Effect of graded levels of Nutrients and Organic amendments on growth and flower yield of African marigold (*Tagetes erecta* L.)

Abstract

Production of marigold can be improved to a large extent by the judicious cultural operations i.e., application of optimum fertilizer at required time and appropriate crop management practices. Excessive application of chemical fertilizers produces adverse effects on the atmosphere and groundwater quality, causing several health hazards. In India, effective nutrient management has played a major role in accomplishing the enormous increase in food production. However, it is not possible to supply all the nutrient requirements of crops through inorganic fertilizers. Integrated Nutrient Management provides an excellent opportunity to sustain soil health and enhance the crop production. To improve the physical, chemical and biological properties of the soil, and increase the efficiency of applied fertilizers, apply the required quantity of organic manures and bio-fertilizers along with balanced use of chemical fertilizers (Verma *et al*., 2011).

In this experiment, the organic amendments *viz.*, Vermicompost, Humic acid and Arka microbial consortium applied as basal and the recommended full dose of phosphorus through single super phosphate and pottasium through Muriate of potash were applied just before transplanting of seedlings. Nitrogen through urea was applied in two split doses, *i.e.*, first ½ dose of total nitrogen was applied at the time of transplanting of seedlings and remaining dose of nitrogen was applied at 45 DAT according to the treatment combinations. The experiment was carried out in Randomized Block Design with three replications and thirteen treatment combinations *viz*. Control (RDF 100% - 90:90:75 kg N, P_2O_5 and K_2O kg ha^{-1}) (T_1), RDF 75% + Vermicompost (T_2), RDF 100% + Vermicompost (T_3), RDF 75% + Humic acid (T_4), RDF 100% + Humic acid (T_5), RDF 75% + Vermicompost + Humic acid (T_6), RDF 100% + Vermicompost + Humic acid (T_7), RDF 75% + Humic Acid + Arka microbial consortium (T_8), RDF 100% + Humic Acid + Arka microbial consortium (T_9), RDF 75% + Vermicompost + Arka microbial consortium (T_{10}), RDF 100% + Vermicompost + Arka microbial consortium (T_{11}), RDF 75% + Vermicompost + Humic Acid + Arka microbial consortium (T_{12}), RDF 100% + Vermicompost + Humic Acid + Arka microbial consortium (T_{13}).

The treatment T_{13} recorded the maximum plant height (109.28 cm), number of branches $plant^{-1}$ (18.74) and number of leaves $plant^{-1}$ (136.94) were recorded for those plants applied with RDF 100% + Vermicompost + Humic Acid + AMC (T_{13}) in 30, 60 and 90 days after transplanting. Similarly, maximum single flower weight (6.95 g), number of flowers $plant^{-1}$

(58.42), flower yield plant^{-1} (312.63 g) and plot^{-1} (10.5 kg), estimated flower yield 13.86 t ha^{-1} and xanthophyll content (18.26 g kg^{-1} of petal meal). Hence, it is concluded that application of Vermicompost @ 5 t ha^{-1} + Humic acid @ 5 kg ha^{-1} along with Arka microbial consortium@ 12.5 kg ha^{-1} in addition with 100 % RDF (90:90:75 kg N, P_2O_5 and K_2O kg ha^{-1}) will be effective in increasing the growth, flower yield and xanthophyll content of African marigold.

Key words: Marigold, Vermicompost, Humic acid, Arka microbial consortium.

Introduction

Marigold gained popularity in the ornamental gardens and flower dealers on account of its easy culture and wide spectrum of attractive colours, shape, size and good keeping quality. (Jyothi *et al*., 2018). Extraction of essential oil and carotenoid pigments started very late in our country. Marigold petals are one of the common concentrated sources of xanthophylls. Petals taken from deep orange-coloured flowers were found to be the best for extraction of more xanthophylls. The carotenoid content of fresh flower petals ranges from 0.2 to 2.69 mg/g and dried petals content about 1.6%. Hence, marigold is used for commercial and medicinal purposes. Continuous application of imbalanced and excessive nutrients has led to decline in nutrient-use efficiency making fertilizer consumption uneconomical and producing adverse effects on atmosphere and ground water quality, causing health hazards. Integrated Nutrient Management (INM) provides an excellent opportunity to overcome all the imbalances besides sustaining soil health and enhancing crop production. The use of organic manures and bio-fertilizers along with balanced use of chemical fertilizers is known to improve the physio-chemical and biological properties of soil, besides improving the efficiency of applied fertilizers (Verma *et al.,* 2011). Abhinav Kumar and Ashok Kumar (2017) also reported increased yield with the application of bio-fertilizers and nutrients on growth and flower yield of African marigold (*Tagetes erecta* L.). Vermicompost is finely divided peat-like material with high porosity, aeration, drainage and water-holding capacity. It contains nutrients in such forms that are readily available to the plants, such as nitrates, exchangeable phosphorus, soluble potassium, calcium, magnesium, etc. Edwards and Burrows (1988). Humic acid is a commercial product contains many elements which improve the soil fertility and increasing the availability of nutrient elements and consequently affected plant growth and yield Hartwigson and Evans, (2000). Arka microbial consortium is a carrier based microbial product which contains N-fixing, P- solubilizing and plant growth promoting microbes Scott *et al,* (1999). Hence, an experiment was laid out to find the influence of organic amendments *viz.,* Vermicompost, Humic acid and

Arka microbial consortium in addition with graded levels of recommended dose of nutrients on growth, flowering and yield in African Marigold.

Materials and Methods

The present investigation was carried out to study the effect of graded levels of nutrients and organic amendments on growth and yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda in the experimental farm of Adhiparasakthi Horticultural College, Kalavai, Vellore district of Tamilnadu during the period of August 2019 to December 2019. The experimental site is geographically located at 12° 46' 13" North latitude and 79° 25' 11" East longitude and at an altitude of 138 meter above mean sea level. The Treatment details are:

Tr. No.	Treatment details
T_1	Control (RDF 100%)
T_2	RDF 75% + Vermicompost
T_3	RDF 100% + Vermicompost
T_4	RDF 75% + Humic acid
T_5	RDF 100% + Humic acid
T_6	RDF 75% + Vermicompost + Humic acid
T_7	RDF 100% + Vermicompost + Humic acid
T_8	RDF 75% + Humic Acid + Arka microbial consortium
T_9	RDF 100% + Humic Acid + Arka microbial consortium
T_{10}	RDF 75% + Vermicompost + Arka microbial consortium
T_{11}	RDF 100% + Vermicompost + Arka microbial consortium
T_{12}	RDF 75% + Vermicompost + Humic Acid + Arka microbial consortium
T_{13}	RDF 100% + Vermicompost + Humic Acid + Arka microbial consortium

RDF 100%	:	90:90:75 kg N, P_2O_5, K_2O ha^{-1}	Humic acid 50%	:	5 kg ha^{-1}
RDF 75%	:	67.5:67.5:56 kg N, P_2O_5, K_2O ha^{-1}	Arka microbial consortium	:	12.5 kg ha^{-1}
Vermicompost	:	5 tonnes ha^{-1}			

The effect of thirteen treatments was studied under randomized block design with three replications. Each treatment was applied to a plot size of 3 x 3 m size with plants spaced at 45 x 35 cm. The experimental plot was kept free from weeds by periodic hand weeding. Protective irrigation was given at an interval of 8-10 days. Five plants from each plot and in all the replications were randomly selected and tagged for recording biometric observations.

Observations on plant height, number of branches per plant, number of leaves per plant, number of flower per plant s, single flower weight, flower yield per plant and flower yield per plot and xanthophyll content were recorded. The data were statistically analyzed following the standard procedures given by Panse and Sukhatme (1961) and using AGRISTAT software in a personal computer. Wherever the results were found significant, critical differences (CD) were worked out at 1 and 5 percent level of probability.

Results and Discussion

From the data it is evident that significant differences were noticed in almost all the characters due to the application of graded levels of nutrients along with organic amendments**.** There was a significant increase in plant height due to various combinations of treatments. The maximum plant height of 109.28 cm observed in T_{13} (RDF 100% + Vermicompost + Humic Acid + AMC) which was found to be significantly high when compared with T_{12} (RDF 75% + Vermicompost + Humic Acid + AMC) which recorded a plant height of 104.90 cm. The lowest plant height of 68.44 cm was observed in T_1 (Control-100% RDF). The maximum number of branches (18.74) were observed in T_{13} (RDF 100% + Vermicompost + Humic Acid + AMC) which was significantly higher than T_{12} (RDF 75% + Vermicompost + Humic Acid + AMC) which recorded 17.73 branches. The least number of 11.69 branches were observed in T_1 (Control-100% RDF). The number of leaves per plant was significantly enhanced due to graded levels of nutrients and organic amendments. The highest number of leaves (136.94) was observed in T_{13} (RDF 100% + Vermicompost + Humic Acid + AMC), was significantly higher than T_{12} (RDF 75% + Vermicompost + Humic Acid + AMC) which recorded 133.39 leaves. The least number of 106.16 leaves were observed in T_1 (Control-100% RDF). From the Table it is evident that significant differences were recorded for number of flowers per plant. Maximum number of flowers (58.42) was recorded under the treatment T_{13} (RDF 100% + Vermicompost + Humic Acid + AMC) which is followed by the treatment T_{12} (RDF 75% + Vermicompost + Humic Acid + AMC) with 57.43 flowers. However, the minimum number of flowers (49.18) were recorded under in T_1 (Control-RDF 100%). The maximum weight of flower (6.95 g) was observed in the treatment T_{13} (RDF 100% + Vermicompost + Humic Acid + AMC) which is followed by T_{12} (RDF 75% + Vermicompost + Humic Acid + AMC) which recorded a flower weight of 6.72 g. The lowest flower weight (4.93 g) was observed in T_1 (Control-RDF 100%). The treatment T_{13} (RDF 100% + Vermicompst + Humic Acid + AMC) recorded the maximum flower yield (312.63 g plant^{-1}). It was followed by T_{12} (RDF 75% + Vermicompost + Humic Acid + AMC) which recorded a flower yield of 297.17 g plant^{-1}. The lowest flower yield of

186.69 g $plant^{-1}$ was observed in T_1 (Control-RDF 100%). The maximum flower yield per plot (10.5 kg) was observed in the treatment T_{13} (RDF 100% + Vermicompost + Humic Acid + AMC) which is followed by T_{12} (RDF 75% + Vermicompost + Humic Acid + AMC) which recorded a flower yield of 9.98 kg. However, the lowest flower yield per plot (6.27 kg) was observed in T_1 (Control-RDF 100%).

The positive influence of N, P and K on growth could be attributed due to the role of N in cell division as well as protein synthesis. This would have ultimately resulted in increased rate of leaf growth and stems. Better availability of nutrients might have increased crop growth and yield components due to optimum level of fertilizer application, which influenced the plant to absorb more nutrients. Vermicompost is not only rich in nutrients but also contains certain organic stimulants like auxins and cytokinins, which enhance sufficient quantity of nutrient flow in the plant system (Radha *et al.*, 1986). Vermicompost contains major and minor nutrients in available forms which also contain enzymes, beneficial microorganisms and other growth substances which have definite advantage over other organic manures in respect of quality and shelf life of the produce (Meerabai and Asha Raj, 2001). The results of the experiment revealed that the application of humic acid along with the organic manure had positive effect on growth and flower yield. The influence of humic acid on growth and its ultimate expression (*i.e.*) flower yield and xanthophyll content could be attributed to role in accelerating the enzyme and hormone systems increasing cell communication and coordination, in increasing synthesis of every molecules and inducing cell division and growth (Adani *et al*., 1998). The results revealed that the application of Arka microbial consortium along with the organic manure had positive effect on growth and flower yield. This may be due to early breaking of apical dominance followed by easy and better translocation of nutrients to the flowers brought about by inoculation with beneficial microbial inoculants like *Azotobacter tropicalis, Bacillus aryabhattai,* and *Pseudomonas taiwanensis* (Ramesh Koli and R Jayanthi, 2018).

Figure 1. Effect of graded levels of nutrients and organic amendments on plant height in African marigold (*Tagetes erecta* L.)

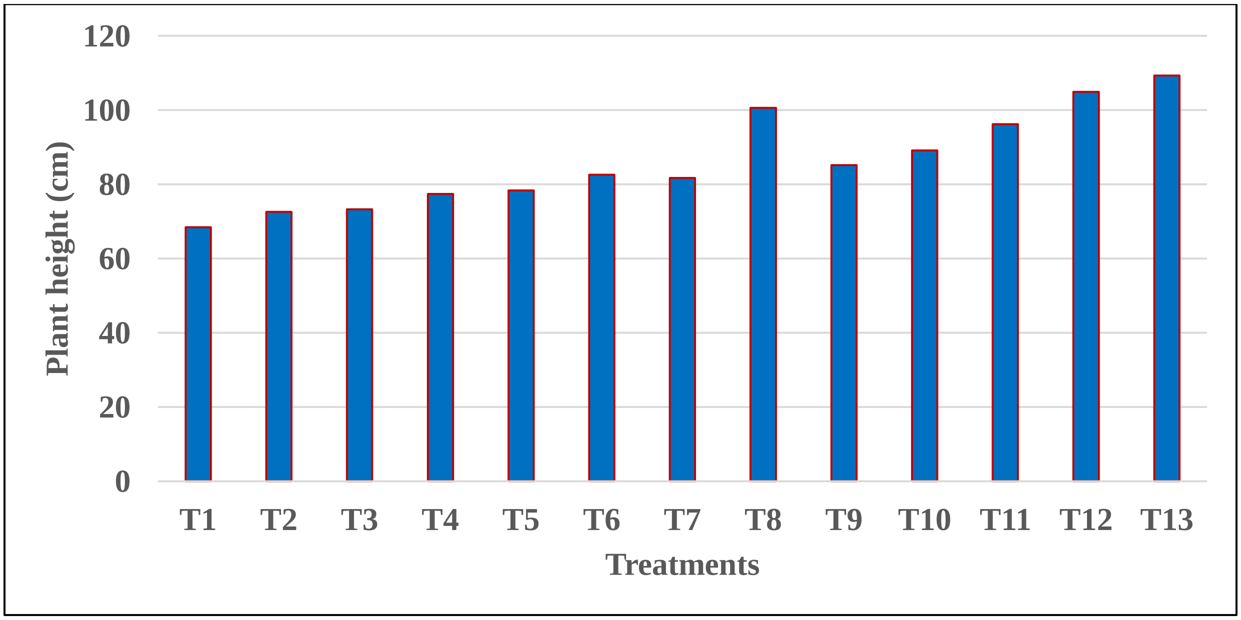
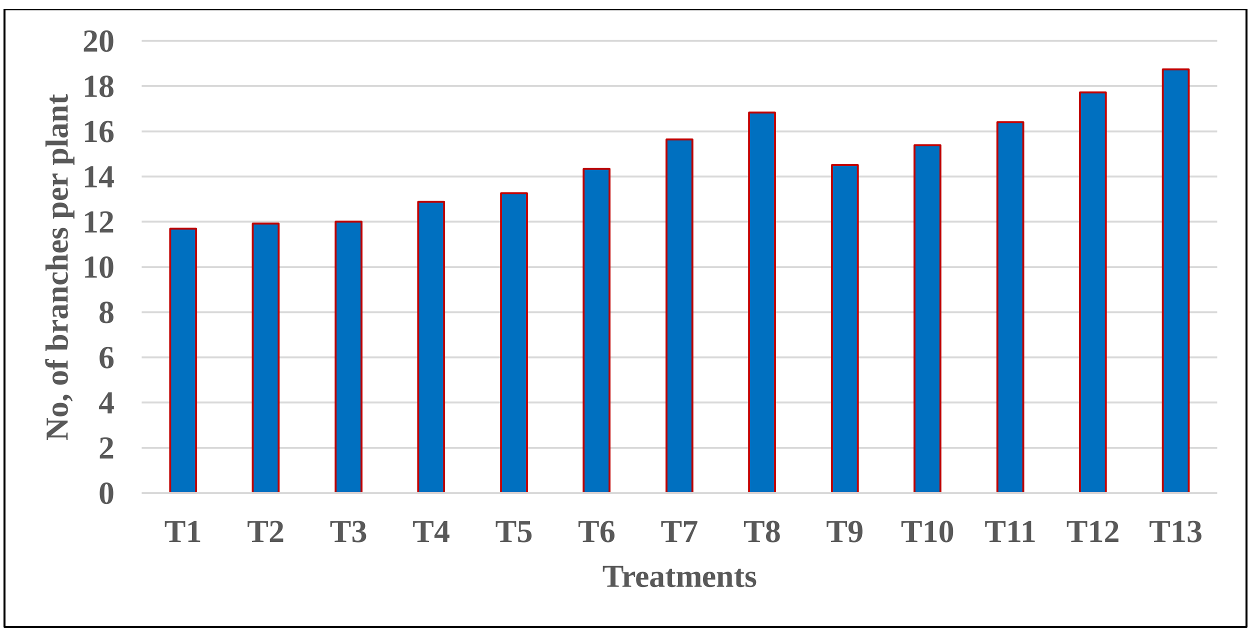


Figure 2. Effect of graded levels of nutrients and organic amendments on number of branches plant^{-1} in African marigold (*Tagetes erecta* L.)



T_1	Control (RDF 100%)	T_8	RDF 75% + Humic Acid + AMC

T_2 RDF 75% + Vermicompost
T_3 RDF 100% + Vermicompost
T_4 RDF 75% + Humic acid
T_5 RDF 100% + Humic acid
T_6 RDF 75% + Vermicompost + Humic acid
T_7 RDF 100% + Vermicompost + Humic acid
T_9 RDF 100% + Humic Acid + AMC
T_{10} RDF 75% + Vermicompost + AMC
T_{11} RDF 100% + Vermicompost + AMC
T_{12} RDF 75% + Vermicompost + Humic Acid + AMC
T_{13} RDF 100% + Vermicompost + Humic Acid + AMC

Figure 3. Effect of graded levels of nutrients and organic amendments on flower stock length, flower head diameter and single flower weight in African marigold (*Tagetes erecta* L.)

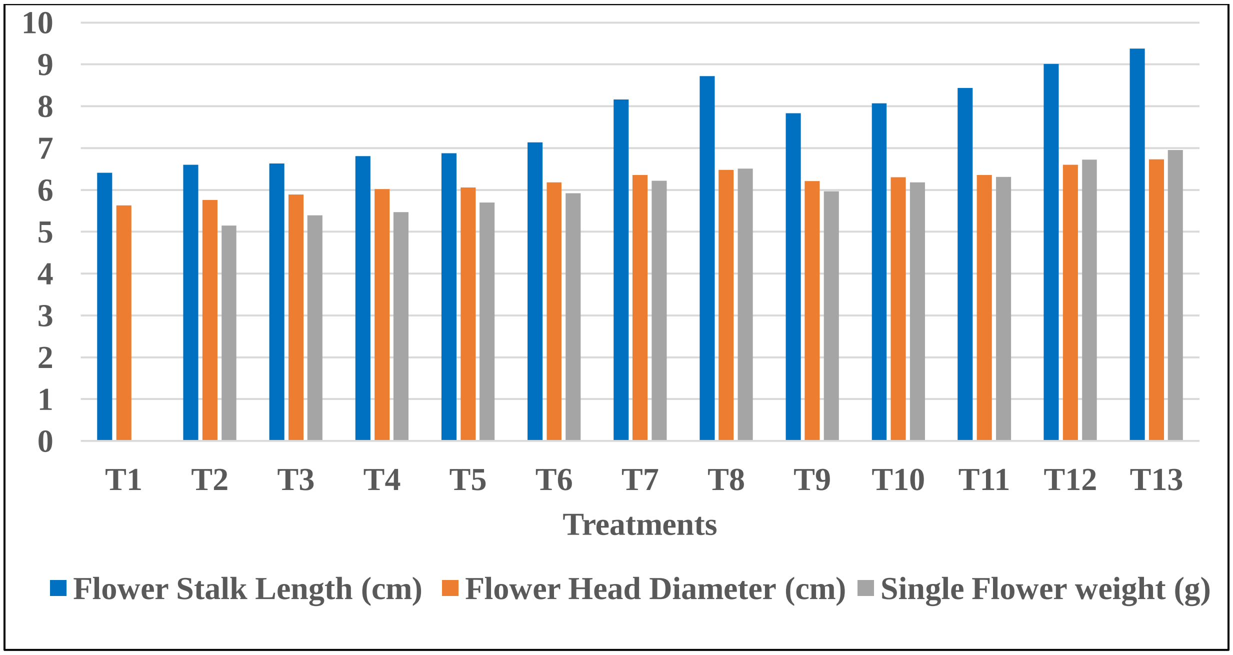
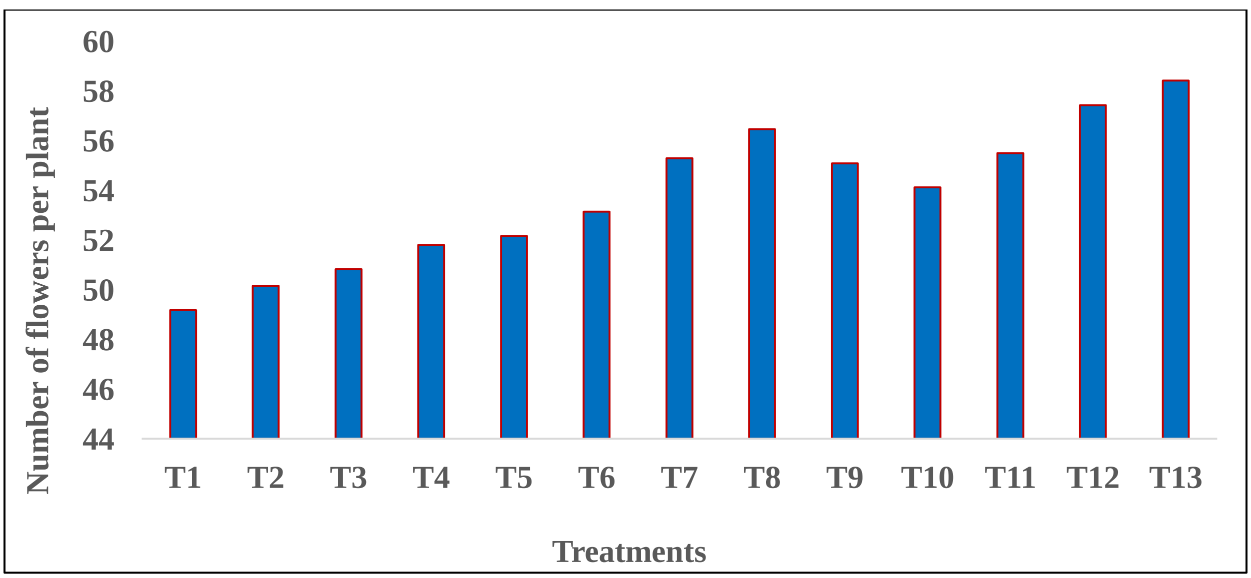


Figure 4. Effect of graded levels of nutrients and organic amendments on number of flowers plant^{-1} in African marigold (*Tagetes erecta* L.)



T_1 Control (RDF 100%)
T_8 RDF 75% + Humic Acid + AMC

T_2	RDF 75% + Vermicompost	T_9	RDF 100% + Humic Acid + AMC
T_3	RDF 100% + Vermicompost	T_{10}	RDF 75% + Vermicompost + AMC
T_4	RDF 75% + Humic acid	T_{11}	RDF 100% + Vermicompost + AMC
T_5	RDF 100% + Humic acid	T_{12}	RDF 75% + Vermicompost + Humic Acid + AMC
T_6	RDF 75% + Vermicompost + Humic acid	T_{13}	RDF 100% + Vermicompost + Humic Acid + AMC
T_7	RDF 100% + Vermicompost + Humic acid		

Figure 5. Effect of graded levels of nutrients and organic amendments on Flower yield per plot and flower yield per hectare in African marigold (*Tagetes erecta* L.)

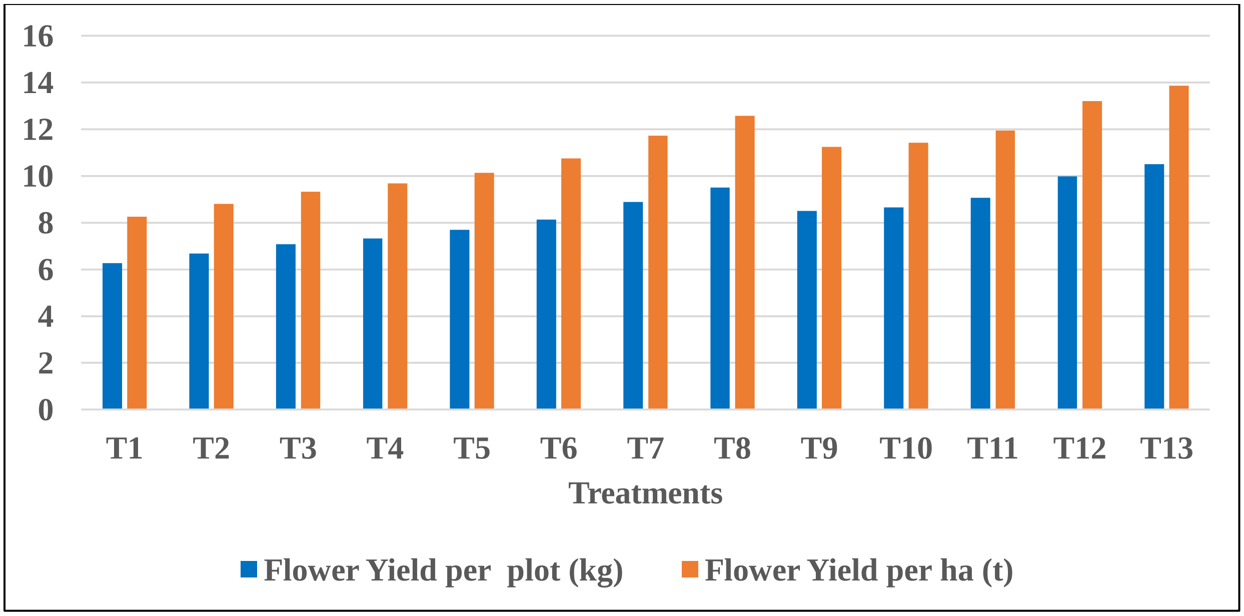
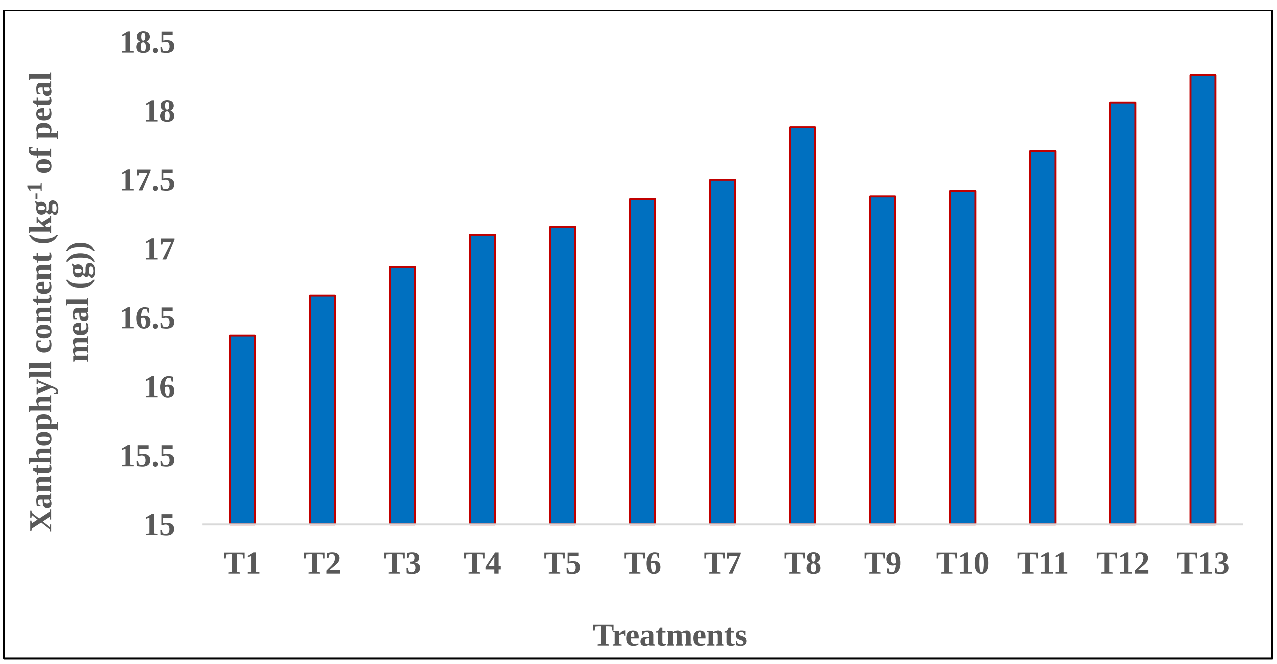


Figure 6. Effect of graded levels of nutrients and organic amendments on xanthophyll content in African marigold (*Tagetes erecta* L.)



T_1	Control (RDF 100%)	T_8	RDF 75% + Humic Acid + AMC

T_2	RDF 75% + Vermicompost
T_3	RDF 100% + Vermicompost
T_4	RDF 75% + Humic acid
T_5	RDF 100% + Humic acid
T_6	RDF 75% + Vermicompost + Humic acid
T_7	RDF 100% + Vermicompost + Humic acid
T_9	RDF 100% + Humic Acid + AMC
T_{10}	RDF 75% + Vermicompost + AMC
T_{11}	RDF 100% + Vermicompost + AMC
T_{12}	RDF 75% + Vermicompost + Humic Acid + AMC
T_{13}	RDF 100% + Vermicompost + Humic Acid + AMC

Conclusion

From the above experimental results, it is concluded that an application of vermicompost @ 5 t ha^{-1} + humic acid @ 5 kg ha^{-1} along with Arka microbial consortium@ 12.5 kg ha^{-1} in addition with 100 % RDF (90:90:75 kg N, P_2O_5 and K_2O kg ha^{-1}) will be effective in increasing the growth, flower yield and xanthophyll content of African marigold.

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Effect of graded levels of nutrients and organic amendments on growth and flowering in African marigold (*Tagetes erecta* L.)

Treatment details	Plant height (cm)	Number of branches	Number of Leaves	Number of flowers per plant	Single Flower Weight (g)	Flower Yield per plant (g)	Flower Yield per plot (kg)	Estimated Flower Yield ha^{-1} (t)
ol (RDF 100%)	68.44	11.69	106.16	49.18	4.93	186.69	6.27	8.26
5% + VC	72.59	11.92	110.53	50.16	5.15	198.91	6.68	8.80
00%+ VC	73.30	12.01	114.05	50.83	5.39	210.96	7.08	9.33
5% + HA	77.41	12.88	117.55	51.81	5.47	218.22	7.33	9.68
00% + HA	78.36	13.27	118.63	52.16	5.70	228.93	7.69	10.13
5% + VC+ HA	82.58	14.34	122.15	53.14	5.92	242.23	8.14	10.75
00%+ VC+ HA	81.75	15.64	127.74	55.29	6.22	264.81	8.89	11.73
5% + HA + AMC	100.59	16.83	132.49	56.46	6.51	283.02	9.51	12.57
00% + HA + AMC	85.15	14.51	123.17	55.08	5.97	253.20	8.51	11.24
75% + VC+ AMC	89.18	15.38	126.66	54.12	6.18	257.54	8.65	11.42
100% + VC+ AMC	96.17	16.41	129.08	55.50	6.31	269.66	9.06	11.95
75% + VC+ HA + AMC	104.90	17.73	133.39	57.43	6.72	297.17	9.98	13.20
100% + VC+ HA + AMC	109.28	18.74	136.94	58.42	6.95	312.63	10.5	13.86
S.Ed.	0.73	0.48	1.33	0.43	0.10	4.64	0.09	0.18
CD(p=0.05)	1.48	0.96	2.68	0.88	0.22	9.34	0.18	0.36

RDF 100%	:	90:90:75 kg N, P_2O_5, K_2O ha^{-1}	Humic Acid - 50% (HA)	:	5 kg ha^{-1}
RDF 75%	:	67.5:67.5:56 kg N, P_2O_5, K_2O ha^{-1}	Arka microbial consortium (AMC)	:	12.5 kg ha^{-1}
Vermicompost (VC)	:	5tonnes ha^{-1}			