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Effect of integrated nutrient management on the growth of African marigold (*Tagetes erecta* L.) CV. local orange

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Abstract
The study on the effect of integrated nutrient management on the growth of African marigold (*Tagetes erecta* L.) was carried out in the Department of Horticulture, Faculty of Agriculture, Annamalai University. African marigold is a flower crop which is widely cultivated in south India, demanding heavy nutrients for better productivity and quality. The organic manures and EM have also been found to influence the growth of African marigold. In this present study, the organic manure ie., vermicompost @ 5 t ha^{-1} and EM @ 1:1000 dilution as foliar plus soil application along with inorganic fertilizers were applied in different combinations. The experiment was laid out in Randomized Block Design with 11 treatments in three replications. All the treatments significantly influenced the growth components of African marigold. The application of 75% RDF + vermicompost @ 5 t ha^{-1} plus EM @ 1:1000 dilution (soil + foliar application) resulted in improving the growth characters like plant height, plant spread, number of primary branches $plant^{-1}$, number of secondary branches, number of leaves, leaf area and dry matter production. Hence, from the results of the present study, it can be concluded that application of 75% RDF + vermicompost @ 5 t ha^{-1} plus EM @ 1:1000 dilution (soil + foliar application) was found to be the best for enhancing the growth in African marigold.

Keywords: Organic manures, Vermicompost, effective microorganisms

Introduction
Marigold (*Tagetes erecta* L.), a member of the family asteraceae or compositae, is a potential commercial flower that is grown as an ornamental crop for its flowers, which are sold in the market as loose flowers in bulk, as speciality cut flowers, for making garlands and decorative purposes in various kinds of religious and social functions. It is grown as an annual in herbaceous border and is also ideal as filler for newly planted shrubberies to provide colour and to fill the spaces. Marigold cultivars with orange colour flowers have higher xanthophylls as compared with yellow. Lutein (C_{40} H_{56} O_2) is the primary xanthophyll pigment that produces the orange colour in marigold flower (Deineka *et al*., 2007) [2]. Like several other crops, African marigold also responds well to the application of organic inputs depending on the climatic conditions and soil types. Application of organic manures is economic in the long run as well as environmental friendly. The use of organic manures like vermicompost and Effective microorganisms (EM) partly substitute chemical fertilizers and also reduce the cost of production. Vermicompost is supposed to increase the soil organic matter, soil water retention, transmission and other physical properties of soil like decrease in bulk density and increased aggregation (Zebarth *et al*., 1993). It also contains growth enhancing substances, number of beneficial microorganisms like N fixing, P solubilising and cellulose decomposing organisms (Sultan, 1997) [13]. Effective microorganisms solutions contain a mixture of five genera organisms, namely Actinomycetes, Ray fungi, Photosynthetic bacteria, Yeast and Lactic acid bacteria (Higa, 1991) [6]. These are contained in a molasses base at a pH below 4.0. The role of EM in agriculture has been reported as one of decomposing organic matter, while enhancing the qualities of the rhizosphere. In view of the above facts, the present investigation was undertaken to study the effect of organic manures and EM on the growth of African marigold.

Materials and Methods
The present study was carried out in the Floriculture unit, Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalainagar to study the influence of integrated nutrient management on the growth of African marigold (*Tagetes erecta* L.) under irrigated condition. The experiment included eleven treatments namely, T_1 (75% RDF + Vermicompost

@ 5 t ha^{-1}); T_2 (50% RDF + Vermicompost @ 5 t ha^{-1}); T_3 (75% RDF + EM @ 1:1000 Dilution (Soil Application)); T_4 (50% RDF + EM @ 1:1000 Dilution (Soil Application)); T_5 (75% RDF + EM @ 1:1000 Dilution (Foliar Application)); T_6 (50% RDF + EM @ 1:1000 Dilution (Foliar Application)); T_7 (75% RDF + EM @ 1:1000 Dilution (Soil Application + Foliar Application)); T_8 (50% RDF + EM (1:1000 Dilutions) (Soil Application + Foliar Application)); T_9 (75% RDF + Vermicompost @ 5 t ha^{-1} + EM @ 1:1000 Dilution (Soil Application + Foliar Application)); T_{10} (50% RDF + Vermicompost @ 5 t ha^{-1} + EM @ 1:1000 Dilution (Soil Application + Foliar Application)); T_{11} (100% RDF (Control)) with three replications.

The cultivar used for the study was African marigold (*Tagetes erecta* L.) cv. Local Orange. The main field was prepared by ploughing thoroughly using a tractor drawn disc plough. Well decomposed farm yard manure was applied at the rate of 25 tonnes per hectare. The field was laid out in randomized block design with individual plots of 3 m ×1 m dimension. Nursery bed were prepared and then the seeds were broadcasted and mulching was done Thirty days old healthy uniform seedlings were transplanted in the main field. Watering was done to the plants immediately after transplanting. Subsequent watering was done in alternate every day to keep the optimum moisture. Weeds were removed periodically by hand weeding. Pest and diseases were controlled periodically during the crop growth using the recommended plant protection agents. The organic inputs such as the vermicompost and Effective microorganisms were applied according to the treatments.

Results and Discussion

The results of the present investigation showed that application of 75% RDF + Vermicompost + EM effective microorganisms (soil + foliar application) markedly influenced the growth characters of marigold viz., plant height (95.13 cm), plant spread (44.51 cm), number of primary branches (8.85), number of secondary branches (30.42), number of leaves (209.61), leaf area (51.06 cm^2) and total dry matter production (119.20 g $plant^{-1}$) (Table 1). Plant growth characters showed a progressive increase with applied nutrients in general.

The plant height is considered to be an important factor to judge the vigour in marigold. In the present investigation, application of 75% RDF + vermicompost @ 5 t ha^{-1} + EM (1:1000 dilution) in both soil and foliar application recorded greater plant height, plant spread, more number of branches, number of leaves and leaf area. This was followed by the treatment which received 75% RDF + EM (1:1000 dilution) in both soil and foliar application. Similar results were reported by Farzad Nazari *et al*. (2008) [3] and Sunitha *et al*. (2007) [14] in African marigold. The results of the present study are in agreement with findings of Leopold (1974) [8] who stated that organic manures improve the soil physical conditions and promote microbial and soil organic matter, which in turn produce organic acids, which inhibits enzymes, particularly IAA oxidase, resulting in enhancing the effect of auxin-IAA which has direct effect on plant growth.

The increase in plant height and number of branches in the treatment could be attributed to vermicompost application which might has supplied plant nutrients directly to the plants and solubilizing effect on fixed from of nutrients. These nutrients flow into plants and thereby favouring the plants growth and stimulation of auxillary buds resulting in more plant height and more number of branches per plant. Similar findings were reported by Yassin and Pappiah (1990) [15] in chrysanthemum and Kulkarni *et al*. (1996) [7] in China aster.

The increase in growth parameters due to application of vermicompost may be due to the presence of growth substances (Gavirilov, 1962), nitrogen fixers (Loquet *et al*., 1977) [9], other essential nutrients and also due to higher fertilization by a symbiotic mycorrhizal association as reported by Bano and Kale (1987) [1]. Incorporation of vermicompost promotes the lush growth of plants which may be due to the presence of plant growth promoters like auxins and cytokinins, which are responsible for the cell division and cell elongation.

The increase in the growth characters was attributed to the ability of EM to decompose organic materials in the soil, thereby releasing additional available nutrients for plant growth. The ability of EM to change the conditions of the rhizosphere to a zymogenic state and thereby providing a more favourable environment for plant growth (Higa, 1988) [5].

Productivity of the crop is primarily a resultant function of dry matter production. The increased dry matter production was result of better plant growth as reflected by increased plant height, more branching, higher number of leaves and leaf area. The DMP was found to be significantly higher in the treatment which received the application of 75% RDF + vermicompost @ 5 t ha^{-1} + EM (1:1000 dilution) in both soil and foliar application. This was followed by the treatment which received 75% RDF + EM (1:1000 dilution) in both soil and foliar application. The most likely explanation is that EM enhanced the decomposition of the organic amendments, as well as the indigenous soil organic matter, thus releasing available nutrients to the growing plants and developing more favourable rhizosphere conditions (Sangakkara and Higa, 1994; Sangakkara, 1996) [10, 11].

Nitrogen enhanced the vegetative growth with greater number of branches, while phosphorus increased root population. This would have resulted in an increased accumulation of dry matter and efficient portioning of photosynthates towards sink. Better absorption of potassium would have helped in the translocation of photosynthates to the reproductive sink viz., the flowers. Similar findings were reported by Shadanpour *et al*. (2011) [12] in African marigold.

Table 1: Effect of integrated nutrient management on plant height, plant spread, number of primary branches, number of secondary branches, number of leaves, leaf area and total dry matter production in African marigold cv. Local Orange

Treatments	Plant height (cm)	Plant spread (cm)	Number of primary branches	Number of secondary branches	Number of leaves	Leaf area (cm^2)	Total dry matter production (g $plant^{-1}$)
T_1	83.48	32.42	13.47	19.33	173.6	39.44	85.98
T_2	79.66	32.93	12.65	17.89	168.48	37.28	80.71
T_3	89.59	38.46	15.75	23.46	187.02	43.70	94.15
T_4	87.19	35.96	14.28	20.75	180.70	40.95	88.60
T_5	95.23	40.16	17.22	26.15	194.20	46.51	100.81
T_6	90.81	37.50	15.08	22.18	185.90	42.50	91.89
T_7	95.13	43.09	18.86	29.00	204.50	49.52	109.60
T_8	93.24	39.97	16.53	24.88	192.21	45.24	97.90
T_9	99.12	44.51	19.64	30.42	209.61	51.06	112.96
T_{10}	91.68	41.67	18.00	27.28	199.36	48.00	106.00
T_{11}	75.5	29.42	11.85	18.12	160.12	34.19	75.10
S.E. ±	1.49	0.67	0.37	0.68	2.48	0.71	1.56
C.D.(P=0.05)	2.99	1.35	0.74	1.37	4.98	1.42	3.14

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