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Impact of integrated nutrient management (INM) on plant growth and flower yield of African marigold (*Tagetes erecta* L.)

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Abstract
The present investigation entitled "Impact of Integrated Nutrient Management (INM) on plant growth and flowers yield of African marigold (*Tagetes erecta* L.)" was carried out at Department of Horticulture, Gochar Mahavidhyalaya, Rampur Maniharan, Saharanpur during October 2017 and February 2018. The recommended dose of organic nutrients and fertilizers (RDF) was applied with vermicompost, Farm Yard Manure (FYM), Poultry manure, azotobacter and Phosphate Solubilising Bacteria (PSB) in different doses. The result showed that the maximum plant height was recorded under T_3 (100%RDF + Vermicompost) treatment and plant spreading, diameter of plant, number of primary and secondary branches and in the flowering parameters i.e. bud initiation, number of flowers per plant, total flower yield were recorded maximum under T_6 (75% RDF + vermicompost + azotobacter) treatment. The flower weight and flower size were recorded maximum under T_{12} (50% RDF + Vermicompost + Azotobacter), while all growth parameters of plants and flowers yield were found minimum under reference.

Keywords: Integrated nutrient management, marigold, farm yard manure, vermicompost, phosphate solubilising bacteria

Introduction
Flowers are a unique work of nature. Ornamental flowers are associated with the beginning of human civilization. From the beginning of life (birth) to death, the flower is an integral part of life, various types of flowers to celebrate different types of festivities. Many Gods and Goddesses have different flowers: whose testimony is also found in Hindu mythology. Food (Anna) is important for human hunger as for human beings, similarly flowers are necessary for mental peace. They are symbol of affection, beauty, friendship and love. They are also used for decoration and aesthetic purpose and they have tremendous economic value as cut flower, loose flower, for perfumes and other products. Now a day's floriculture is recognized as a lucrative business, because of its higher potential per unit area than most of the other field crops. The demand of flowers has a positive correlation with the increasing population, the increasing demand of flowers create a lot of burden on the resources, so this is the fundamental duty to save the resources with fulfilling the demand of flowers.

Marigold gained popularity amongst gardeners and flower dealers on account of its easy culture and wide adaptability. Its habit of wide range of flowering, short duration to produce marketable flowers, wide spectrum of attractive colour, shape, size and good keeping quality, no doubt theses characteristics attracted the attention of flower growers (Singh, *et al.* 2016) [7].

In India flowers are grown in an area of 313 thousand ha with an annual production of 2865 thousand MT (NHB Database (2018-19). Nutrient plays very important role for determining the growth and yielding ability of crop. But, the indiscriminate application of chemical fertilizers alters the soil fertility, leading to the pollution of soil and water bodies. There is big gap between demands, requirements of nutrients deriving food production and supply of nutrients through chemical fertilizers. This deficit will have to be met through supplementary and complementary use of organic and biological sources of nutrient in integrated nutrient management system.

Biofertilizers are microbial inoculants of selective micro organisms like bacteria, algae, fungi which already existing in nature. They may help for improving soil fertility by the way of accelerating biological nitrogen fixation from atmosphere, solubilisation of the insoluble nutrient in soil, generate little quantity of Plant Growth Regulators decomposing plant residues and stimulating plant growth and production. Keeping the above fact in view, the present investigation has been carried out to find the suitable INM treatment to get maximum vegetative growth, flowering quality and yield of African marigold.

Materials and methods

The present study entitled "Impact of Integrated Nutrient Management (INM) on plant growth and flowers yield of African marigold (*Tagetes erecta* L.)" is carried out during Oct. 2017 to Feb. 2018 at Horticulture Research Farm, Department of Horticulture, Gochar Mahavidhyalaya Rampur Maniharan, Saharanpur. The details of materials used and research methodology followed during course of present investigation. The present study is divided into two parts first are the plants and second are the flowers. Both selected parameters are as follow:

A. Growth parameters of plant

To know the impact of INM on plant of *Tagetes erecta* various parameters were selected. The study is focused on plant height at peak flowering period, plant spread at plant spreading at peak flowering period, number of primary branches per plant, Number of secondary branches per plant and diameter of plant stem.

B. Flowering parameters

To study the impact of INM during the present investigation, selected parameters were studied i.e. Days taken to first flower bud initiation, days taken to first flower bud opening, duration of flowering, average number of flowers per plant, average flower size, average flower weight, flower yield per plant, total flower yield (q ha^{-1}). The experiment was laid out in Randomized Block Design (RBD). All treatments were randomly allocated among the plots and replicated three times.

Results and discussion

In the present study various growth parameters of plant height and flowers were investigated during this study the following parameters were observed:

A. Plant

i) **Plant height:** In the present study it was observed that the maximum plant height 74.99cm and minimum plant height 73.40cm were recorded in the treatment T_3 (100% RDF + Vermicompost) and treatment T_{17} respectively (Table1, Fig3). Singh, *et al.* (2017) studied the impact of various treatments on plant height and found the same result that the combination of treatment T_6 (75% RDF + vermicompost + azotobacter) is one of the more effective treatment for plant height, while the minimum value was recorded under control treatment, which is T_{17} (Reference) treatment.

ii) **Plant spreading:** The plant spreading is one of the most important parameter of plant growth. During the present investigation, the highest plant spreading 73.40cm was observed under treatment T_6 (75% RDF + vermicompost + azotobacter) treatment, while the lowest value 63.17cm again recorded under T_{17} (reference) treatment (Table1, Fig3). Kumura *et al.* (2019) [4] have investigated the effects of integrated nutrient management on growth and flowering parameters of *Tagetes erecta* and found that the 75% RDF make a positive effects on selected growth parameters of plant and flowers.

iii) **Number of primary and secondary branches:** The maximum number of primary and secondary branches 17.44 and 50.78 was observed again under treatment T_6 (75% RDF + vermicompost + azotobacter), on the other the hand the minimum number of primary and secondary branches 11.74 and 28.43 were observed under T_{17} (reference) treatment, respectively (Table1, Fig4). Sharma *et al.* (2017) [6] made a study on different growth parameters of flower and vase life of marigold and observed the maximum plant spreading, branches and maximum shelf life and vase life of flowers under 75% RDF.

iv) **Plant diameter:** The plant diameter one of the key parameter for effective flower production and during the study period highest plant diameter 1.413cm was recorded under T_6 (75% RDF + vermicompost + azotobacter) treatment while the lowest value 1.18cm of plant diameter was recorded under T_{17} (reference) treatment (Table1, Fig4). Subrata *et al.* (1998) [8] studied on Effect of nitrogen, phosphorus and potassium on growth, flowering and seed yield of China aster and recorded the enormous impact with different ratio of RDF on different growth parameters. On the other hand Chaurasia *et al.* (2017) [2] made a study on effects of integrated nutrient management on plant growth and found the positive impact of 75% RDF on primary and secondary branches.

Table 1: Impact of INM on plant height during October 2017 to February 2018

S. No.	Treatments	Plant height (cm)	Spreading (cm)	Number of primary branches	Number of Secondary branches	Plant diameter (cm)
	T_1	64.000	64.333	14.03	39.467	1.297
	T_2	67.000	64.	14.46	41.577	1.317
	T_3	74.993	65.337	16.063	44.227	1.293
	T_4	68.000	64.807	14.413	47.673	1.317
	T_5	65.667	67.83	14.11	47.867	1.343
	T_6	71.000	73.403	17.443	50.783	1.413
	T_7	69.000	67.397	13.483	44.25	1.32
	T_8	66.000	69.453	13.297	42.553	1.273
	T_9	69.667	69.83	13.987	43.54	1.263
	T_{10}	66.000	70.453	13.833	38.757	1.293
	T_{11}	65.000	68.827	13.217	38.743	1.28
	T_{12}	65.000	68.73	12.14	38.453	1.28
	T_{13}	64.000	66.733	12.833	38.367	1.293
	T_{14}	62.333	66.373	11.8	38.713	1.29
	T_{15}	64.667	65.857	13.383	38.497	1.293
	T_{16}	62.333	65.777	13.467	34.447	1.257
	T_{17}	55.333	63.17	11.74	28.437	1.183
	SEm	1.314	0.417	0.276	0.634	0.022
	CD at 5%	3.803	1.206	0.797	1.836	0.064

B. Flower

Flowers are the product of plant and have a significant effect of integrated nutrient management (INM). Flowers can be directly linked with the plant parameters as the plants have significant effect of INM. The flowering parameters are as follows:

i) **Bud initiation time:** Bud initiation time is the key parameter for flower growth as the buds are the first indication of a flower. If the buds initiate at early phase, they become a flower very fast. The minimum duration of bud initiation was recorded 47.88 days under T_6 (75% RDF + vermicompost + azotobacter) treatment; while the maximum duration was recorded 68.36 days under T_{17} (reference) treatment (Table2, Fig5). Jamil *et al.* (2016) [3] have investigated the impact of different combination of chemical fertilizers and observed the maximum output in the selected flowering plant at different RBD.

ii) **Flower per plant:** The maximum flowers per plant were recorded 53.20 under T_6 (75% RDF + vermicompost + azotobacter) treatment and the minimum flowers per plant recorded 36.41 under T_{17} (reference) treatment (Table2, Fig5). The production of flower by the plant is prime parameters of growth as the plenty of nutrients make a plant more flowery in the aspects of quality and quantity. Chaurasiya *et al.* (2017) [2] have made a study on effects of INM on the flowering parameters of marigold and found that the T_8 treatment which contain (100% Vermicompost + 1.5 kg ha-1*Azotobacter* + 1.5 kg ha-1 *Phosphobacterium*) followed by T6 (100% RDF + 1.5 kg ha-1 *Azotobacter* + 1.5 kg ha-1. Is the powerful treatment to produce more flowers from the selected plant.

iii) **Flower size:** There is a direct relation between flower size and INM, during the present investigation the maximum flower size 7.31cm under T_{12} (50% RDF + vermicompost + azotobacter) treatment and the minimum flower size 5.19cm was observed under T_{17} (reference) treatment (Table2, Fig6). Flower size is an important aspect of flower as this parameter is directly linked with the weight of flowers. **Sharma *et al.*** (2017) [6] studied the growth and flower yield of marigold and recorded that T_8 treatment (50% NPK+FYM+AZB+PSB) produced more flowers with good quality and quantity and the study showed the minimum production of flowers under control treatment.

iv) **Flower weight:** The maximum weight of a single flower was recorded 7.06gm under T_{12} (50% RDF + vermicompost + azotobacter) treatment, while the minimum weight of a single flower was recorded 4.91gm under T_{17} (reference) treatment (Table2, Fig6). Flower weight is an important aspect of flowers as the weight of flowers directly linked with economic parameters. Kumar *et al.* (2016) have investigated the response of INM to increase the flower weight, the different ratio play a key role to maintain different flowering parameters like bud initiation time, flower weight, flower per plant etc. he has suggested the vermicompost with 75% RDF to gain more flower weight.

v) **Total yield:** The total yielding of flower is an important parameter and has a link with INM. The highest yield 185.11 Q/ha was recorded under T_6 (75% RDF + vermicompost + azotobacter) treatment, while the lowest yield 94.33 Q/ha was recorded under T_{17} (reference) treatment (Table2, Fig5). **Prasad *et al.*** (2018) worked on effects of INM on flowering yield and flowers of Dahlia and found that Different treatment combinations were made with different percentages of Recommended Dose Fertilizer (RDF) for Dahlia 100:120:100 kg of Nitrogen (N), Phosphorus (P) and Potassium (K) per hectare, along with organic fertilizers like FYM, Vermicompost, Poultry manure and Bio fertilizers like Azotobacter. Observations to be recorded earliness minimum (57.40 days) for flower bud emergence, flower diameter maximum (22.06 cm), flower weight maximum (63.89 g), flower yield per plant maximum(697.81 g), number of flowers per plant maximum (9.87), flower yield per hectare maximum (9.60 t/ha) was produced by T4 whereas minimum was received in treatment T0 (control). At all flowering stages, treatment comprising of T4 (75% RDF+ Vermicompost @1.25 t/ha) was superior for all other treatments.

Table 2: Impact of INM on flower yield during October 2017 to February 2018

S. No.	Treatments	Bud initiation time (in days)	Flower per plant	Flower size (cm)	Flower weight (gm)	Total yield Q/ ha
1.	T_1	55.25	41.743	5.327	5.400	172.187
2.	T_2	57.493	41.83	5.200	5.960	178.463
3.	T_3	54.357	41.817	5.883	5.763	178.567
4.	T_4	54.527	44.253	5.710	5.687	179.693
5.	T_5	54.16	45.4	5.817	6.043	178.77
6.	T_6	47.883	53.207	6.287	5.963	185.117
7.	T_7	54.08	46.787	5.807	5.857	168.583
8.	T_8	53.54	45.1	5.790	6.130	170.65
9.	T_9	55.78	44.283	5.657	5.787	147.26
10.	T_{10}	55.48	42.083	5.263	5.670	141.667
11.	T_{11}	60.007	40.12	5.417	5.167	137.11
12.	T_{12}	58.703	40.147	7.317	7.063	137.257
13.	T_{13}	59.697	39.93	5.560	5.197	138.04
14.	T_{14}	60.48	40.22	5.417	5.460	140.193
15.	T_{15}	59.887	40.003	5.313	5.223	139.787
16.	T_{16}	63.313	42.007	5.317	5.233	133.453
17.	T_{17}	68.363	36.41	5.190	4.913	94.337
18.	SEm	0.83	0.984	0.120	0.084	1.654
19.	CD at 5%	2.401	2.848	0.348	0.242	4.785

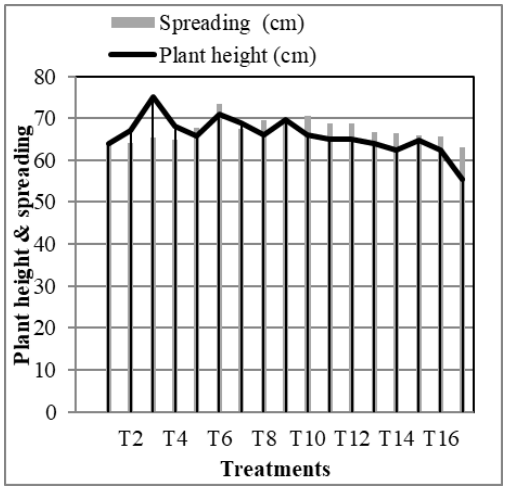

Fig 1: Graph showing plant spreading and height

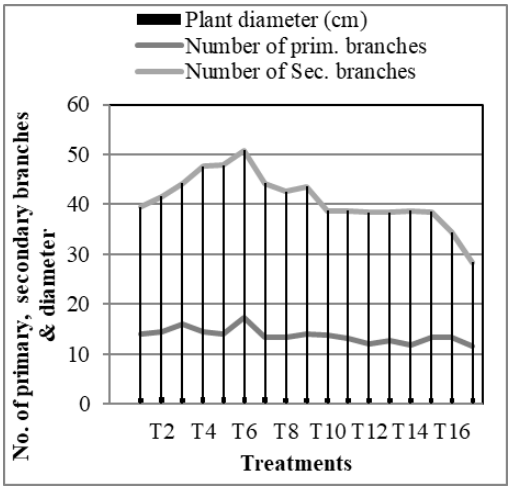

Fig 2: Graph showing plant diameter, number of primary and secondary branches

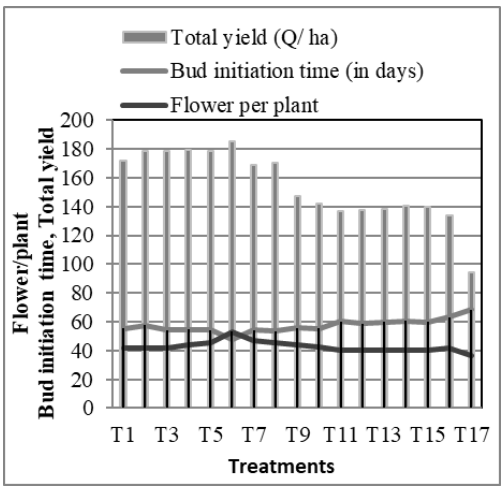

Fig 3: Graph showing selected flowering parameters

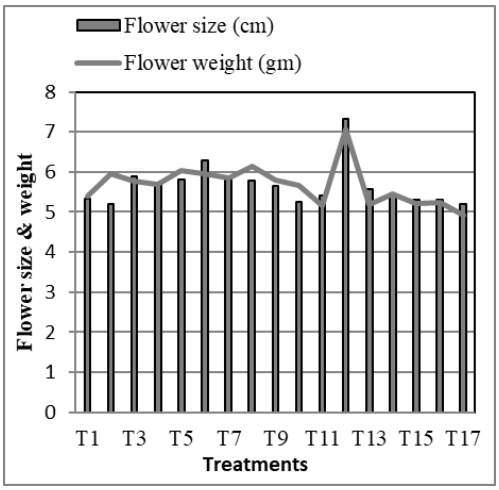

Fig 4: Graph showing flower size and weight

Conclusion

During the present investigation, it was concluded that the T_6 (75% RDF + vermicompost + azotobacter treatment) is the best treatment for number of flowers, total flower yields, plant spread, number of primary and secondary branches, bud initiation, plant diameter, while the plant height was observed maximum under T_3 (100% RDF + Vermicompost) treatment and T_{12} (50% RDF + vermicompost + azotobacter) was effective only for flower size and weight of a single flower of Marigold.

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