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Effect of bio fertilizers on plant growth and flower yield of African marigold *Tagetes erecta*

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Abstract
The present experiment was conducted to determine the Effect of different bio fertilizers on plant growth, and flower yield of African marigold (*Tagetes erecta* L.) in the department of horticulture, Sam Higginbottom institute of agriculture technology and sciences, Prayagraj, (U.P), India. During the summer season 2019. Taken 8 bio fertilizers i.e. FYM 25/tones/hectare, *Pecilomyces lilacinus* 10kg/hectare (Bio pesticide), *Pseudomonas Fluorescens* 2.5kg/hectare (Plant Growth Promoting Rhizobacteria), *Trichoderma viridae* & 2.5kg/hectare (Bio pesticide), *Bacillus Megaterium 13*kg/acre (phosphate solubilizing bacteria), *Fructuria eurantia* 5kg/hectare (potash Mobilizing Bacteria) *Azospirillium* & *Azotobacter* 2.5kg/hectare (Nitrogen Fixing Bacteria) and *Beauveria Basina* 2.5kg/hectare all are the soil application 12 treatments were included in the trial viz., T_0 [FYM 25/tones/hectare]; T_1[*Pecilomyces lilacinus* + *Pseudomonas fluorescens*], T_2[*Pseudomonas fluorescens* + *Trichoderma viridae*], T_3[*Trichoderma viridae* + *Beauveria basina*], T_4[*Beauveria basina* + *Azotobacter*],T_5[*Azospirillium* +*Fructuria eurantia*], T_6[*Fructuria eurantia* + *Bacillus megaterium*], T_7 [*Bacillus Megaterium* + *Pecilomyces lilacinus*], T_8[*Trichoderma viridae* + *Azotobacter* + *Bacillus megaterium*], T_9[*Trichoderma viridae* + *Azospirillium* +*Fructuria eurantia*], T_{10}[*Pseudomonas fluorescens* + *Azotobacter* + *Bacillus megaterium*], T_{11}[*Pseudomonas fluorescens* + *Azospirillium* +*Fructuria eurantia*] were tested in three replication. The results reveal that bio fertilizers treatments had significant response on plant height (cm), Number of primary branches per plant, Number of secondary branches per plant, Plant spread (cm), First day to flower bud appearance, Days to 50% flowering, Number of flowers/plant, Flower diameter (cm), Individual flower weight (gm), Flower yield/plant (gm), Flower yield/hectare (tones).The maximum plant spread (N-S)[20.86], E-W [20.23] were produced by treatment T_1[*Paecilomyces lilacinus* (1.28mg/m2) + *Pseudomonas*(320mg/m2)], maximum primary branches(12.11) were produced by treatment T_7[*Bacillus Megaterium* (1.664mg/m2) + *Paecilomyces lilacinus* (1.28mg/m2)], maximum secondary branches(19.78) were produced by treatment T_4[*Beauveria Basina* (0.32mg/m2) + *Azotobacter* (0.32mg/m2)], first day to bud appearance (44.89)was seen in T3[*Trichoderma viridae* + *Beauveria basina*], and 50% of flowering (49.33) were seen in T_{11}[*Pseudomonas* (0.32mg/m2) + *Azosprillium* (0.320g/m2) + *Fructuria.spp* (1.664mg/m2)], maximum flower diameter (8.37) was seen in T_{11}[*Pseudomonas* (0.32mg/m2) + *Azosprillium* (0.320g/m2) + *Fructuria*. *spp* (1.664mg/m2)]and maximum plant height(56.3),flowers per plant(12.67),flower weight(2.79), maximum yield per plant (38.00) and maximum yield per hectare (6.33) T2[*Pseudomonas fluorescens* + *Trichoderma viridae*] and this is the best result in the treatments.

Keywords: Marigold, FYM, bio fertilizers, growth, flower, and yield

Introduction
Marigold belongs to family Asteraceae and genus Tagetes. There are 33 species under this genus of which 2 species *Tagetes erecta* and *Tagets patula* are popularly grown Marigold is a native of central and south America, especially Mexico, it spread to different parts of the world during early part of the 16th century.

Marigold is a hardy flower crop grown throughout the India. Flowers are used for making garlands, wreaths, religious offering social functions. It gained popularity amongst gardens and flower dealers on account of its easy culture and wide adaptability, its habit of free flowering short duration to produce marketable flowers, wide spectrum of attractive color shape, size and good keeping quality. It is highly suitable as a bedding plant in herbaceous borders and is also ideal for newly planted shrubberies to provide color and fill the space both leaves and flowers are equally important from medicinal point of view. Leaf paste is used externally against boils and carbuncles. Leaf extract is a good remedy for earache and has fungicidal effect Marigold species vary in size from 0.1 to 2.2 m tall most species have pinnate green leaves blooms naturally occur in golden, orange, yellow and white colors, often with maroon highlights. Among the different marigold species *Tagetes patula* (French marigold) is a major flower producing species which is grown throughout India and produce good quality of flowers.

It is grown on small farms all over the country under open field condition for centuries. A large number of French marigold variety developed in 2009 by *Pusa arpita* is nowadays successfully grown in various parts of the country.
Since the growth and production of marigold are influenced by chemical fertilizers their nutrient requirement is fulfilled especially by supplying phosphate fertilizers. However, indiscriminate and long-term use of chemicals fertilizers has not only led to imbalance of nutrients in soil resulting in degradation of soil structure but has also affected the growth and production of flowers. Nowadays, a lot of emphasis is being given on the use of bio fertilizers to increase the production of crops. Bio fertilizers usually consist of live or latent cells of microorganisms which include biological nitrogen fixers, p-solubilising mineralization of nitrogen and transformation of several elements into available forms. VAM fungi, *Azotobacter*, *Azospirillium* and phosphate solubilising bacteria are commonly applied bio fertilizers in horticultural crops (Zaredost *et al.* 2014). Bio fertilizers such as *Trichoderma***,** *Paecilomyces*, *Beauveria*, *Rhizobium*, *Azotobacter*, *Azospirillium*, *Pseudomonas*, and *Bacillus megaterium* are normally used as bio fertilizers to improve crop yield. Bio fertilizers contain live cells of specific isolated strains of bacteria and fungi which is formulated in suitable carriers. These microbes upon application to the soil under suitable conditions secrete metabolites and enzymes which make the deficient element available to the plant in an assemble from. Nitrogen bacteria fixes atmospheric nitrogen in soil while phosphor bacteria solubilizes insoluble fixed phosphorus in soil, potassium mobilizing bacteria mobilizes the immobile potassium in soil and similarly other microbes mobilize and solubilize the element in soil and make it available to the plant. VAM infected roots penetrate the soil effectivity make relatively unavailable such as phosphorus, copper and zinc available to the plant. These beneficial microorganisms works incognito to maintain the ecological balance by active participation in carbon nitrogen sulphur, and phosphorus cycle in nature.
Indiscriminate application of chemical fertilizers alters the soil fertility, leading to pollution of soil and water bodies. however, considering the recent concept of eco technology and increase cost of inorganic fertilizers, use of cost effective and eco-friendly bio fertilizers, which has currently a special significance in crop production to address the sustainability problem and tremendous success has been achieved in several; other crops. Use of bio fertilizers reduces per unit consumption of inorganic fertilizers and increases the quality and quantity of flowers (Syamal *et al*.) 2006 [1].
Fertilizers is the main source of nutrient to provide the crop for better output in which bio fertilizer may play important role for the nutritional security of the crop. Bio fertilizers help in the fixation of atmospheric nitrogen as well as improving phosphorus uptake by plants. (Kumar *et al*.) 2008.

Materials and Methods

The experimental was conducted in Randomized block design (RBD) with 12 treatments of taken 8 bio fertilizers with three replications in the Departmental Research field of horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during March 2019 to May 2019. Total number of treatments were 12 *viz*. T_0 [FYM 25/tones/hectare]; T_1[*Pecilomyces lilacinus* + *Pseudomonas fluorescens*], T_2[*Pseudomonas fluorescens* + *Trichoderma viridae*], T_3[*Trichoderma viridae* + *Beauveria basina*], T_4[*Beauveria basina* + *Azotobacter*],T_5[*Azospirillium* +*Fructuria eurantia*], T_6[*Fructuria eurantia* + *Bacillus megaterium*], T_7 [*Bacillus megaterium* + *Pecilomyces lilacinus*], T_8[*Trichoderma viridae* + *Azotobacter* + *Bacillus megaterium*], T_9[*Trichoderma viridae* + *Azospirillium* +*Fructuria eurantia*], T_{10}[*Pseudomonas fluorescens* + *Azotobacter* + *Bacillus megaterium*], T_{11}[*Pseudomonas fluorescens* + *Azospirillium* +*Fructuria eurantia*].

Climatic condition in the experimental site

The area of Prayagraj district comes under subtropical belt in the south east of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 ºC – 48 ºC and seldom falls as low as 4 ºC – 5 ºC. The relative humidity ranges between 20-94. The average rainfall in these areas is around 1013.4mm annually. However, occasional precipitation is also not uncommon during summer season months.

Results and Discussion

The present investigation entitled on "Effect of bio fertilizers on plant growth and flower yield of African marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda" was carried out during March 2019 to May 2019 in the Departmental Research field of horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India. The results of the present investigation, regarding the effect of FYM, Plant height (cm), Number of primary branches per plant, Number of secondary branches per plant, Plant spread (cm), First day to flower bud appearance, Days to 50% flowering, Number of flowers/plant, Flower diameter (cm), Individual flower weight (gm), Flower yield/plant (gm), Flower yield/hectare (tones), have been discussed and interpreted in the light of previous research work done in India and abroad. The experiment was conducted in Randomized block design with 12 treatments, and three replications.
The results of the experiment are summarized below.

A. Growth Parameters

The maximum plant height (56.73 cm) was observed in the Treatment T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] followed by treatment T_4 [*Beauveria basina* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare] (52.79cm) the plant height was found minimum (40.53cm) in the treatment T_3 [*Trichoderma viridae* @ 2.5kg/hectare + *Beauveria basina* @ 2.5kg/hectare].The maximum number of primary branches per plant (12.11cm) was observed in the treatment T_7 [*Bacillus megaterium* @ 13kg/hectare + *Paecilomyces lilacinus* @ 10kg/hectare] followed by T_{10} [*Azotobacter* @ 2.5kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare + *Bacillus megaterium* @ 13kg/hectare] (8.78 cm). The number of primary branches per plant was found minimum (4.00 cm) in the treatment, T_4 [*Beauveria basina* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare]. The maximum number of secondary branches per plant (19.78cm) was observed in the treatment T_4 [*Beauveria Basina* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare] followed byT_{11} [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare] (18.33 cm). The number of secondary branches per plant was found minimum (7.44 cm) in the treatment, T_3 [*Trichoderma viridae* @ 2.5kg/hectare + *Beauveria basina* @ 2.5kg/hectare]. The maximum plant spread (North-South) (20.86cm) was

observed in the treatment T_1 [*Paecilomyces lilacinus* @ 10kg/hectare + *Pseudomonas Fluorescens* @ 2.5kg/hectare] followed by treatment T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] (19.84 cm) the plant spread was found minimum (14.97cm) in the treatment T_{11} [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare]. The maximum plant spread (East-West) (20.23 cm) was observed in the treatmentT_1 [*Paecilomyces lilacinus* @ 10kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare*]* followed by treatment (19.24 cm). T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] the plant spread was found minimum (14.26 cm) in the treatment T_{11} [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare].

B. Floral Parameters

The number of days for bud initiation was found maximum (44.89 days) in treatment T_3 [*Trichoderma viridae* @ 2.5kg/hectare + *Beauveria basina* @ 2.5kg/hectare] followed by treatment T_{11} [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare] (46.00 days). The number of days for bud initiation was found minimum (82.67 days) in treatment T_5 [*Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare] The Number of days for 50% flowering was found minimum (49.33 days) in treatment T_{11} [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare]. Followed by the treatment T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] (49.89 days). The number of days taken for 50% flowering was found maximum (93.78 days) T_5 [*Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare].the treatment T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] have maximum flowers per plant (12.67) followed by treatment T_1 [*Paecilomyces lilacinus* @ 10kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare] and T_4 [*Beauveria basina* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare] (10.78). The number of flowers per plant was found minimum (4.33) in the treatment T_2 [*Pseudomonas Fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] number of diameter per flower (8.37) T_{11} [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare]. Have maximum diameter per flower (5.63) T_4 [*Beauveria basina* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare] the number of diameter per flower was found minimum (3.93) in the treatment T_9 [*Trichoderma viridae* @ 2.5kg/hectare + *Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare]. Maximum weight of flower was recorded in treatment T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma Viridae* @ 2.5kg/hectare] and followed by treatment T_1 [*Paecilomyces lilacinus* @ 10kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare] (2.78 g). The minimum weight of flower was recorded in treatment T_3 [*Trichoderma viridae* @ 2.5kg/hectare + *Beauveria basina* @ 2.5kg/hectare] (1.53 g).

C. Yield Parameters

The maximum flower yield per plant was recorded in treatment (38.00 g) T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] and followed by treatment T_1 [*Paecilomyces lilacinus* @ 10kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare] and T_4 [*Beauveria basina* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare] (32.33 g). The minimum weight of flower was recorded in treatment T_3 [*Trichoderma viridae* @ 2.5kg/hectare + *Beauveria Basina* @ 2.5kg/hectare] (13.00 g).The maximum flower yield (t/ha) was recorded in treatment (6.33) T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] and followed by treatment T_1 [*Paecilomyces lilacinus* @ 10kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare] and T_4 [*Beauveria basina* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare] (5.39). The minimum weight of flower was recorded in treatment T_9 [*Trichoderma viridae* + *Azospirillium* +*Fructuria eurantia*] (2.89).

Table 1: Effect of bio fertilizers on plant growth and flower yield of African marigold (*Tagetes erecta L.)* Cv. Pusa Narangi Gainda

Treatment Symbol	Treatment Details	Plant Height	Primary Branches	Secondary Branches	Plant Spread (N-S)	Plant Spread (E-W)	1st Flower	50% Flowering	No. of flower / plant	No. of diameter / flower	Wt. of flower / plant	Flower yield / plant	Flower yield / ha
T_0	Control @ 25tone/hectare	47.20	7.67	14.00	18.77	18.40	80.22	89.33	7.44	5.36cm	2.56	22.33	3.72
T_1	*Paecilomyces lilacinus* @ 10kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare	50.98	5.33	16.22	20.86	20.23	76.89	86.56	10.78	5.60	2.78	32.33	5.39
T_2	*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare	56.73	4.33	14.33	19.84	19.24	73.78	81.22	12.67	5.61	2.79	38.00	6.33
T_3	*Trichoderma viridae* @ 2.5kg/hectare + *Beauveria basina* @ 2.5kg/hectare	40.53	7.56	7.44	16.94	16.54	44.89	49.89	4.33	3.30	1.53	13.00	3.09
T_4	*Beauveria basina* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare	52.79	4.00	19.78	17.56	17.29	77.44	86.33	10.78	5.63	2.50	32.33	5.39
T_5	*Azospirillium* @	41.60	5.44	13.11	17.28	17.19	82.67	93.78	10.56	5.48	2.24	31.67	5.28

	2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare												
T_6	*Fructuria eurantia* @ 5kg/hectare + *Bacillus megaterium* @ 13kg/Hectare	44.68	6.67	17.11	17.82	17.06	74.56	91.33	7.78	5.52	2.69	23.33	3.89
T_7	*Bacillus megaterium* @ 13kg/hectare + *Paecilomyces lilacinus* @ 10kg/hectare	44.82	12.11	15.33	18.00	17.63	80.11	86.78	10.11	5.39	2.69	30.33	5.06
T_8	*Trichoderma viridae* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare + *Bacillus megaterium* @ 132kg/hectare	41.08	6.89	11.00	15.53	13.98	73.56	82.89	8.11	5.04	2.50	24.33	4.06
T9	*Trichoderma viridae* @ 2.5kg/hectare + Azospirillium @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare	43.32	6.22	11.11	17.27	16.26	53.11	59.11	5.78	3.93	1.94	17.33	2.89
T10	*Azotobacter* @ 2.5kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare + *Bacillus megaterium* @ 13kg/hectare	45.74	8.78	16.56	17.06	16.10	79.89	89.11	10.22	5.50	2.77	30.67	5.11
T11	*Pseudomonas fluorescens* @ 2.5kg/hectare + *Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare	43.97	6.22	18.33	14.97	14.26	46.00	49.33	6.78	8.37	1.69	20.33	3.39
F-test		S	S	S	N/S	N/S	S	**S**	S	**S**	S	S	S
SE(m)		3.091	1.193	2.293	1.552	1.532	7.409	7.454	0.839	0.322	0.322	2.518	0.420
C.D. at 5%		9.067	3.498	6.725	4.551	4.495	21.729	21.861	2.462	0.945	0.945	7.385	1.231

Conclusion

On the basis of present investigation, it is concluded that treatment (56.73 cm) T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] was found to be best treatment in terms of plant height, (12.11cm) T_7 [*Bacillus megaterium* @ 13kg/hectare + *Paecilomyces lilacinus* @ 10kg/hectare] was found to be best treatment in terms of primary branches, (19.78cm) T_4 [*Beauveria basina* @ 2.5kg/hectare + *Azotobacter* @ 2.5kg/hectare] was found to be best treatment in terms of secondary branches, (20.86cm) T_1 [*Paecilomyces lilacinus* @ 10kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare] was found to be best treatment

in terms of plant spread in north-south, (20.23 cm) T_1 [*Paecilomyces lilacinus* @ 10kg/hectare + *Pseudomonas fluorescens* @ 2.5kg/hectare]was found to be best treatment in terms of plant spread in east-west, 44.89 days T_3 [*Trichoderma viridae* @ 2.5kg/hectare + *Beauveria basina* @ 2.5kg/hectare] was found to be best treatment in terms of bud initiation, (49.33 days) in treatment T_{11} [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Azospirillium* @ 2.5kg/hectare + *Fructuria eurantia* @ 5kg/hectare].was found to be best treatment in terms of number of days for 50% flowering, (12.67) T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] was found to be best treatment in terms of number of flowers per plant, (2.79 g) T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] was found to be best treatment in terms of weight of flower, yield parameters, (38.00 g) T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare] was found to be best treatment in terms of flower yield per plant, (6.33) T_2 [*Pseudomonas fluorescens* @ 2.5kg/hectare + *Trichoderma viridae* @ 2.5kg/hectare]was found to be best treatment in terms of flower yield (t/ha) of African marigold cv Pusa Narangi Gainda.

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