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Effect of different bio-fertilizers on growth and flowering of marigold

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Abstract
The present investigation was carried out to effect of different bio-fertilizers on growth and flowering of marigold 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 experiments were taken. The experiment was laid out in randomized block design with replicated three times and sixteen treatment combinations. The treatments comprised of N_2 fixer (*Azotobactor*), PSB (*Pseudomonas* + *Bacillus polymyxa*), RDFYM and three levels of NPK. Result raveled that growth parameter like number of primary branches/plant (13.42), secondary branches/plant (26.00), length of primary branches (58.83 cm), number of leaves/plant (408.79), leaf area (22.86 cm^2), leaf area index (4.61) and spread of plant (39.14 cm) were recorded highest when plants treated with 75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM. While the minimum number of days to bud initiation (35.16 days), days to flowering (48.68 days) and maximum bud diameter (2.00 cm) were recorded with the application of 75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM, whereas maximum bud length (2.41 cm) was measured with application of 75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*). The greater diameter of flower (6.39 cm) was measured with 75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM and maximum duration of flowering (55.36 days) was noticed in with 75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) whereas, maximum flower longevity (42.74 days) was recorded with 75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM. The lowest values for growth and flowering traits were recorded in control.

Keywords: *Azotobactor*, *Pseudomonas*, *Bacillus polymyxa*, FYM, NPK and marigold

Introduction
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 (Yadav *et al*., 2014) [13]. Marigold is an important flower crop which commonly cultivated in urban and rural areas. They are extensively used for making garlands, beautification and other purposes i.e. pigment and oil extraction and therapeutic uses. Apart from these uses marigold is a widely grown in gardens and pots. It is highly suitable for bedding purpose, herbaceous border and newly planted shrubberies to provide colour and fill the space (Yadav *et al*., 2015) [12]. 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 (Vessey, 2003) [10]. The term bio-fertilizer has been coined to include soil micro-organism which fix nitrogen, mobilize or conserve plant nutrients. The term bio-fertilizers or microbial inoculants can be define as the preparations containing strains of micro-organism which can augment the mcrobiological 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 (Gaur, 2010) [2]. Keeping the above facts in view, the present investigation was conducted with the objectives of to see the effect of bio-fertilizers and its combination and to find out appropriate dose of bio-fertilizers on flowering parameters on growth and flowering parameters of marigold plants respectively.

Materials and Methods
The present investigation was conducted at the Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P. during 2015-16 and 2016-17 to effect of different bio-fertilizers on growth and flowering of marigold and pooled data of both years were taken. Marigold variety Pusa Narangi Gainda was planted in the month

October-November with a spacing 45×45 cm and experiment was laid in randomized block design with three replications. The experiment consisted of 16 treatments *viz.* 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. The data of two years were pooled and analyzed statistically for interpretation of results.

Results and Discussion

The data on growth parameters is presented in Table 1 and clearly indicates that T_{15} resulted in maximum number of primary branches/plant (13.42) followed by T_{14} (11.10) albeit, T_1 produced minimum number of primary branches/plant (7.07). Maximum number of secondary branches/plant (26.00) was recorded T_{15} in followed by T_{14} (23.84) though, control plants produced minimum number of secondary branches/plant (12.76). The maximum length of primary branches (58.83 cm) were recorded with T_{15} followed by T_{14} (55.53 cm) while minimum length of primary branches (24.53 cm) was recorded in T_1. Similar findings were also reported by the Sreenivas and Godwa (1999) [9]. Maximum number of leaves/plant (408.79) were recorded in T_{15} followed by T_{14} (391.70) while, control plants produced minimum number of leaves/plant (216.33). Results of an experiment showed that, the plants inoculated with nitrogen and phosphate bio-fertilizers produced more leaves than plants which treated by chemical fertilizers (Weisany *et al*., 2012) [11]. Treatment T_{15} resulted in highest leaf area (22.86 cm^2) followed by T_{14} (21.82 cm^2), Notwithstanding, T_1 recorded with least leaf area (10.75 cm^2). Maximum leaf area index (4.61) was resulted in T_{15} followed by T_{14} (4.22), when in fact, T_1 produced minimum leaf area index (1.14). Biological fertilizers, through influence on availability of the nutrients, promote vegetative growth of basil by increasing the number of leaves, which in turn caused more leaf area index (Sifola and Barbieri, 2006) [6]. Treatment T_{15} resulted in maximum spread of plant (39.14 cm) which was followed by T_{14} (37.00 cm) whereas, T_1 recorded minimum plant spread (23.64 cm). These findings are accordance with the Jahan *et al*. (2012) [3].

Table 1: Effect of different bio-fertilizers on growth of marigold (Pooled data).

Treatments	Number of primary branches/plant	Number of secondary branches/plant	Length of primary branches (cm)	Number of leaves/ plant	Leaf area (cm^2)	Leaf Area Index	Spread of plant (cm)
T_1	7.07	12.76	24.53	216.33	10.75	1.14	23.64
T_2	8.22	13.99	27.80	233.38	11.14	1.28	26.70
T_3	8.62	16.83	32.17	250.80	12.34	1.53	29.74
T_4	9.12	18.42	33.75	260.00	14.67	1.88	30.97
T_5	9.35	18.66	36.63	264.27	15.74	2.05	31.27
T_6	9.58	18.81	37.40	277.78	16.22	2.22	31.59
T_7	9.50	18.20	42.47	281.17	17.89	2.48	31.87
T_8	9.67	20.33	43.81	287.67	18.52	2.64	32.97
T_9	10.67	20.50	47.20	306.97	19.55	2.96	33.80
T_{10}	10.35	21.46	49.31	316.88	19.84	3.10	34.09
T_{11}	10.27	21.70	47.89	320.11	19.28	3.05	34.50
T_{12}	10.72	22.39	51.84	332.33	20.19	3.31	35.73
T_{13}	11.02	22.41	54.91	357.45	21.01	3.71	35.84
T_{14}	11.10	23.84	55.53	391.70	21.82	4.22	37.00
T_{15}	13.42	26.00	58.83	408.79	22.86	4.61	39.14
T_{16}	10.83	23.73	50.42	385.36	20.91	3.98	35.50
SEm ±	0.94	1.51	1.97	8.87	0.78	0.12	1.85
CD at 5%	2.71	4.35	5.70	25.62	2.24	0.35	5.33

The data on flowering traits are presented in Table 2. It is clearly showing that T_{15} recorded with least number of days to bud initiation (35.16 days) followed by T_{14} (37.93 days) whereas, maximum number of days to bud initiation (46.83 days) were recorded with T_1 (control). Treatment T_{15} resulted in minimum number of days to flowering (48.68 days) followed by T_{16} (49.75 days) whereas, T_1 was reported for maximum number of days to flowering (58.03 days). Bohra and Kumar (2014 [1]) reported that the treatment combination of NPK along with *Azospirillum* was more effective in improving earlier bud initiation and floral character of *Dendrobium*. It is clearly indicated that T_{15} resulted maximum bud diameter (2.00 cm) followed by T_{14} (1.90 cm) while, minimum bud diameter (1.08 cm) was reported in T_1 (control). The upmost bud length (2.41 cm) was recorded in T_{14} followed by T_{15} (2.40 cm) whereas, T_1 treated plant produced least bud length (1.55 cm). Singh *et al*. (2015) [7] obtained same results on bud diameter. Singh and Kumar (2016) [8] obtained similar findings regarding bud diameter and bud length. Data clearly showed that T_{15} resulted in greater diameter of flower (6.39 cm) followed by T_{14} (6.27 cm) while, control plants recorded minimum diameter of flower (3.06 cm). The increase in flower diameter might be due to the fact that the balanced application of fertilizers resulted in increased carbohydrate assimilation leading to increased vegetative growth. These carbohydrates when translocated to reproductive organs underwent hydrolysis and got converted into the reducing sugars which ultimately helped in increasing flower size (Naik, 2014) [4]. Maximum duration of flowering (55.36 days) was recorded under T_{14} followed by T_{15} (54.91 days) whereas, minimum duration of flowering (38.91 days) was observed with T_1. Maximum

flower longevity (42.74 days) was recorded under T_{15} followed by T_{13} (41.91 days) whereas, minimum of flower longevity (28.24 days) was observed with T_1. The results of the present study are in conformity with those of Naik (2015) [5].

Table 2: Effect of different bio-fertilizers on flowering of marigold (Pooled data).

Treatments	Days to bud initiation	Days to flowering	Bud diameter (cm)	Bud length (cm)	Diameter of flower (cm)	Duration of flowering (days)	Flower longevity (days)
T_1	46.83	58.03	1.08	1.55	3.06	38.91	28.24
T_2	44.74	57.60	1.12	1.58	4.18	40.63	29.09
T_3	43.77	56.92	1.34	1.57	4.73	42.64	30.33
T_4	42.81	56.02	1.33	1.72	4.77	44.59	31.40
T_5	42.97	55.79	1.35	1.77	5.04	46.48	32.93
T_6	41.87	55.18	1.39	1.87	5.23	49.32	34.46
T_7	42.49	53.92	1.43	2.02	5.34	50.01	35.37
T_8	42.44	53.31	1.47	2.12	5.37	51.02	36.03
T_9	41.05	53.21	1.50	2.12	5.41	51.21	36.67
T_{10}	40.33	52.94	1.53	2.28	5.60	51.62	38.10
T_{11}	40.64	51.67	1.60	2.27	5.62	51.75	40.81
T_{12}	39.96	51.14	1.78	2.32	5.75	53.01	40.69
T_{13}	38.23	50.33	1.77	2.31	5.99	53.43	41.91
T_{14}	37.93	49.89	1.90	2.41	6.27	54.91	41.88
T_{15}	35.16	48.68	2.00	2.40	6.39	55.36	42.74
T_{16}	37.93	49.75	1.58	2.35	5.40	51.71	39.04
SEm ±	2.08	1.91	0.14	0.13	0.25	1.75	1.98
CD at 5%	6.02	5.51	0.39	0.38	0.72	5.05	5.73

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