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# Influence of Different Bio-Fertilizers and Its Consortium on Growth, Flowering and Seed Yield of Marigold

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**ABSTRACT**

*A field experiment was carried out at the Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P. during 2015-16 and 2016-17 to find out the influence of different bio-fertilizers and its consortium on growth, flowering and seed yield of marigold and pooled data of both the years of experiments are taken. The experiment was laid out in randomized block design comprising sixteen treatment combinations replicated thrice. The treatments comprised of $N_2$ fixer (Azotobactor), PSB (Pseudomonas + Bacillus polymyxa), RDFYM and three levels of NPK. On the basis of data, fresh weight of leaf (4.50 g) was highest in $T_{15}$ albeit, $T_{14}$ resulted maximum dry weight of leaf (1.75 g) and leaf biomass/plant (1773.57 g). The maximum stem diameter (1.84 cm) and plant height (136.44 cm) were recorded in $T_{15}$ and $T_{14}$, respectively. The maximum length of peduncle (5.08 cm) was recorded in $T_{14}$ whereas, maximum number of flowers/plant (44.04) and number of petals/flower (75.81) were noticed in $T_{15}$ and $T_{14}$, respectively. The maximum fresh weight of flower (7.35 g) and dry weight of flower (1.81 g) were recorded with $T_{15}$. The minimum number of days to seed ripening (60.61 days) was taken by $T_{14}$. The maximum number of seeds/peduncle (152.88), weight of seeds/peduncle (1.06 g), 100 seeds weight (1.29 g) were recorded with both $T_{15}$ and $T_{14}$ and greater seed yield/plant (51.94 g) was recorded with $T_{15}$.*

***Key words:*** *bio-fertilizers, consortium, FYM, Marigold, NPK and Pusa Narangi Gainda.*

## INTRODUCTION

Marigold is the scared flower of the Aztecs and the earliest use was by the Aztecs people who attributed magical, religious and medicinal properties to marigolds. The first recorded use of marigolds was found in the De La Crus-Badiano Aztect Herbal of 1552. The Aztecs bred the marigold for increasingly large blooms. This becomes popular in Southern Europe under the name "Rose of Indies". Marigold is native of Central and South America, especially Mexico. From Mexico it spread to different parts of the world during early part of the 16th century. Marigolds are broadly divided into two groups, namely, African marigold and French marigold[21]. They are extensively used for making garlands, beautification and other purposes i.e. pigment and oil extraction and therapeutic uses.

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It is highly suitable for bedding purpose and herbaceous border and also for newly planted shrubberies to provide colour and fill the space[20]. Flowers remain fresh for 4-5 days at room temperature and are used for religious offerings and social functions[13]. Bio-fertilizer is a substance which contains living microorganisms which and when applied to seed, plant surfaces, soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant[19]. The term bio-fertilizers or microbial inoculants can be define as the preparations containing strains of micro-organism which can augment the microbiological process *viz*. nitrogen fixation, phosphate solubilisation or mineraliztion, extraction of plant growth promoting substances or cellulose or lignin biodegradation in soil, compost or other environment[6]. As reported in numerous studies, *Azotobacter* is well known symbiotic N-fixing bacteria which help the plants indirectly through better nitrogen fixation or improving the nutrient availability in the soil. While, Phosphate Solubilizing Bacteria (PSB) are used to increase the availability of phosphorus in soil. The increase in growth characteristics like plant height, early flowering, nutrient uptake were observed in French marigold and Roses by *Azospirillum* inoculation[10]. Keeping the above facts in view, the present investigation was conducted with the objectives of to see the influence of bio-fertilizers and its consortium on growth, flowering and seed characters of marigold plants.

## MATERIALS AND METHODS

A field experiment was conducted using marigold cv. Pusa Narangi Gainda at the Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P. during 2015-16 and 2016-17 and pooled data of both year the experiments were taken. The seedling of marigold was planted in the month of October-November at a spacing of 45×45 cm and experiment was laid in randomized block design with three replications. Normal recommended cultural practices and plant protection measures were followed. The treatments detail is as follows, $T_1$-Control (No fertilizers, Organic manures and Bio-fertilizers), $T_2$-$N_2$ fixer (*Azotobactor*), $T_3$-PSB (*Pseudomonas* + *Bacillus polymyxa*), $T_4$-$N_2$ fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*), $T_5$-$N_2$ fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM, $T_6$-50% NPK, $T_7$-50% NPK + $N_2$ fixer (*Azotobactor*), $T_8$-50% NPK + PSB (*Pseudomonas* + *Bacillus polymyxa*), $T_9$-50% NPK + $N_2$ fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*), $T_{10}$-50% NPK + $N_2$ fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM, $T_{11}$-75% NPK, $T_{12}$-75% NPK + $N_2$ fixer (*Azotobactor*), $T_{13}$-75% NPK + PSB (*Pseudomonas* + *Bacillus polymyxa*), $T_{14}$-75% NPK + $N_2$ fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*), $T_{15}$-75% NPK + $N_2$ fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM and $T_{16}$-100% NPK. Five competitive plants were randomly selected for recording biometrical measurement on fresh weight of leaf (g), dry weight of leaf (g), leaf biomass (g), stem diameter (cm), plant height (cm), length of peduncle (cm), number of flowers/plant, number of petals/flower, fresh weight of flower (g), dry weight of flower (g), days to seed ripening, number of seeds/peduncle, weight of seeds/peduncle (g), 100 seeds weight (g) and seed yield/plant (g). Observations on various growth, flowering and seed characters were recorded and obtained results were subjected to statistical analysis for interpretation of data.

## RESULTS AND DISCUSSIONS

The findings pertaining on growth parameters is presented in Table 1 and it is crystal clear that $T_{15}$ resulted in maximum fresh weight of leaf (4.50 g) followed by $T_{14}$ (4.40) whereas, control plants noticed in minimum fresh weight of leaf (2.10 g). Maximum dry weight of leaf (1.75 g) was recorded in treatment $T_{14}$ followed by $T_{15}$ (1.74 g) while, minimum dry

weight of leaf (0.68 g) was recorded in control ($T_1$). Application of bio-fertilizers significantly influenced the fresh and dry weight of leaves over control. Maximum fresh and dry weight of leaves were recorded with 1.00 kg/ha *Azotobacter*[17]. Treatment $T_{14}$ has produced maximum leaf biomass/plant (1773.57 g) followed by $T_{15}$ (1771.70 g) while, minimum leaf biomass/plant (452.35 g) was noticed under $T_1$. These findings were supported by Singh, 2007[14] and accordance with the Mishra *et al*., 2003[8]. $T_{15}$ resulted in more stem diameter (1.84 cm) which was followed by $T_{14}$ (1.63 cm) however, less stem diameter was recorded with treatment $T_1$ (0.96 cm). Gayathri *et al.*[7] reported increased plant height with the application of 75% NPK + vermicompost + *Azotobacter* + PSB. Results are also supported by Singh *et al*[15]. The highest plant height (136.44 cm) was recorded in $T_{14}$ followed by $T_{15}$ (135.35 cm) while, $T_1$ produced lowest plant height (98.37 cm). Timely supply of required plant nutrients to the plants is one of the main factors affecting the plant height[12].

**Table 1: Influence of different bio-fertilizers and its consortium on growth of marigold (Pooled data)**

| Treatments | Fresh weight of leaf (g) | Dry weight of leaf (g) | Leaf biomass (g) | Stem diameter (cm) | Plant height (cm) |
|---|---|---|---|---|---|
| $T_1$ | 2.10 | 0.68 | 452.35 | 0.96 | 98.37 |
| $T_2$ | 2.20 | 0.72 | 512.58 | 0.97 | 108.20 |
| $T_3$ | 2.25 | 0.73 | 564.76 | 1.08 | 110.85 |
| $T_4$ | 2.46 | 0.77 | 637.07 | 1.12 | 111.70 |
| $T_5$ | 2.53 | 1.03 | 668.43 | 1.16 | 111.60 |
| $T_6$ | 2.63 | 1.05 | 731.37 | 1.20 | 113.26 |
| $T_7$ | 3.10 | 1.07 | 870.45 | 1.22 | 117.10 |
| $T_8$ | 3.17 | 1.14 | 912.92 | 1.30 | 119.18 |
| $T_9$ | 3.26 | 1.19 | 1001.56 | 1.33 | 120.08 |
| $T_{10}$ | 3.42 | 1.37 | 1081.34 | 1.38 | 125.81 |
| $T_{11}$ | 3.78 | 1.38 | 1211.41 | 1.38 | 126.15 |
| $T_{12}$ | 4.14 | 1.53 | 1378.15 | 1.43 | 128.41 |
| $T_{13}$ | 4.27 | 1.62 | 1531.75 | 1.51 | 129.31 |
| $T_{14}$ | 4.40 | 1.75 | 1723.57 | 1.63 | 132.27 |
| $T_{15}$ | 4.50 | 1.76 | 1842.20 | 1.84 | 139.33 |
| $T_{16}$ | 4.03 | 1.57 | 1547.98 | 1.55 | 135.35 |
| SEm ± | 0.21 | 0.17 | 77.63 | 0.14 | 4.24 |
| CD at 5% | 0.60 | 0.48 | 224.23 | 0.41 | 12.24 |

The evidence on flowering parameters is contained in Table 2. The maximum length of peduncle (5.08 cm) was recorded in $T_{14}$ followed by $T_{15}$ (5.07 cm) whereas, minimum length of peduncle (2.74 cm) was recorded with $T_1$. Maximum number of flowers/plant (44.04) were recorded under $T_{15}$ followed by $T_{14}$ (43.15) while, minimum number of flowers/plant (26.15) produced in $T_1$ (control). These findings corroborate with those of Yadav *et al.*[22] in tuberose, Basoli *et al.*[3] in gladiolus, Ali *et al.*,[2] in gladiolus, Sunitha *et al.*,[16] and Mittal *et al.*,[9] in marigold. Maximum number of petals/flower (75.81) were recorded in $T_{14}$ followed by $T_{15}$ (75.74) while, $T_1$ resulted in minimum number of petals/flower (39.61). The highest fresh weight of flower (7.35 g) was recorded with $T_{15}$ followed by $T_{14}$ (6.50 g) whereas, minimum fresh weight of flower (4.12 g) was noticed under $T_1$. The maximum dry weight of flower (2.11 g) was recorded with $T_{15}$ followed by $T_{13}$ (1.66 g) and minimum dry weight of flower (0.90 g) was noticed under $T_1$. The increase in flower weight due to nitrogen is explained in the basis of the fact that appropriate dose of nitrogen resulted in assimilation of more carbohydrates, which results in the increased vegetative growth. These carbohydrates when translocated to reproductive organs undergo hydrolysis and get converted into reproductive sugars, which ultimately help in increasing flower size and weight in marigold[18].

**Table 2: Influence of different bio-fertilizers and its consortium on flowering of marigold (Pooled data)**

| Treatments | Length of peduncle (cm) | Number of flowers/ plant | Number of petals/ flower | Fresh weight of flower (g) | Dry weight of flower (g) |
|---|---|---|---|---|---|
| $T_1$ | 2.74 | 26.15 | 39.61 | 4.12 | 0.90 |
| $T_2$ | 3.54 | 26.22 | 46.96 | 4.21 | 1.00 |
| $T_3$ | 3.64 | 27.48 | 53.49 | 4.34 | 1.07 |
| $T_4$ | 3.72 | 31.61 | 54.24 | 4.40 | 1.11 |
| $T_5$ | 3.79 | 33.76 | 56.97 | 4.55 | 1.16 |
| $T_6$ | 4.07 | 33.01 | 58.56 | 4.85 | 1.26 |
| $T_7$ | 4.20 | 34.80 | 60.70 | 4.94 | 1.31 |
| $T_8$ | 4.25 | 36.67 | 65.73 | 4.95 | 1.33 |
| $T_9$ | 4.39 | 35.83 | 68.28 | 4.98 | 1.34 |
| $T_{10}$ | 4.55 | 38.31 | 68.52 | 5.39 | 1.43 |
| $T_{11}$ | 4.64 | 40.23 | 71.56 | 5.81 | 1.52 |
| $T_{12}$ | 4.68 | 41.19 | 72.83 | 5.93 | 1.59 |
| $T_{13}$ | 4.93 | 41.71 | 73.93 | 6.42 | 1.66 |
| $T_{14}$ | 5.08 | 43.15 | 75.81 | 6.50 | 1.63 |
| $T_{15}$ | 5.07 | 44.04 | 75.74 | 7.35 | 2.11 |
| $T_{16}$ | 4.67 | 39.29 | 72.83 | 6.39 | 1.45 |
| SEm ± | 0.24 | 1.41 | 2.46 | 0.29 | 0.11 |
| CD at 5% | 0.70 | 4.07 | 7.10 | 0.84 | 0.32 |

The results on seed yield presented in Table 3. Treatment $T_{14}$ recorded for least number of days to seed ripening (60.61 days) and followed by $T_{15}$ (61.45 days) albeit, maximum number of days to seed ripening (75.28 days) was recorded with $T_1$. The similar results were obtained by Rajadurai *et al.*[11], Bhaskaran *et al.*[4] and Ahemed *et al.*[1]. The maximum number of seeds/flower (152.88) was found in $T_{15}$ followed by $T_{14}$ (151.40) though, $T_1$ produces minimum number of seeds/flower (129.12). $T_{15}$ has produced more weight of seed/flower (1.06 g) followed by $T_{16}$ (0.99 g) while, minimum weight of seed/flower (0.70 g) was noticed with $T_1$. Both, $T_{15}$ and $T_{14}$ resulted in maximum 100 seeds weight (1.29 g) followed by $T_{11}$ (1.28 g) albeit, minimum 100 seeds weight (0.66 g) was noticed under $T_1$. Treatment $T_{15}$ has produced more seed yield/plant (51.94 g) which was closely followed by $T_{14}$ (48.02 g), Notwithstanding, minimum seed yield/plant (18.30 g) was noticed with $T_1$. Positive increasement in seed yield and their related characters by the applications of bio-fertilizers may be due to the increasement in availability of micro and macro nutrients to the plants and increasement in hormonal activities within the plant. Chandrikapure *et al.*[5] also reported similar findings in marigold.

**Table 3: Influence of different bio-fertilizers and its consortium on seed yield of marigold (Pooled data)**

| Treatments | Days to seed ripening | Number of seeds/ flower | Weight of seeds/ flower (g) | 100 seeds weight (g) | Seed yield/ plant (g) |
|---|---|---|---|---|---|
| $T_1$ | 75.28 | 129.12 | 0.70 | 0.66 | 18.30 |
| $T_2$ | 71.76 | 133.57 | 0.72 | 0.69 | 19.26 |
| $T_3$ | 69.02 | 135.12 | 0.73 | 0.73 | 19.77 |
| $T_4$ | 68.64 | 136.80 | 0.74 | 0.73 | 23.36 |
| $T_5$ | 68.43 | 137.16 | 0.76 | 0.76 | 26.93 |
| $T_6$ | 67.61 | 138.86 | 0.77 | 0.83 | 26.48 |
| $T_7$ | 66.65 | 139.90 | 0.79 | 0.88 | 28.19 |
| $T_8$ | 66.42 | 143.33 | 0.82 | 0.91 | 31.55 |
| $T_9$ | 65.90 | 145.09 | 0.85 | 0.92 | 31.56 |
| $T_{10}$ | 65.64 | 146.69 | 0.92 | 0.97 | 36.58 |
| $T_{11}$ | 63.32 | 146.99 | 0.94 | 1.28 | 44.35 |
| $T_{12}$ | 62.10 | 148.56 | 0.96 | 1.23 | 44.67 |
| $T_{13}$ | 61.78 | 149.80 | 0.98 | 1.23 | 45.76 |
| $T_{14}$ | 60.61 | 151.40 | 0.98 | 1.29 | 48.02 |
| $T_{15}$ | 61.45 | 152.88 | 1.06 | 1.29 | 51.94 |
| $T_{16}$ | 62.04 | 149.09 | 0.99 | 1.12 | 42.39 |
| SEm ± | 1.89 | 3.87 | 0.06 | 0.05 | 2.62 |
| CD at 5% | 5.46 | 11.17 | 0.19 | 0.14 | 7.57 |

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