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RESEARCH PAPER

Effect of *Azotobacto*r and *Pseudomonas* along with various levels of NPK on growth and flowering of marigold cv. Pusa Narangi Gainda

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Abstract : The experiment was carried at Agriculture Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, India. This investigation was done to study the effect of different biofertilizers and NPK level on vegetative growth and flowering parameters of marigold cv. Pusa Narangi Gainda during 2019-20. Experiment was laid out in a Randomized Block Design with three replications. Results revealed that, number of leaves/plant (303.98), fresh weight of leaf (4.34 g), dry weight of leaf (1,68 g), leaf biomass/plant (1103.03 g) and stem diameter (1.54 cm) were resulted when plants of marigold treated with treatment T_{10} (75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM). In concern with flowering parameters, the results revealed that the number of flowers/plant (36.07), fresh weight of flower (6.89 g) and longer flower longevity (34.61 days) were resulted by under T_{10} (75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM) not with standing, more dry weight of flower (1.91 g) and longer duration of flowering (49.51 days) were recorded under the treatment T_9 *i.e.* 75% NPK + PSB (*Pseudomonas*).

Key Words : Marigold, Biofertilizers, PSB, *Azotobactor,* Pusa Narangi Gainda

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INTRODUCTION

Marigold (*Tagetes erecta*) is an important commercial flower of India belongs to family Asteraceae (Compositae) having chromosome number 2n=24. It was originated in central and South America especially Mexico (Dikr and Belete, 2017). It spreads to different parts of world during early part of 16th century from Mexico. Marigolds are broadly divided into two groups, namely, African marigold and French marigold (Yadav *et al*., 2014). Marigold (*Tagetes erecta*) is a medicinal and ornamental plant. 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

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and newly planted shrubberies to provide colour and fill the space (Yadav *et al*., 2015).

Bio-fertilizers are 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). *Azotobacter* is a free-living bacterium which may add 25-30 kg nitrogen/ha/year in a field of non-legume crop under favorable conditions and also secrets some growth promoting substances. Spacing plays an important role for manipulating plant growth, flowering behaviour and seed yield. Inter row and intra row spacing and balanced supply of nutrients are important for obtaining higher yield of good quality seeds (Sunitha *et al*., 2007). Phosphate solubilizing Bacteria (PSB) are a group of beneficial bacteria capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds. Some PSB produce phosphatase like phytase that hydrolyse organic forms of phosphate compounds efficiently. The use of phosphate solubilizing bacteria as inoculants simultaneously increases P uptake by the plant and crop yield. Strains from the genera *Pseudomonas*, *Bacillus* and *Rhizobium* are among the most powerful phosphate solubilizers (Pandey *et al*., 2018).

MATERIAL AND METHODS

The trial was conducted at Agricultural Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab where adequate facilities for irrigation and drainage existed. Mandi Gobindgarh is situated between 30° 56' 11.90"N latitudes and 76" 18'13.18"E longitutedes and altitude of 268 meters above the mean sea levels. The mean of maximum and minimum temperature show considerable variations during different months of the year. The maximum temperature often exceeds 40^{0}C during summer whereas, minimum temperature decreases below 6^{0}C with some coldest spells during the winter month of December and January occurs. The average annual rainfall of Mandi Gobindgarh is 730.2 mm, about 3/4th of which is contributed by the South-West monsoon during July to September. Scanty rainfall is received during winter months of December, January and February. Total ten treatments which contain *Azotobacter*, *Pseudomonas*, RDFYM and different levels of NPK along with control *i.e.* T_1: Control, T_2: N_2 fixer (*Azotobactor*), T_3: PSB (*Pseudomonas*), T_4: N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM, T_5: 50% NPK + N_2 fixer (*Azotobactor*), T_6: 50% NPK + PSB (*Pseudonomas*), T_7: 50% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM, T_8: 75% NPK + N_2 fixer (*Azotobactor*), T_9: 75% NPK + PSB (*Pseudomonas*) and T_{10}: 75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM and Pusa Narangi Gainda cultivar were used as experimental material for the investigation. The treatments were given by the soil application. The experiment was laid out in a Randomized Block Design with three replications. Observations on various growth and flowering parameters were recorded. Results thus, obtained, were subjected to statistical analysis.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth parameters :

Findings on growth parameters presented in Table 1. Maximum number of leaves/plant (274.08) were exhibited with T_{10} (75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM), whereas T_2 *i.e.* N_2 fixer (*Azotobactor*) resulted lesser number of leaves/ plant (244.14). Biological fertilizers, through influence on availability of the nutrients, promote vegetative growth of basil by increasing the number of leaves (Sifola and Barbieri, 2006). Number of leaves per plant increase may be due to balanced availability of macro and micronutrients and growth promoting hormones produced by different biofertilizers applied in different treatment combinations (Venugopal, 1991). Treatment T_{10} (75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM) resulted in greater fresh weight of leaf (4.34 g) While, T_1 (control) recorded with lesser fresh weight of leaf (3.07 g) in compare to other treatments. The findings are in line with those observed by Attia (2000) on *Lawsonia inermis* L., Koreish *et al*. (2004) on faba bean and El-Fawakhry *et al*. (2004) on ficus. Generally, the significant increases in vegetative growth parameters as a result of combined application of biofertilizers with organic manure or mineral fertilizer could be attributed to the occurred in net assimilation rate as mentioned by Shalaby *et al*. (2000). Maximum dry weight of leaf (1.68 g) was resulted in treatment T_{10} (75% NPK + N_2 fixer

(*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM). Whereas, T_2 reported for minimum dry weight of leaf (0.70 g) in compare to other treatments. Similar results were reported by Yadav *et al*. (2017). It has been reported that various biofertilizers along with different levels of NPK showed significant effect on leaf biomass/ plant. Treatment T_9 - *i.e.* resulted in 75% NPK + PSB (*Pseudomonas*) maximum leaf biomass/plant (1103.03 g) While, T_1 (control) recorded with minimum leaf biomass/plant (781.38 g) in compare to other treatments. High above-ground biomass yield is obviously accompanied by an active root system, which releases an array of organic compounds into the rhizosphere (Mandal, 2007). Positive response of nitrogen fertilizers has been reported by Omer (1998). These findings are in close conformity with Sharma and Agrawal (2004) and Gaur *et al*. (2006). It increase total microbial population of nitrogen fixing bacteria, actinomycetes and symbiotic association of mycorrhiza on plant root system and *Azospirillum* helps improving fertility of soil and help plant growth by increasing the number and biological activity of derived microorganisms in the root environment and NPK gives more available form of nutrient, due to combine effect of number of leaves per plant in chrysanthemum Shankar and Dubey (2005) and Venugopal (1991). The highest stem diameter (1.54 cm) of marigold plant was recorded with T_{10} (75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM). Treatment T_1 (control) was reported with lower stem diameter (0.94 cm). This might be due to

Table 1: Effect of *Azotobactor* and *Pseudomonas* along with various levels of NPK on growth of marigold cv. Pusa Narangi Gainda

Treatments	Number of leaves/plant	Fresh weight of leaf (g)	Dry weight of leaf (g)	Leaf biomass /plant (g)	Stem diameter (cm)
T_1	245.33	3.07	0.83	781.38	0.94
T_2	244.14	3.09	0.70	782.36	0.96
T_3	261.44	3.11	0.79	815.32	1.10
T_4	260.43	3.16	1.21	814.72	1.10
T_5	266.74	3.22	1.32	829.46	1.12
T_6	278.08	3.56	1.34	924.16	1.29
T_7	280.22	4.13	1.45	1007.24	1.37
T_8	281.11	4.26	1.55	1031.04	1.42
T_9	296.89	4.25	1.67	1089.77	1.48
T_{10}	303.98	4.34	1.68	1103.03	1.54
S.E.±	10.06	0.15	0.17	77.87	0.04
C.D. (P=0.05)	29.90	0.46	0.51	231.38	0.14

Table 2: Effect of *Azotobactor* and *Pseudomonas* along with various levels of NPK on flowering of marigold cv. Pusa Narangi Gainda

Treatments	Number of flowers /plant	Fresh weight of flower (g)	Dry weight of flower (g)	Duration of flowering (days)	Flower longevity (days)
T_1	25.98	4.45	1.17	39.70	25.55
T_2	27.00	4.27	1.25	42.64	26.99
T_3	25.24	5.02	1.24	42.24	27.97
T_4	29.72	4.96	1.27	40.34	30.78
T_5	33.45	5.19	1.51	43.38	30.51
T_6	31.85	5.97	1.51	45.21	32.05
T_7	32.94	5.62	1.60	47.50	35.77
T_8	34.48	5.91	1.52	48.75	33.77
T_9	34.46	6.11	1.91	49.51	34.42
T_{10}	36.07	6.89	1.89	49.25	34.21
S.E.±	1.11	0.31	0.12	1.10	0.67
C.D. (P=0.05)	3.30	0.93	0.37	3.29	34.61

nitrogen is an essential part of nucleic acid this plays vital role in promoting the plant growth. This confirms the finding of Singh and Singh (2003). 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).

Flowering characters :

The evidence on flowering characters of marigold is shown in Table 2. The different biofertilizers and NPK levels exerted significant effect on number of flowers/ plant. The maximum number of flowers/plant (36.07) were counted with the application of T_{10} (75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM). Whereas, minimum number of flowers/plant (25.98) were counted with T_1 (control). The significant increase in number of flowers might be attributed to more leaf area which might have resulted in production and accumulation of maximum photosynthates, resulting into production of more number of flowers. Further, these results got support from Mittal *et al.* (2010) in African marigold, Meshram *et al.* (2008) in annual Chrysanthemum and Chougala *et al.* (2014) in double daisy. These results are in agreement with those of Wange and Patil (1995) on tuberose and El-Naggar and Hedia (2005) on narcissus. These results are in accordance with the similar findings of Bhalla *et al.* (2006) Bhatia *et al.* (2007) and Renukaradya *et al.* (2011) in Carnation. Significant variation was reported in fresh weight of flower due to application of various biofertilizers along with different levels of NPK. Treatment T_{10} (75% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM) resulted in greater fresh weight of flower (6.89 g). While, T_2 i.e. N_2 fixer (*Azotobactor*) recorded with lesser fresh weight of flower (4.27 g) in compare to other treatments. There similar findings were also confirmed with Pratap *et al.* (1999). Similar findings were obtained by Rajanna (2001) in China aster, these results are also similar with Bhat *et al.* (2010); Yadav (2017) and Mukesh *et al.* (2007) in marigold. The significant increase in number of flowers might be attributed to more leaf area which might have resulted in production and accumulation of maximum photosynthates, resulting into production of more number of flowers. Treatment T_9 *i.e.* 75% NPK + PSB (*Pseudomonas*) resulted in maximum dry weight of flower (1.68 g). Results represented that plant height was significantly affected by different fertilizer treatments and years (fall and spring planting) however different ecotypes and interaction between treatments hadn't significant effect on this morphological trait (Shams *et al.*, 2012). The duration of flowering significantly enhanced by different biofertilizers along with various levels of NPK. Treatment T_9 (75% NPK + PSB (*Pseudomonas*)) also resulted longer duration of flowering (49.51 days). Whereas, lesser duration of flowering (39.70) was resulted in control. Similar finding was reported by Venugopal (1991). This result got support from Airadevi (2012) in annual chrysanthemum who recorded maximum flowering duration. This might be due to the reason that February-March planted crop could have put more vegetative growth that would have produced more number of flower bud which ultimately contributed for longest flowering duration in African marigold. Chanda and Roychoudhary (1991) reported the similar results in African marigold. Significant variation was recorded on flower longevity due to application of various biofertilizers along with different levels of NPK. Maximum flower longevity (35.77 days) was recorded with T_7 (50% NPK + N_2 fixer (*Azotobactor*) + PSB (*Pseudomonas*) + RDFYM). T_1 (control) resulted minimum flower longevity (25.55 days). The results of the present study are in conformity with those of Naik (2015). Similar finding were obtained by Rajanna (2001) in China aster, these results are also similar with Bhat *et al.* (2010), Mukesh *et al.* (2007) and Yadav *et al.* (2018) in marigold.

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