RESEARCH ARTICLE

INFLUENCED BY EFFECTIVE MICROBIAL CONSORTIA ON GROWTH AND FLOWERING OF MARIGOLD (*TAGETES ERECTA* L.) WITH GRADED LEVELS OF NPK

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Abstract: A field experiment was conducted to know the field response of Marigold (*Tagetes erecta* L.) cv. Double Orange to liquid formulations of effective microbial consortia with graded levels of NPK on growth and flowering at Department of Horticulture, College of Agriculture, Shivamogga, Karnataka during 2014-15. The experiment was laid out in randomized complete block design with 3 replications and 15 treatment combinations, among 15 treatment combinations, 100 % RDF + *Azotobacter* (T_3) recorded significantly maximum plant height, stem girth, internodal length, number of leaves, leaf area, LAI and chlorophyll content. However, the maximum number of primary and secondary branches per plant was observed in the treatment which received 75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K' (T_2) and 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}), respectively. Significantly maximum plant spread was recorded in T_{11} which received 100 % RDF + *Azotobacter* + *Frateuria aurantia*. The plants treated with 75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K' (T_2) reported significantly maximum flowering duration of 71.17 days over (T_1) 100 % RDF.

Keywords: Marigold, EM consortia, Growth, Flowering

INTRODUCTION

Marigold (*Tagetes erecta* L.) occupying a prominent place in ornamental horticulture, is one of the commercially exploited flower crop belonging to the family Asteraceae. Its habit of free flowering, short duration to produce marketable flowers, wide spectrum of attractive colours, shape, size and good keeping quality have attracted the attention of flower growers. It is put to many uses like cut flowers, garden displays, garlands, bouquets and for worship. Apart from its significance in Ornamental Horticulture, it has been valued for other purposes too. Marigold is being cultivated today as commercially important source of carotenoid pigments. The principal pigment present in the flower is xanthophyll, particularly lutein which accounts for more than 80 - 90 per cent and is present in the form of esters of palmitic and myristic acids (Alam *et al.*, 1968). Marigold carotenoids are the major sources of pigments for poultry industry as a feed additive to intensify the yellow colour of egg yolks and broiler skin (Scott *et al.*, 1968). The ground blossom meal (petal meal) or the extract, usually saponified for better absorption and is added to the poultry feed. These products are traded as 'Aztec marigold' or marigold extract as 'Adoptinal'.
Though the African marigold is one of the important commercial flower crops of Karnataka, its yield levels are quite low and hence there is a need to standardize the optimum dose of nutrients particularly in the form of organic and integrated nutrients for improving the soil structure, physico-chemical properties, yield and quality of flowers and seeds. Keeping these beneficial points in view of soil health and sustainability in crop production, the present investigation was undertook to study the response of Marigold to liquid formulations of EM consortia with graded levels of NPK on growth and flowering under transitional zone of Karnataka.

MATERIAL AND METHOD

The present investigation was carried out in the Department of Horticulture, College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka during the period from September 2014 to January 2015. Shivamogga is situated at 13° 58' North latitude and 75° 34' East latitude with an altitude of 650 meters above mean sea level. It comes under Agro-climatic Region-4 and Zone-VII (Southern Transitional Zone) of Karnataka. The experiment was conducted in red gravely loam soil, having a pH of 6.40. During the experimentation the rainfall was 790 mm and the average maximum and minimum temperature was 31.23^0 C and 18.97^0 C respectively and relative humidity was 84.57 to 86.27 per cent. The experiment was laid out in randomized complete block design with 3 replications and 15 treatment combinations *viz.*, T_1: 100 % RDF (C), T_2: 75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K', T_3: 100 % RDF + *Azotobacter*, T_4: 75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K', T_5: 100 % RDF + *Bacillus megaterium*, T_6: 75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P', T_7: 100 % RDF + *Frateuria aurantia*, T_8: 75 % RD'N'

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and 'P' + *Azotobacter* + *Bacillus megaterium* + 100 % RD'K', T_9: 100 % RDF + *Azotobacter* + *Bacillus megaterium*, T_{10}: 75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P', T_{11}: 100 % RDF + *Azotobacter* + *Frateuria aurantia*, T_{12}: 75 % RD'P' and 'K' + *Bacillus megaterium* + *Frateuria aurantia* + 100 % RD'N', T_{13}: 100 % RDF + *Bacillus megaterium* + *Frateuria aurantia*, T_{14}: 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* and T_{15}: 100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*. Liquid EM cultures having population of 10^{13} cells/ml were inoculated by pouring uniformly @ 10 ml per/liter in furrows after seed sowing as seed treatment. Thirty days of healthy and uniform seedlings were used for transplanting. Seedlings were dipped in liquid microbial consortium @ 10 ml/liter of water for about 30 minutes and transplanting was done in the micro plots with a spacing of 60 cm x 45 cm at the rate of one seedling per hill. Well decomposed FYM @ 20 tonnes per hectare was applied at the time of land preparation. The recommended dose of 225:60:60 kg NPK/hectare was applied in the form of urea, single super phosphate and muriate of potash, respectively. One week after transplanting, 50 per cent N and full dose of P and K were applied in a circular band about 10 cm around each plant at a depth of 3 to 4 cm and remaining 50 per cent 'N' was applied in two split doses at 30 and 45 days after transplanting as a top dressing. All the recommended cultural operations were carried out during the crop period. The data recorded on various parameters of growth and flowering behavior were tabulated and subjected to statistical analysis (Sunderaraju *et al.*, 1972).

RESULT AND DISCUSSION

The results brought out that Marigold do respond well to inoculation of microbial consortium under field conditions. The plants supplied with 100 % RDF + *Azotobacter* (T_3) recorded significantly maximum plant height (104.81 cm), stem girth (1.37 cm) and internodal length (7.32 cm). However, the maximum number of primary (17.35) and secondary branches (99.59) per plant was observed in the treatment received 75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K' (T_2) and 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}), respectively. Significantly maximum N-S plant spread (66.80) was recorded in T_{11} which received 100 % RDF + *Azotobacter* + *Frateuria aurantia* (Table 1). Similarly, number of leaves (308.80), leaf area (81.54 dm^2) and leaf area index (3.02) were also higher with the application of 100 % RDF + *Azotobacter* (T_3) over 100 % RDF (T_1). Results pertaining to the above growth parameters could be attributed to the appropriate nutrients in available form under this type of combination. Nitrogen is the major constituent of proteins, enzymes, hormones, vitamins, alkaloids chlorophyll and their synthesis in plants that influence plant growth. Plant growth is thus known to be accelerated by the adequate supply and availability of nitrogen in association with biofertilizers. *Azotobacter* is the free living nitrogen fixing bacteria which fixes the nitrogen and it also produces hormones like IAA and GA_3, vitamins like biotin and folic acid and with judicious use of organic matter ensures good growth. The increased nitrogen nutrition may also have accelerated the process of cell division and differentiation. The results of present investigation are in close conformity with the findings of Jadhav *et al*. (2014) and Kumar *et al*. (2009) in African marigold, Kirar *et al*. (2014) in China aster, Bhatia and Guptha (2007) in Carnation

The chlorophyll 'a' (1.43 mg/g) and total chlorophyll (1.99 mg/g) content of leaves were significantly higher in the treatment T_3 consisting of 100 % RDF + *Azotobacter* (Table 2). Whereas, T_9 which received 100 % RDF + *Azotobacter* + *Bacillus megaterium* recorded the maximum chlorophyll 'b' content (0.90 mg/g) at peak vegetative stage compared to cent per cent RDF (T_1). This might be due to enhanced availability of nutrients, constituent of protein and protoplasm resulting in greater photosynthetic activity. Cytokinin produced by microbial inoculants might have become a greater sink to attract nutrients like Mg, Fe and K. The indirect role of iron in enhancing the functioning of photosystem, ultimately increased the chlorophyll content in the leaves. These results are in line with the earlier findings of many other scientists in African marigold (Bhat *et al.*, 2010), Jasmine (Jayamma *et al*., 2008), Gladiolus (Qasim *et al*., 2014) and Tomato (Bharathiraja *et al*., 2012).

Duration of flowering significantly varied among different treatments. In the treatment plants treated with 75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K' (T_2) reported significantly maximum flowering duration of 71.17 days (Table 3) compared to (T_1) cent per cent RDF (65.86 days). The favorable action of bio-inoculants in combination with optimum levels of NPK and by improving the uptake of macro and micro nutrients might be the answer for the increased duration of flowering. Similar trend of increased flowering duration was also reported by Thumar *et al*. (2013) in Marigold, Sheergojri *et al.* (2013) in Dahlia and Parolekar *et al*. (2012) in Tuberose.

Table 1. Effect of liquid formulations of EM consortia on vegetative traits of Marigold (Tagetes erecta L.) cv. Double Orange

Treatment		Plant height (cm)	Stem girth (cm)	Internodal length (cm)	Number of primary branches	Number of secondary branches	Plant spread (cm)	
							North-South	East-West
T_1	100 % Recommended dose of fertilizer (C)	80.91	1.12	6.03	18.62	85.09	52.71	59.14
T_2	75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K'	95.18	1.29	6.77	20.49	92.06	59.47	64.39
T_3	100 % RDF + *Azotobacter*	104.81	1.37	7.32	20.95	98.26	59.32	67.12
T_4	75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K'	91.12	1.23	6.96	19.82	93.73	57.10	58.43
T_5	100 % RDF + *Bacillus megaterium*	88.91	1.20	6.91	19.75	87.02	56.53	63.11
T_6	75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P'	91.90	1.22	6.55	18.62	97.49	52.75	60.38
T_7	100 % RDF + *Frateuria aurantia*	87.36	1.23	7.00	19.22	93.13	58.59	59.65
T_8	75 % RD'N' and 'P'+ *Azotobacter* + *Bacillus megaterium* + 100 % RD'K'	93.07	1.21	7.28	19.02	91.19	61.52	60.83
T_9	100 % RDF + *Azotobacter* + *Bacillus megaterium*	90.57	1.28	6.71	18.82	89.99	60.96	64.46
T_{10}	75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P'	92.73	1.26	6.74	20.09	89.79	63.74	67.56
T_{11}	100 % RDF + *Azotobacter* + *Frateuria aurantia*	93.46	1.25	6.70	18.89	86.89	66.80	64.70
T_{12}	75 % RD'P' and 'K' + *Bacillus megaterium* + *Frateuria aurantia* + 100 % RD'N'	86.25	1.21	6.86	17.88	88.92	59.75	59.44
T_{13}	100 % RDF + *Bacillus megaterium* + *Frateuria aurantia*	92.42	1.24	6.90	20.22	93.01	59.04	60.73
T_{14}	75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*	99.52	1.32	7.25	19.82	99.59	64.45	65.94
T_{15}	100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*	91.81	1.25	7.22	20.35	97.86	61.25	64.24
S. Em ±		3.36	0.03	0.22	0.60	2.20	2.29	3.88
C. D. @ 5 %		9.74	0.10	0.64	NS	6.38	6.65	NS

Table 2. Effect of liquid formulations of EM consortia on photosynthetic area and chlorophyll content of Marigold (Tagetes erecta L.) cv. Double Orange

Treatment		Number of leaves	Leaf area (dm^2)	LAI	Chlorophyll 'a' (mg/g)	Chlorophyll 'b' (mg/g)	Total chlorophyll (mg/g)
T_1	100 % Recommended dose of fertilizer (C)	266.69	60.45	2.23	0.48	0.23	0.72
T_2	75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K'	285.26	65.83	2.44	0.63	0.31	0.94
T_3	100 % RDF + *Azotobacter*	308.80	81.54	3.02	1.43	0.58	1.99
T_4	75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K'	280.10	64.01	2.37	0.98	0.44	1.41
T_5	100 % RDF + *Bacillus megatherium*	274.29	69.65	2.58	0.61	0.29	0.91
T_6	75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P'	265.43	71.20	2.64	0.88	0.66	1.54
T_7	100 % RDF + *Frateuria aurentia*	270.76	70.80	2.62	0.98	0.39	1.36
T_8	75 % RD'N' and 'P'+ *Azotobacter* + *Bacillus megaterium* + 100 % RD'K'	288.70	73.03	2.70	0.52	0.26	0.78
T_9	100 % RDF + *Azotobacter* + *Bacillus megaterium*	273.53	69.58	2.58	1.05	0.90	1.96
T_{10}	75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P'	289.33	73.90	2.74	0.67	0.31	1.00
T_{11}	100 % RDF + *Azotobacter* + *Frateuria aurantia*	279.69	69.32	2.57	0.61	0.30	0.91
T_{12}	75 % RD'P' and 'K' + *Bacillus megaterium* + *Frateuria aurantia* + 100 % RD'N'	262.03	56.96	2.11	0.81	0.47	1.28
T_{13}	100 % RDF + *Bacillus megaterium* + *Frateuria aurantia*	289.23	70.44	2.61	1.00	0.41	1.41
T_{14}	75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*	293.23	73.74	2.73	1.22	0.46	1.69
T_{15}	100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*	288.66	71.44	2.65	0.48	0.69	1.57
S. Em ±		5.82	4.07	0.15	0.12	0.07	0.18
C. D. @ 5 %		16.88	11.80	0.43	0.37	0.20	0.52

Table 3. Effect of liquid formulations of EM consortia on flowering behavior of *Tagetes erecta* L. cv. Double Orange

Treatment		Days taken for first flower bud initiation	Days taken for first flower opening	Days taken for 50 % flowering	Duration of flowering (days)
T_1	100 % Recommended dose of fertilizer (C)	29.53	43.73	48.73	65.86
T_2	75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K'	27.07	43.06	48.80	71.17
T_3	100 % RDF + *Azotobacter*	27.33	42.26	48.13	68.96
T_4	75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K'	26.87	41.26	47.26	67.46
T_5	100 % RDF + *Bacillus megaterium*	26.67	41.53	47.06	66.76
T_6	75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P'	27.47	41.26	49.00	67.56
T_7	100 % RDF + *Frateuria aurantia*	27.47	41.20	48.46	68.20
T_8	75 % RD'N' and 'P'+ *Azotobacter* + *Bacillus megaterium* + 100 % RD'K'	27.07	41.33	47.13	68.80
T_9	100 % RDF + *Azotobacter* + *Bacillus megaterium*	28.07	41.73	47.93	69.60

T_{10}	75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P'	29.20	41.33	49.00	68.30
T_{11}	100 % RDF + *Azotobacter* + *Frateuria aurantia*	27.60	41.93	47.33	68.40
T_{12}	75 % RD'P' and 'K' + *Bacillus megaterium* + *Frateuria aurantia* + 100 % RD'N'	27.07	42.40	47.93	66.76
T_{13}	100 % RDF + *Bacillus megaterium* + *Frateuria aurantia*	27.67	42.26	47.80	67.26
T_{14}	75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*	26.60	41.86	47.86	67.96
T_{15}	100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*	26.73	41.00	48.66	66.26
S. Em ±		0.61	0.85	1.13	0.87
C. D. @ 5 %		NS	NS	NS	2.53

CONCLUSION

It is concluded that microbial inoculants improves the soil physical, chemical and biological properties of soil and also provides nutrients *viz.*, N, P, K which is essential for plant growth. Bio-inoculants helps in better root proliferation, more uptake of nutrients and water, luxuriant vegetative growth and more photosynthesis and enhance food accumulation which is good for growth and development. So, it can be concluded that application of 100 % RDF + *Azotobacter* is most effective among various treatments for better vegetative growth and 75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K' in enhancing flowering duration of Marigold (*Tagetes erecta* L.) cv. Double Orange, under transitional tract of Shivamogga. This also indicates the possibility of reducing the dose of chemical fertilizers, which is cost effective and eco friendly for the cultivation.

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