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Influence of organic amendments on the growth and flowering of African marigold (*Tagetes erecta* L.) cv. Seracole

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Abstract
The present investigation was carried out in experimental farm, Department of Horticulture, Assam Agricultural University, Jorhat, Assam, between 2020-2021 to study the impact of different organic inputs on the growth and flowering of *African marigold* cv. Seracole. The experiment was set up in a Randomized Block Design with seven treatments and three replications. The treatments were T1 {RDF (10:10:10 g/m2 NPK) + FYM @ 4 kg/m2}, T2 {Vermicompost (2.5t/ha) + Rock Phosphate (100 kg/ha) + Microbial consortium}, T3 {Vermicompost (5t/ha) + Rock phosphate (100 kg/ha) + Microbial consortium}, T4 {compost (2.5t/ha) + Rock phosphate (100 kg/ha) + Microbial consortium}, T5 {Compost (5t/ha) + Rock phosphate (100kg/ha) + Microbial consortium}, T6 {Enriched compost (2.5 t/ha)} and T7 {Enriched compost (5 t/ha)}. From the data recorded it can be concluded that treatment T3 and T7 showed the highest levels of growth and flowering traits, even though application of all the different nutritional sources had a substantial impact.

Keywords: African marigold, seracole, organic, microbial consortium, enriched compost, vermicompost

Introduction
Marigold is a flower that grows wild throughout Central and South America, particularly in Mexico. During the early 16th century, it expanded from Mexico to various regions of the world. Genus Tagetes belongs to subfamily Asteroideae of family Asteraceae. Four annual species Tagetes patula, Tagetes lunulata, Tagetes erecta and Tagetes tenuifolia are commonly cultivated throughout the world for ornamental purposes. The taller and large flowered Tagetes erecta is known as African marigold while the smaller Tagetes patula is called French marigold. Tagetes erecta, popularly known as 'Mexican marigold' or 'Aztec Marigold,' is one of the genus Tagetes' most important species. The chromosome number of African marigold is 2n=24. This plant reaches a height of 50-100 cm. It has a tendency to flower for a short period, resulting in marketable flowers with a wide range of appealing colours, shapes, and sizes, as well as good keeping qualities. Marigold was introduced by Portuguese in India during 16th century (Gawle *et al.* 2012) [7]. To meet the rising demand, both quantity and quality production are critical. Higher yields can be obtained by applying inorganic fertilizers, but continued use of agrochemicals degrades soil health and causes environmental imbalance by polluting the air, water and soil. Chemical fertilizer use has a negative impact on soil texture and structure, as well as organic content and microbial activity. (Alam *et al*., 2007) [2].

Materials and Methods
The present experiment was conducted during 2020-2021 at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat. The experiment was laid out in Randomized Block Design (RBD) with three replications. There were 7 treatments which were applied as T1 {RDF (10:10:10 g/m2 NPK) + FYM @ 4 kg/m2}, T2 {Vermicompost (2.5t/ha) + Rock Phosphate (100 kg/ha) + Microbial consortium}, T3 {Vermicompost (5t/ha) + Rock phosphate (100 kg/ha) + Microbial consortium}, T4 {compost (2.5t/ha) + Rock phosphate (100 kg/ha) + Microbial consortium}, T5 {Compost (5t/ha) + Rock phosphate (100kg/ha) + Microbial consortium}, T6 {Enriched compost (2.5 t/ha)} and T7 {Enriched compost (5 t/ha)}. Microbial consortium slurry was prepared with water and the root dip treatment of seedlings was done an hour prior to transplanting.

Consortium used in the treatment was a mixture of Azospirillum, Azotobacter and Phosphate solubilizing bacteria (PSB). The inputs like vermicompost, compost and enriched compost used in the experiment was procured from Assam Agricultural University, Jorhat and applied during the land preparation. The cuttings used were about 5-7 cm height when planted and were of a uniform height. The cuttings were planted in a prepared plot at a spacing of 30 cm x 30 cm.

Results and Discussion

1. Vegetative parameters

Plant height: The highest plant height of 50.88 cm and 49.95 cm was recorded in T3 (Vermicompost @5t/ha + Rock Phosphate @100 Kg/ha + Microbial consortium) and (Enriched compost @5t/ha), both being at par. This might be due to the absorption of various micronutrients and macronutrients which was made available at optimum levels by application of different organic inputs like vermicompost, enriched compost and microbial consortium. Vermicompost includes an average of 9.15 to 17.98% organic carbon, as well as micronutrients such as sodium (Na), calcium (Ca), zinc (Zn), sulphur (S), magnesium (Mg) and iron (Fe) (Adhikary, 2012) [1]. Plant growth might have been augmented due to the abundance of Fe and Zn which enhances the microflora and enzymatic activity of soil. A similar increase in plant height was also reported by Kumar and Saravanan (2019) [8] in gladiolus, Rajan (2020) [15] in gerbera cv. Goliath and Shree *et al.* (2021) [15] in chrysanthemum cv. Basanti.

Number of leaves

The number of leaves recorded were 259.77 and 259.70 in T_3 (Vermicompost @5t/ha + Rock Phosphate @100 Kg/ha + Microbial consortium) and T_7 (Enriched compost @5t/ha) respectively, both being at par. These findings have been in conformity with the findings of Kumar (2015) [9] in chrysanthemum cv. Yellow gold and Elisheba and Sudhagar (2019) [6] in tuberose cv. Prajwal. Number of leaves per plant might have increased under enriched compost on account of the increased availability of nutrient to the plants thereby manufacturing more carbohydrates. The increased availability of N in soil might be the reason why production of more number of leaves was recorded as N is an important component of Chlorophyll and protein thus promoting vegetative growth (Kumar and Singh, 2007) [10].

Table 1: Plant height (cm) in African marigold as influenced by different organic inputs

Treatments	Plant height (cm)		
	30 DAP	60 DAP	90 DAP
T_1 = RDF (10:10:10 NPK g/m2) + FYM @4 kg/m2.	11.89	22.62	44.66
T_2 = Vermicompost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	14.44	20.08	45.53
T_3 = Vermicompost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	15.96	26.30	50.88
T_4 = Compost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	10.63	19.23	40.57
T_5 = Compost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	12.81	23.67	43.25
T_6 = Enriched compost@2.5t/ha.	12.80	23.50	44.63
T_7 = Enriched compost@5t/ha.	15.90	25.69	49.95
S.Ed. (±)	0.50	0.66	0.53
CD0.05	1.05	1.38	1.11

Table 2: Number of leaves in African marigold as influenced by different organic inputs

Treatments	No. of leaves		
	30 DAP	60 DAP	90 DAP
T_1= RDF (10:10:10 NPK g/m2) + FYM @4 kg/m2	147.75	186.00	254.98
T_2 = Vermicompost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium	146.42	193.85	257.32
T_3= Vermicompost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium	150.33	200.01	259.77
T_4= Compost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium	136.63	178.97	239.63
T_5= Compost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium	145.29	181.00	252.56
T_6= Enriched compost@2.5t/ha	140.47	186.00	257.33
T_7= Enriched compost@5t/ha	149.84	199.67	259.70
S.Ed. (±)	0.84	0.77	0.56
CD0.05	1.76	1.60	1.16

2. Flowering parameters

Flower bud visibility

The number of days required for flower bud visibility and days to full bloom (Table 3) were significantly influenced by different treatment. The treatment T_3 (Vermicompost @5t/ha + Rock Phosphate @100 Kg/ha + Microbial consortium) and T_7 (Enriched compost @5t/ha), both being at par resulted in the earliest period of (59.33 days and 60.33 days) respectively for flower bud visibility and (75.33 days and 75.67 days) respectively for days to full bloom, both being at par. These results were in line with the results reported by Baruati *et al*., (2018) [4] in gladiolus and Moghadam *et al*., (2012) [12] in Asiatic hybrid lilium var. Navona. This might be due to the effect of vermicompost which contains enzymes like amylase, lipase, cellulase and chitinase which continue to break down organic matter in the soil and make nutrients available to the plant roots. They also increase some important soil enzymes like dehydrogenase, acid and alkaline phosphatase and urease. This increase might also be due to the presence of gibberellins in vermicompost, which are associated with the regulation of flowering.

Number of flowers/plant

The highest count for number of flowers/plant (85.67) was observed in T_3 (Vermicompost @5t/ha + Rock Phosphate @100 Kg/ha + Microbial consortium) which was followed by (84.00) in T_7 (Enriched compost @5t/ha). This might be related to the fact that vermicompost releases growth

promoting substances that helped in enhancing plant height, number of leaves and number of branches which resulted in increased number of blooms.

Yield

The highest yield/plant was obtained in treatment T_3 (Vermicompost @5t/ha + Rock Phosphate @100 Kg/ha + Microbial consortium) and T_7 (Enriched compost @5t/ha) i.e., 470.02g and 467.03g respectively. The higher values recorded for the yield attributes might be due to the active and rapid multiplication of microbes, especially in the rhizosphere, creating favorable conditions for nitrogen fixation and phosphate solubilization at higher rates making it available to the plants leading to more uptake of nutrient and water. These findings were in agreement with Angadi (2014) [3] in garland chrysanthemum and Ranjan *et al*., (2014) [16] in tuberose.

Table 3: Days to bud visibility & Days to full bloom in *African marigold* cv. Seracole as influenced by organic inputs

Treatments	Days to bud visibility	Days to full bloom
T_1 = RDF (10:10:10 NPK g/m2) + FYM @4 kg/m2.	66.00	79.67
T_2 = Vermicompost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	70.00	80.67
T_3 = Vermicompost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	59.33	75.33
T_4 = Compost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	75.33	86.67
T_5 = Compost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	65.32	80.00
T_6 = Enriched compost@2.5t/ha.	61.33	78.67
T_7 = Enriched compost@5t/ha.	60.33	75.67
S.Ed. (±)	0.95	0.72
CD0.05	1.97	1.50

Table 4: No. of flowers/plant & yield in *African marigold* cv. Seracole as influenced by organic inputs

Treatments	No. of flowers/plant	Yield/plant (g)
T_1 = RDF (10:10:10 NPK g/m2) + FYM @4 kg/m2.	79.33	377.98
T_2 = Vermicompost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	80.65	414.37
T_3 = Vermicompost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	85. 67	470.02
T_4 = Compost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	74.00	283.99
T_5 = Compost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	80.19	387.25
T_6 = Enriched compost@2.5t/ha.	79.71	393.21
T_7 = Enriched compost@5t/ha.	84.00	467.03
S.Ed. (±)	0.66	9.77
CD0.05	1.37	20.37

3. Physiological parameters

Total chlorophyll content

The highest total chlorophyll content in leaf (2.83 mg g^{-1} fresh weight and 2.75 mg g^{-1} fresh weight) was recorded in the treatment T_7 (Enriched compost @5t/ha) which was found to be at par with T_3 (Vermicompost @5t/ha + Rock Phosphate @100 Kg/ha + Microbial consortium). Vermicompost has been shown to boost the number of soil microorganisms, which creates plant growth regulators that are essential for plant development and photosynthetic activity (Levy and Taylor, 2003) [11]. The increase in chlorophyll content might also be due to the better nutrient availability especially nitrogen and micronutrients such as Mg. It is an established fact that N and Mg are the most important constituent of chlorophyll (Yawalkar *et al*., 1967) [19]. This result is in agreement with the work of Sangwan *et al.* 2010 [17] in marigold and Priya *et al.* (2020) [14] in tuberose.

Net assimilation rate: Net assimilation rate (NAR) is the measurement of average photosynthetic efficiency. Leaf chlorophyll contents are the key factors determining the rate of photosynthesis (Jain, 1972). The highest net assimilation rate in leaf (0.0070 mg cm^{-2} day^{-1} and 0.0068 mg cm^{-2} day^{-1}) were recorded in the treatment T_3 (Vermicompost @5t/ha + Rock Phosphate @100 Kg/ha + Microbial consortium) and T_7 (Enriched compost @5t/ha) both being statistically at par. This might be due to the application of vermicompost and enriched compost which increases the chlorophyll content and as a result of which increases the rate of photosynthesis and ultimately increases the plant growth. This result is in conformity with Noorjahan, (2017) [13] in marigold and Bordoloi and Talukdar, (2019) [5] in chrysanthemum.

Table 5: Chlorophyll content & net assimilation rate in African marigold cv. Seracole as influenced by organic inputs

Treatments	Chlorophyll (mg g^{-1} fresh wt.)	NAR (mg cm^{-2} day^{-1})
T_1 = RDF (10:10:10 NPK g/m2) + FYM @4 kg/m2.	1.37	0.0028
T_2 = Vermicompost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	2.30	0.0060
T_3 = Vermicompost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	2.83	0.0070
T_4 = Compost@2.5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	2.05	0.0046
T_5 = Compost@5t/ha + Rock phosphate@100 kg/ha+ Microbial consortium.	2.36	0.0051
T_6 = Enriched compost@2.5t/ha.	2.21	0.0059
T_7 = Enriched compost@5t/ha.	2.75	0.0068
S.Ed. (±)	0.16	0.0004
CD0.05	0.37	0.0008

Conclusion

From the foregoing discussion, it can be concluded that the treatments T_3 (Vermicompost @5t/ha + Rock Phosphate @100kg/ha + Microbial consortium) followed by T7 (Enriched compost @5t/ha) were found to be the most efficient treatment in terms of both vegetative, flowering and physiological parameters.

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