan God, who is renowned for his beauty. This is where the generic term *Tagetes* comes from. The term "Tagetes" was originally used by the French and subsequently adopted by other languages (3). Before being brought to Europe and South Asia, particularly India, marigolds were domesticated and cultivated as attractive plants throughout the pre-Columbian era. Both *T. erecta* and *T. patula* are grown commercially in India for cut flowers, but *T. erecta* commands higher rates. African marigold cultivars differ

in terms of bloom size, quality, yield and plant height and spread (4) The flowers are big and shaped like globules. Light yellow, creamy yellow, bright yellow, cadmium orange, deep orange, sulphur, yellow and white are among the colour hues. The African marigold has 2n = 24 chromosomes.

Marigold is an ornamental plant commonly grown throughout India including Himalayan state Sikkim, where floriculture has been established as one of the promising sectors for the marginal and small-scale farmers. Marigold is not only brightly coloured and has cultural significance but also commands a high price in the market that makes it as one of the most commercially viable flowers for small and marginal farmers in the region. In landscaping architecture, it is grown in flower beds, borders and even as potted plants. Flowers are sold in the market as loose flowers or for making garlands. High-quality perfumes can also be made from their essential oils, which contain mucilage, saponins, flavonoids, xanthophylls, phenolics, essential oils and carotenoids. It has antispasmodic and anti-inflammatory properties and is used to treat skin, gastric and eye conditions as well as some burns (5, 6).

The agro-climatic conditions of Sikkim, varying from subtropical to temperate, are well-suited for cultivation of marigold, particularly in the mid-hills. The flower is grown extensively within religious offerings, wedding decorations and garland making because festivals such as Dasain and Tihar (Diwali) are widely celebrated in the state. Marigold farming offers great potential for income generation, employment, with export opportunities, particularly for rural women and youth. The increasing amount of support from the Sikkim government assists this farming through various missions of organic farming and horticulture.

Organic nutrient management has a key function in marigold (*T. erecta*) farming in Sikkim because it follows the state's bar on chemical additions as the Sikkim Organic Mission (7). Soil fertility, microbial activity and moisture retention with organic amendments such as farmyard manure (FYM), vermicompost and biofertilisers (e.g., Azotobacter, PSB) are improved, which is particularly important in the hilly terrain of the region (8). These inputs also reduce input costs, so they are economically sustainable toward smallholder and women farmers (9).

Furthermore, organic cultivation opens opportunities for getting a premium pricing and certification. This rings especially true for high-value items like important oils, natural dyes and export garlands (10). It also does help the fragile Himalayan ecosystem to sustain itself environmentally. This assistance occurs in a case where it works to prevent soil from further eroding, groundwater from eventually becoming contaminated and biodiversity from ultimately being lost (11). Keeping in this view, the present investigation was undertaken to study the effect of organic nutrient management for the quality production of African marigold.

## Materials and Methods

### Experimental site

The study was carried out at Department of Floriculture & Landscaping, College of Horticulture (Central Agricultural University, Imphal), Birmiok, Sikkim during winter season 2022 to 2023. The experiment site is located at an elevation of 941.57 m above sea level at a latitude 27°13'3" N and longitude of 88°28'28" E.

### Experiment design

The experiment was laid out in randomized block design (RBD) constituting eight treatments replicated thrice with plot size 3 m<sup>2</sup> spaced at 60 cm × 45 cm.

The marigold cv. Pusa Narangi Gainda seedlings were raised in the nursery at a spacing of 10 × 5–7 cm in a plot measuring 13 × 1 m. The seedlings were then transplanted into plots measuring 1 × 1 m at a spacing of 45 × 30 cm. Every virtue-based agronomic practice was occasionally used. Until the seedlings were prepared for

transplantation, the nursery beds were kept in a systematic way for up to 45 days. When marigold seedlings reached the 2 to 3 true leaf stage, they were moved to the main field. Soil was tightly packed around the seedlings during the transplanting process to prevent irrigation water from disturbing them right away. Before 10 days after planting, each plot received a manual application of the organic manures (Farmyard manure (FYM), poultry manure (PM), compost and vermicompost) in accordance with treatments. For the in-depth investigation of vegetative growth, floral and flower yield, 5 plants were chosen from each treatment in each replication using the random sample technique. This observation was made after 30, 60 and 90 days of crop growth.

### Treatment details

The treatment details are T<sub>1</sub>: FYM (20 t/ha), T<sub>2</sub>: PM (6 t/ha), T<sub>3</sub>: Goat manure (GM) (10 t/ha), T<sub>4</sub>: FYM+ Phosphate solubilizing bacteria (PSB) (200 g/m<sup>2</sup>), T<sub>5</sub>: FYM +VAM (100 g/m<sup>2</sup>), T<sub>6</sub>: FYM + PSB + VAM, T<sub>7</sub>: FYM+ PM +GM with control (T<sub>8</sub>).

Manual weeding was done on a regular basis to keep the experimental plot free of weeds.

The data were statistically examined using AGRISTAT software and in accordance with the usual protocols provided by previous researchers (12). Critical differences (CD) were calculated at the 1 and 5 % probability levels.

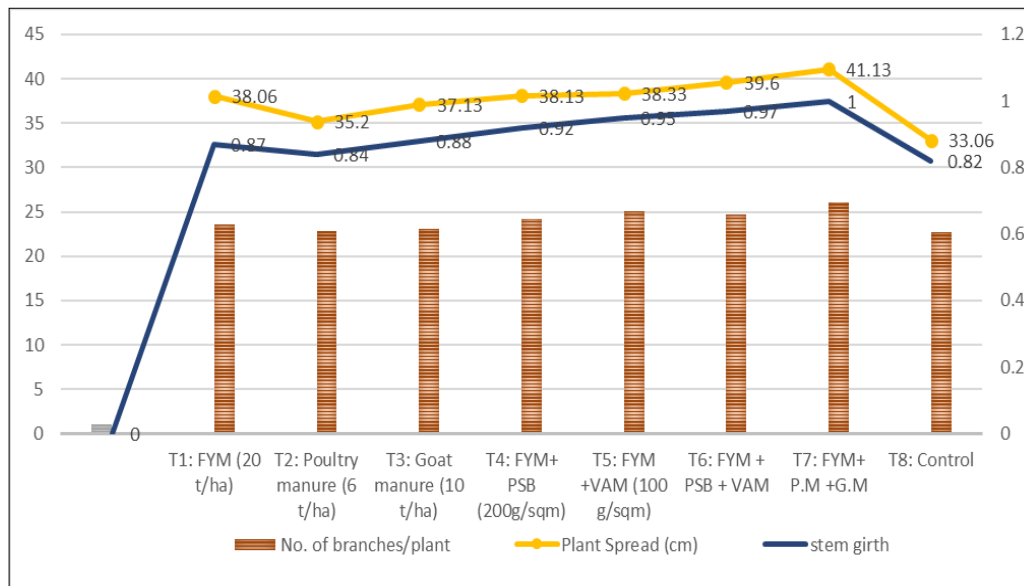
## Results and Discussion

### Vegetative parameters

From the experiment it was observed that effect of organic nutrient is significant with respect to the plant growth data presented in Table 1. and Fig. 1. Maximum plant height (27.26 cm, 35.20 cm and 56.45 cm) was observed at 30 days after transplanting (DAT), 60 DAT, 90 DAT, plant spread (41.13 cm), stem girth (0.44 cm, 0.87 cm and 1.00 cm) at 30 DAT, 60 DAT, 90 DAT, number of branches per plant (26.06) were recorded with the treatment (T<sub>7</sub>) followed by treatment T<sub>6</sub>(25.40 cm, 33.13 cm and 54.26 cm) at 30 DAT, 60 DAT and 90 DAT, plant spread (39.60 cm), stem girth (0.42 cm, 0.85 cm and 0.97 cm) at 30 DAT, 60 DAT and 90 DAT and number of branches per plant (24.66) respectively. Minimum plant height (15.70 cm, 25.50 cm and 44.60 cm) at 30 DAT, 60 DAT, 90 DAT, plant spread (33.06 cm), stem girth (0.37cm, 0.73 cm at 0.82 cm) at 30 DAT, 60 DAT and 90 DAT and no. of branches per plant (22.73) were recorded in control (T<sub>8</sub>) (Table 1 and Fig. 1). This might be due to nitrogen, a necessary component of nucleic acid, which plays a critical function in accelerating cell division and enlargement as well as initiating plant meristematic activity, which in turn promotes plant development. Therefore, nitrogen plays a major role in plant growth. Poultry manure was

**Table 1.** Effect of organic nutrient management on morphometric characteristic of African marigold (*Tagetes erecta*) var. Pusa Narengi Gainda

Treatment	Plant height (cm)			Plant spread (cm)	Stem girth (cm)			No. of branches/plant
	30 DAT	60DAT	90 DAT		30 DAT	60DAT	90 DAT	
T <sub>1</sub> : FYM (20 t/ha)	22.23	31.40	53.2	38.06	0.38	0.80	0.87	23.56
T <sub>2</sub> : Poultry manure (6 t/ha)	18.70	27.13	45.66	35.20	0.36	0.76	0.84	22.80
T <sub>3</sub> : Goat manure (10 t/ha)	20.66	29.33	47.6	37.13	0.39	0.77	0.88	23.13
T <sub>4</sub> : FYM+ PSB (200g/sqm)	23.33	31.13	50.13	38.13	0.40	0.83	0.92	24.26
T <sub>5</sub> : FYM +VAM (100 g/sqm)	25.13	32.53	52.33	38.33	0.41	0.80	0.95	25.13
T <sub>6</sub> : FYM + PSB + VAM	25.40	33.13	54.26	39.60	0.42	0.85	0.97	24.66
T <sub>7</sub> : FYM+ P.M +G.M	27.26	35.20	56.45	41.13	0.44	0.87	1.00	26.06
T <sub>8</sub> : Control	15.70	25.50	44.6	33.06	0.37	0.73	0.82	22.73
Mean	22.30	30.67	50.53	37.58	0.40	0.80	0.91	24.04
S.Ed	0.93	1.03	1.09	0.760	0.015	0.010	0.010	0.460
CD (5 %)	1.87	2.08	2.2	1.540	0.030	0.300	0.300	0.940



**Fig. 1.** Effect of organic nutrient management on morphometric characteristic of African marigold (*Tagetes erecta*) cv. Pusa Narangi Gaiinda

the best organic source of nutrients, helping to improve the soil's physio-chemical characteristics (pH, EC, organic carbon and macro and micronutrients) due to its higher analytical values. Additionally, it has been demonstrated experimentally that a significant portion of the nitrogen found in poultry manure is made up of uric acid, which is easily absorbed by plants (13). Poultry dung has a smaller C:N ratio than other types, which reduces the amount of nitrogen released (13). When it is added to soil, poultry manure enhances texture, loosens the soil, increases its capacity to store water and elevates the humus status, all of which preserve the ideal circumstances for microbial activity (14). The similar finding was agreed with that organic nutrients enhance the vegetative and yield components of crops (15). Additionally, noted that in addition to nitrogen, phosphorus and potassium (NPK) fertiliser, organic fertiliser provides macro and micronutrients that supply nutrients and have a major impact on the number of branches per plant (16, 17).

### Flowering parameters

Data presented in Table 2 on flowering parameters showed significant response to the different treatments of organic nutrient management. Earliest flower bud initiation (44.50 days), minimum days to 50 % flowering (70.96), maximum flowering duration (86.00 days), flower diameter (7.18 cm), flower stalk length (6.75 cm) and fresh weight of flower (13 gm) was recorded with treatment T<sub>7</sub>. Maximum days required for flower bud initiation (62.33), days to 50 % flowering (78.12), minimum flowering duration (75.30 days), flower diameter (5.64 cm), flower stalk

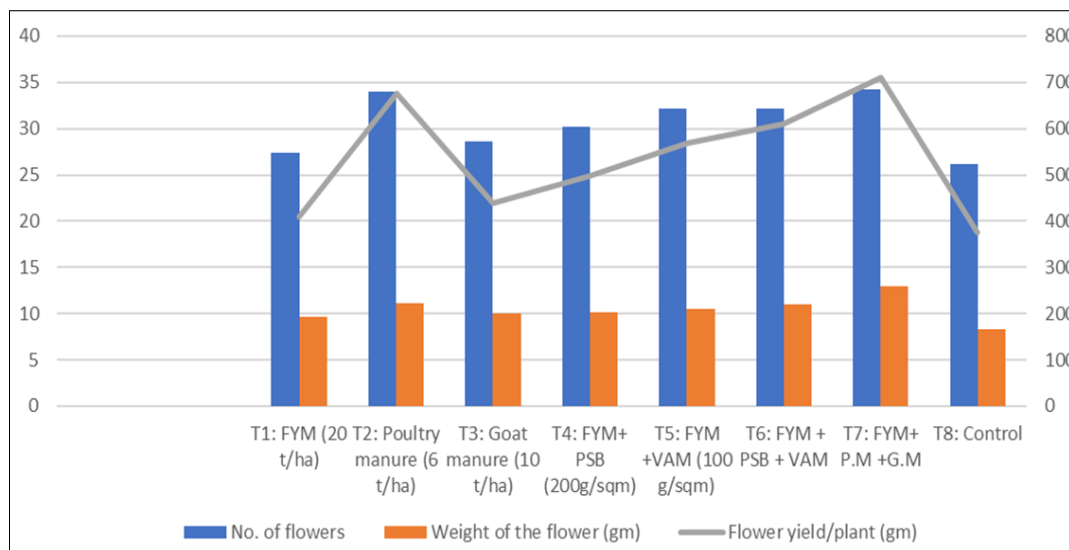
length (6.40 cm) and weight of the flower (8.26 gm) was observed in control (T<sub>8</sub>) (Table 2 & Fig. 2). It might be because of auxiliary buds receiving growth-promoting substances and nutrients more easily, which disrupts apical dominance. Ultimately, this might have created a better sink for the faster mobilisation of photosynthates and the earlier departure of plant parts from the vegetative to reproductive phase. The application of FYM combination with poultry manure and goat manure provides nitrogen and other vital nutrients for a longer period. Poultry manure has high levels of NPK and other vital nutrients, it is a great organic manure. According to earlier reports, P must be given more easily than other organic sources. Poultry manure reduces exchangeable Al and Fe concentrations and soil bulk density while increasing soil organic matter content, accessible P, exchangeable cations and micronutrients (18). Similar results were reported that organic nutrients application enhanced the flower and yield parameters of marigold (*T. erecta*) (19, 15). Integrating organic nutrients results in superior flower quality and yield compared to inorganic fertilisers in marigold (20–24).

### Yield parameters

Tabulation data (Table 2) on yield parameters clearly indicated that a significantly maximum number of flowers per plant (34.22) and flower yield per plant (709.56 g) was found in treatment (T<sub>7</sub>) which was followed by treatment T<sub>2</sub> (33.98) and (676.68 gm). Further plants grown in control (T<sub>8</sub>) resulted in minimum flowers per plant (26.12) and flower yield (376.12 g) (Table 2 & Fig. 2). The combined application of farmyard manure with poultry and

**Table 2.** Effect of organic nutrient management on flowering and yield parameters of African marigold (*Tagetes erecta*) var. Pusa Narengi Gaiinda

Treatment	Days to flower bud initiation	Days to 50 % flowering	Flowering duration (Days)	No. of flowers /plant	Flower diameter (cm)	Length of flower stalk (cm)	Weight of the flower (gm)	Flower yield/ plant (gm)
T <sub>1</sub> : FYM (20 t/ha)	60.00	76.42	83.94	27.42	6.10	6.46	9.64	408.55
T <sub>2</sub> : Poultry manure (6 t/ha)	55.00	74.00	85.00	33.98	6.84	6.71	11.11	676.68
T <sub>3</sub> : Goat manure (10 t/ha)	57.96	74.80	81.00	28.57	6.46	6.52	10.03	439.97
T <sub>4</sub> : FYM+ PSB (200g/sqm)	57.46	74.20	82.13	30.16	6.67	6.62	10.11	497.64
T <sub>5</sub> : FYM +VAM (100 g/sqm)	58.19	76.12	80.08	32.14	7.09	6.70	10.53	567.91
T <sub>6</sub> : FYM + PSB + VAM	61.15	77.84	83.66	32.15	6.69	6.52	11.02	609.11
T <sub>7</sub> : FYM+ P.M +G.M	44.50	70.96	86.00	34.22	7.18	6.76	13.00	709.56
T <sub>8</sub> : Control	62.33	78.12	75.30	26.12	5.64	6.40	8.26	376.12
Mean	57.07	75.30	82.13	30.59	6.58	6.59	10.46	535.69
S.Ed	0.58	0.15	0.49	0.11	0.05	0.024	0.940	15.53
CD (5 %)	1.17	0.29	0.98	0.24	0.08	0.050	1.900	31.05



**Fig. 2.** Effect of organic nutrient management on flowering and yield parameters of African marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda.

goat dung provided a balanced and accessible nutrient supply, enhancing root development and microbial activity. This higher nutritional absorption and photosynthetic efficacy result in enhanced protein and carbohydrate assimilation. Consequently, the plants exhibited vigorous vegetative growth and produced a maximum number of flowers per plant. When added to soil, poultry manure enhances texture, loosens the soil, increases its capacity to store water and elevates the humus status, all of which preserve the ideal circumstances for microbial activity (13). The results of the manuscript were agreed with the finding that the liquid organic fertilisers, formed by composting processing of poultry slaughter waste, can be utilised as alternative source for potted gerbera nutrition, since they provide better and yield (14). Similar results were reported that organic nutrients application increase the yield of marigold (24, 25).

## Conclusion

The present investigation was undertaken to identify a suitable and cost-effective organic manure combination to enhance the growth and flower yield of African marigold (*T. erecta*) under the organic farming conditions of Sikkim. Among the different organic nutrient management treatments evaluated, the T<sub>7</sub> treatment, consisting of FYM in combination with poultry and goat manure, recorded the highest performance in terms of vegetative growth, number of flowers per plant and total yield. The integrated use of these organic manures ensured balanced nutrient availability, improved soil fertility and enhanced microbial activity, leading to sustainable flower production. Thus, the combination of FYM, poultry manure and goat manure can be recommended as an eco-friendly and economically viable nutrient management strategy for small and marginal farmers engaged in organic marigold cultivation in Sikkim.

## Authors' contributions

DS contributed to conceptualization, data curation, formal analysis, investigation, methodology, writing original draft and writing review and editing. SV contributed to data curation, formal analysis, writing original draft and writing review and editing. NG contributed to formal analysis and writing review and editing. SRKS contributed to writing review and editing. AKP contributed

to conceptualisation, methodology, project administration, resources, supervision and writing review and editing. All authors read and approved the final manuscript.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interest to declare.

**Ethical issues:** None

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