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Effect of different bio-fertilizers and its various combinations on root characters and economics of marigold

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Abstract
An investigation was carried out to study the effect of different bio-fertilizers and its various combinations on seed characters and economics of 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 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 NPK, N_2 fixer (*Azotobactor*), PSB (*Pseudomonas* and *Bacillus polymyxa*) and FYM. On the basis of data, for root characters T_{14} resulted maximum number of fibrous roots/plant (410.41) whereas, maximum root diameter (2.37 cm), root length (21.26 cm), fresh weight of roots (29.53 g) and dry weight of roots (8.01 g) were resulted in T_{15}. Regarding the economics of marigold maximum total cost (Rs. 94722), gross income (Rs. 239599.57), net income (Rs. 144877.56) and C:B Ratio (1:1.53) were resulted by T_{15}.

Keywords: Bio-fertilizers, economics, FYM, NPK, Pusa Narangi Gainda and roots

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. 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 (Yadav *et al*., 2014 [15]). They are extensively used for making garlands, beautification and other purposes i.e. pigment and oil extraction and therapeutic uses. It is highly suitable for bedding purpose and herbaceous border and also for newly planted shrubberies to provide colour and fill the space (Yadav *et al*., 2015 [14]). Flowers remain fresh for 4-5 days at room temperature and are used for religious offerings and social functions (Singh, 2006 [10]). 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 (Gaur, 2010 [2]). 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 (Preethi *et al*., 1999 [8]). 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 on roots and economics of different treatments in 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. 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 root parameters is presented in Table 1 and it is crystal clear that maximum number of fibrous roots/plant (410.41) were noticed inT_{14} followed by T_{15} (401.58) and T_{13} (389.09) while, control plants produced with minimum number of fibrous roots/plant (286.23). Findings were accordance with the Waheeduzzama *et al.* (2007 [13]). The improvement of growth parameters, may be due to functions of bio-fertislizers, availability of nitrogen, phosphorous, and certain growth harmones like auxins, gibberlins, vitamins and organic acid secreted by bio-inoculants which increase the surface area per unit root length and were responsible for root hairs (Sndhya *et al*., 2013 [9]). T_{15} resulted in maximum root diameter (2.37 cm) followed by T_{14} (2.24 cm) and T_{13} (2.22 cm) whereas, minimum root diameter (1.38 cm) was recorded with T_1. Highest root length (21.26 cm) was recorded in T_{15} followed by T_{14} (20.99 cm) and T_{13} (20.13 cm) whereas, control plants produced with lowest root length (11.08 cm). Obtained findings were accordance with the Sunitha *et al*. (2007 [11]). Similar, reports were made by Gupta *et al*. (1999 [3]) and Nandre *et al*. (2005 [6]). Maximum fresh weight of root (29.53 g) was reported with T_{15} followed by T_{14} (26.96 g) and T_{13} (26.69 g) while, minimum fresh weight of roots (9.57 g) was noticed under T_1. The uttermost dry weight of root (8.01 g) was reported with T_{15} followed by T_{14} (7.58 g) and T_{13} (7.23 g) whereas, lowest dry weight of roots (2.70 g) was weighted under T_1. Edwards *et al*. (1985 [1]) and Tomati *et al*. (1988 [12]) revealed that hormone-like activities carried out by the vermicompost can lead to an increase in root biomass, root growth and development. These findings confirmed those reported by Nazari *et al*. (2008 [7]).

Table 1: Effect of different bio-fertilizers and its various combinations on root characters of marigold.

Treatments	Number of fibrous roots/plant	Root diameter (cm)	Root length (cm)	Fresh weight of roots (g)	Dry weight of roots (g)
T_1	286.23	1.38	11.08	9.57	2.70
T_2	294.38	1.47	13.23	10.02	2.81
T_3	301.28	1.52	15.48	11.18	3.60
T_4	316.82	1.55	15.67	13.55	3.89
T_5	321.56	1.59	16.69	16.93	4.55
T_6	329.71	1.58	16.63	18.14	4.86
T_7	331.93	1.62	17.09	19.22	4.96
T_8	342.43	1.72	17.27	23.43	5.69
T_9	353.13	1.90	18.22	24.44	6.00
T_{10}	357.76	1.88	18.60	24.85	6.49
T_{11}	365.35	1.95	18.49	25.62	6.83
T_{12}	375.12	2.05	19.33	26.36	7.23
T_{13}	389.09	2.22	20.13	26.69	7.23
T_{14}	410.41	2.24	20.99	26.96	7.58
T_{15}	401.58	2.37	21.26	29.53	8.01
T_{16}	377.95	2.01	18.05	26.00	6.48
SEm ±	8.66	0.15	1.13	1.26	0.30
CD at 5%	25.00	0.45	3.26	3.65	0.86

The evidence on economics is contained in Table 2. The maximum total cost (Rs. 94722) was recorded with T_{15} followed by T_{16} (Rs. 86966) and T_{14} (Rs. 85922) whereas, T_1 resulted with minimum total cost (Rs. 79698). Treatment T_{14} noticed for maximum gross income and net income (Rs. 239599.57 and Rs. 144877.56) followed by T_{14} (Rs. 207838.52 and Rs. 121916.51) and T_{13} (Rs. 198433.34 and Rs. 112610.34) while, minimum gross income and net income (Rs. 79898.85 and Rs. 200.84) were resulted with control. The maximum C:B ratio (1:1.530) was recorded under T_{15} followed by T_{14} (1:1.419) and T_{16} (1:1.139) though, minimum C:B ratio (1:0.003) was recorded under T_1. It might be due to the reason that the plants consumed nutrients provided directly through inorganic and organic fertilizer along with bio-fertilizer. The obtained findings were accordance with the findings of Kumar *et al*. (2009 [5]) and Jadhav *et al*. (2014 [4]).

Table 2: Effect of different bio-fertilizers and its various combinations on economics of marigold.

Treatments	Total cost (Rs.)	Gross income (Rs.)	Net income (Rs.)	C:B Ratio
T_1	79698	79898.85	200.84	1:0.003
T_2	79797	81695.09	1898.08	1:0.024
T_3	80061	88192.70	8131.70	1:0.102
T_4	80160	103108.12	22948.12	1:0.286
T_5	90197	113773.34	23576.33	1:0.261
T_6	83950	118639.78	34689.77	1:0.413
T_7	84049	127362.84	43313.84	1:0.515
T_8	84313	134306.39	49993.39	1:0.593

T_9	84412	132101.93	47689.93	1:0.565
T_{10}	93212	152982.35	59770.35	1:0.641
T_{11}	85460	172990.38	87530.37	1:1.024
T_{12}	85559	180860.21	95301.21	1:1.114
T_{13}	85823	198433.34	112610.34	1:1.312
T_{14}	85922	207838.52	121916.51	1:1.419
T_{15}	94722	239599.57	144877.56	1:1.530
T_{16}	86966	186029.87	99063.87	1:1.139

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