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Impact of biofertilizers on growth performance of African marigold var Pusa Bahar (*Tagetes erecta* L.)

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Abstract
The present investigation entitled "Impact of Biofertilizers on Growth Performance of African marigold var. Pusa Bahar (*Tagetes erecta* L.)" under the Horticulture Research Cum Instructional Farm, was conducted during December 2024-March 2025 at the Department of Floriculture and Landscape Architecture College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur. This experiment was carried out to understand how different biofertilizers and their combinations influence the vegetative growth of African marigold (*Tagetes erecta* L.) cv. Pusa Bahar. Ten treatment combinations involving *Azotobacter*, *Azospirillum*, *PSB*, *KSB* and their combinations were tested under a randomized block design. Among all the treatments, the combination of *Azotobacter*, *PSB* and *KSB* (T_7) performed the best resulting in the tallest plants height, the highest number of branches, the widest plant spread and the longest roots length by 90 days after transplanting. The findings clearly show that using a combination of biofertilizers can significantly enhance the vegetative growth of marigold plants.

Keywords: Marigold, biofertilizers, *Azotobacter*, *Azospirillum*, *PSB*, *KSB*

Introduction
Marigold is one of the most popular annual flowers in India for garden display as well as for commercial cultivation. It was introduced in India during the 16th century and since then it has been naturalized in different agroclimatic regions of India and now appears to be native of this country. The marigold is one of the easiest annual flowers to cultivate and have wide adaptability to different soil and climatic conditions.

Marigold belongs to the family Asteraceae and genus Tagetes. There are about 33 species under this genus (Ghosh *et al.* 2022) [11] but two species; *Tagetes erecta* L., the African Marigold and *Tagetes patula* L. the French Marigold are very common to Indian gardens. Indigenous to Mexico, African Marigold are vigorously tall growing plant having flowers measuring up to 15 cm or more across and in shade of lemon, yellow, orange, bright yellow and nearest to white, while French Marigold are compact in habit, flower profusely in single or double.

Biofertilizers are helpful microbes that naturally support plant growth by making essential nutrients more available in the soil. Among them Azotobacter and *Azospirillum* are known for fixing nitrogen from the air and helping plants grow stronger and healthier. While *Azotobacter* lives freely in the soil, *Azospirillum* forms a close bond with plant roots and boosts root development. Phosphate Solubilizing Bacteria (*PSB*) help unlock phosphorus in the soil which plants need for strong roots and energy. Potassium Solubilizing Bacteria (*KSB*) make potassium more available which improves the plant's ability to handle stress and produce better yields. Together these biofertilizers offer a natural and eco-friendly way to grow healthier crops while reducing the need for chemical fertilizers.

Materials and Methods
The study was conducted in the Horticulture Research Cum Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur. The mean maximum temperature is around 30.27 °C and mean minimum is 19.22 °C. The annual rainfall ranges from 1200-1400 mm, while the average minimum and maximum relative humidity ranged from 31 percent to 91 percent. The soil is clay loam with pH 7.9.

The material comprised of marigold variety Pusa Bahar from IARI New Delhi. The experiment was laid out in Randomized Block Design (RBD) with ten treatments and three replications. The Biofertilizer were applied at the time of transplanting. The plants were transplanted in the beds size of 1.4 x 1.6 m^2 with 45 x 30 cm^2 spacing accommodating 16 plants/plot.

Data were recorded in growth parameter such as plant height (cm), no. of primary branches, no. of secondary branches, plant spread (cm) and root length (cm) at their appropriate time of observation as suggested by marigold descriptors (30 DAT, 60 DAT or 90 DAT).

Table 1: Treatment details:

Notation	Treatment
T_1	Control
T_2	*Azotobacter* @ 10 ml
T_3	*Azospirillum* @ 10 ml
T_4	*PSB* @ 10 ml
T_5	*KSB* @ 10 ml
T_6	*Azotobacter* @ 10 ml +*PSB* @ 10 ml
T_7	*Azotobacter* @ 10 ml +*PSB* @ 10 ml + *KSB* @ 10 ml
T_8	*Azotobacter* @ 10 ml+*KSB* @ 10 ml
T_9	*Azospirillium* @ 10 ml +*KSB* @ 10 ml
T_{10}	*PSB* @ 10 ml +*KSB* @ 10 ml

The data recorded on different observations were tabulated and analysed as per the procedure lay down by Gomez (1984) [12]. The F-test was performed for judging the significance of the treatment mean square. The significant differences between means were judged by using critical differences (CD) were worked out at 5 percent level of significance. Analysis of variance (ANOVA) table was prepared in the following way for each character.

Results and Discussion

The result of the current study indicated that the biofertilizers had significant individual effects and combined effects on the growth of marigold variety Pusa Bahar. The mean. CV and CD at 5% level of significance of growth parameters of marigold under the combined effects of biofertilizers is tabulated in Table 2. Comparing all the treatments, control is found to be having much lower values. On comparing all the treatments, the T_7 (*Azotobacter* @ 10 ml +*PSB* @ 10 ml + *KSB* @ 10 ml) was found to be the best treatment for improving the growth of marigold.

Plant height (cm)

The highest plant (56.38 cm) recorded in treatment T_7 (*Azotobacter* + *PSB* + *KSB*), compared with control was recorded (46.54 cm). The enhanced growth can be attributed to improved nutrient availability and uptake due to the synergistic effect of nitrogen fixation and solubilization of phosphorus and potassium.

Number of primary branches

The application of biofertilizers significantly enhanced the number of primary branches in marigold at all growth stages (30, 60 and 90 DAT). The combined treatment of T_7 (*Azotobacter* + *PSB* + *KSB*) consistently recorded the highest number of branches, followed by T_6 and T_{10}, while the control (T_1) showed the least. The improved performance with biofertilizer combinations can be attributed to better nutrient availability through nitrogen fixation and phosphorus and potassium solubilization, which promoted vegetative growth.

Number of secondary branches

The number of secondary branches per plant was significantly influenced by different biofertilizer treatments at all stages of observation. The highest number was recorded in T_7 (*Azotobacter* + *PSB* + *KSB*) with 29.04, which was significantly superior to the control (T_1). The increased branching may be due to enhanced nutrient uptake and hormonal stimulation by combined biofertilizers, leading to better vegetative growth. Ahmad *et al.*

Plant spread (cm)

The application of biofertilizers significantly enhanced plant spread in both North-South and East-West directions at all growth stages (30, 60 and 90 DAT) in marigold. The maximum plant spread was consistently observed in treatment T_7 (*Azotobacter* + *PSB* + *KSB*), followed by T_6 and T_{10} indicating the superior effect of combined biofertilizer application over single treatments and the control. This may be due to high physiological activity synchronized with maximum nutrient convert in available form and increase the micro-flora due to incorporate of FYM in soil and biofertilizer (*Azotobacter*, *PSB* and *KMB*) may enhance microbial activity may lead to proper utilization of supplied nutrient to the plants.

Root length (cm)

The application of biofertilizers had a significant effect on root length in marigold, with the highest root length recorded in treatment T_7 (*Azotobacter* + *PSB* + *KSB*) each at 20.11 cm followed by T_6 (*Azotobacter* + *PSB*) at 19.85 cm, all of which were superior to the control T_1 at 15.72 cm. The improved root development in these treatments can be attributed to the synergistic effects of nitrogen fixation, phosphorus and potassium solubilization, and stimulation of growth hormones like IAA, which collectively enhance nutrient uptake and root elongation.

The role of the biofertilizers in absorption, availability and concentration of nutrient such as phosphorus and nitrogen increased most of shoot characteristics of plants with biofertilizer inoculation (*Azotobacter*+ *PSB*+ *KSB*). In stimulating production of the biofertilizers play an important role that positively reflect in elongation, increased divisions, and cells expansion, which reflected on shoot growth. Increasing vegetative growth depends on availability of elements in leaves that increase activity and management of photosynthesis, which leads to increase the CO2 in the leaves which is base units for building the amino acids, carbohydrates, and protein structures.

Table 2: Mean, Coefficient of Variation (CV) and Critical Difference (CD) (At 5% level of significance) of growth parameters of marigold under combined effects of the treatments.

Treatment	Plant Height (cm)	No. of primary branches	No. of secondary branches	Plant spread (cm)		Root length (cm)
				[N-S]	[E-W]	
T_1	46.54	10.51	22.09	35.59	35.94	15.72
T_2	47.72	12.13	23.10	36.96	36.85	17.92
T_3	50.55	12.49	23.03	36.27	36.42	16.86
T_4	53.82	13.59	27.28	37.36	37.38	18.76
T_5	50.19	11.40	22.13	36.46	36.60	17.71
T_6	54.82	14.29	28.52	39.36	39.26	19.85
T_7	56.38	14.84	29.04	39.95	39.63	20.11
T_8	50.42	13.27	25.02	38.22	38.36	19.03
T_9	50.60	13.25	25.55	37.90	38.64	19.54
T_{10}	53.58	13.87	27.91	38.70	39.21	18.42
Mean	51.46	12.96	25.37	37.68	35.94	18.69
C.D.at 5%	1.99	0.54	1.15	1.89	1.69	2.10
C.V.	2.25	2.41	3.24	2.93	2.60	6.51

Means followed by the same letter do not statistically differ at 5% level of significance.

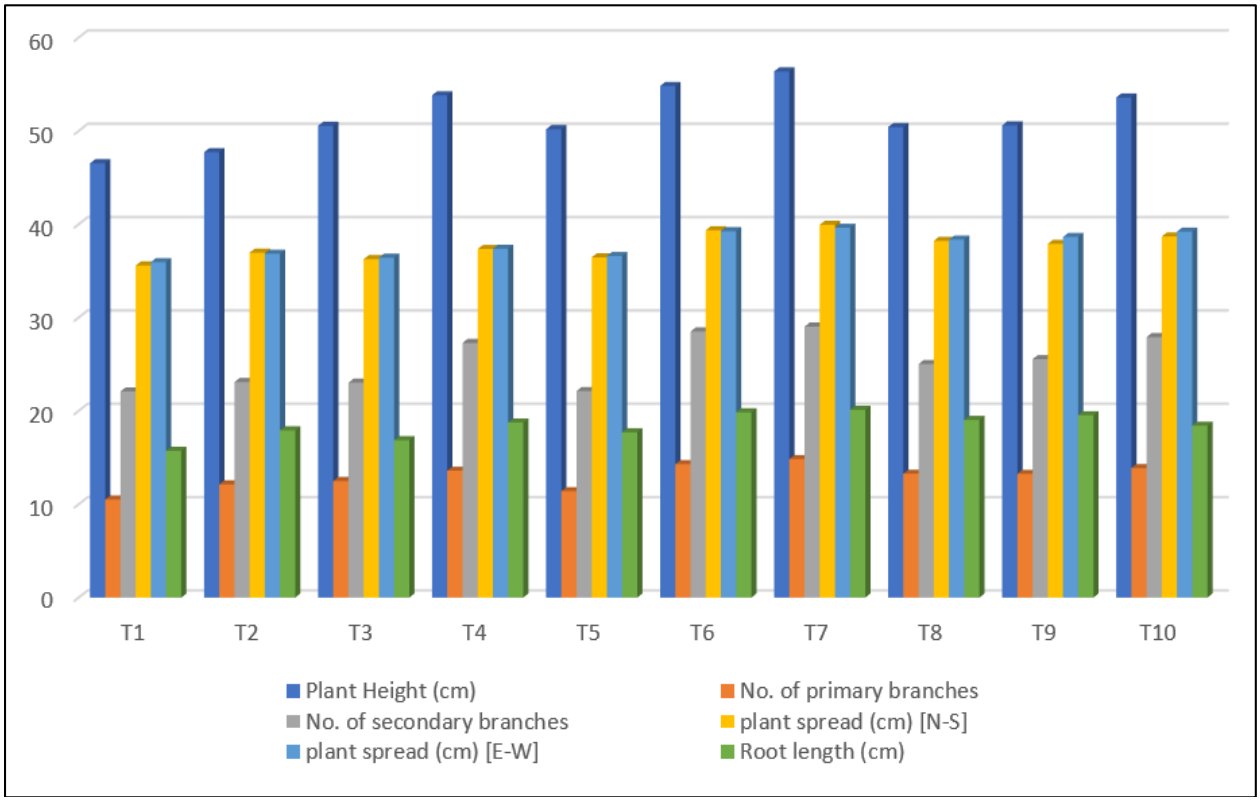

Fig 1: Mean value of growth parameters of marigold under combined effects of the treatments.

Conclusion

The findings on the growth of African marigold from the present study, titled "Impact of Biofertilizers on Growth Performance of African Marigold var. Pusa Bahar (*Tagetes erecta* L.)", clearly demonstrate that the application of biofertilizers, particularly in combination, significantly enhances vegetative growth. Among all the treatments, the combined application of *Azotobacter*, *PSB*, and *KSB* (T_7) was found to be the most effective, resulting in increased plant height, a higher number of branches, greater plant spread, and longer root development. These results emphasize the positive and synergistic impact of using multiple biofertilizers together compared to their individual application.

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