

Original Research Article

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Nutrient Status of Soil and Plant and Total Biomass as Influenced by Liquid Formulations of EM Consortia with Graded Levels of NPK in Marigold (*Tagetes erecta* L.) cv. Double Orange

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ABSTRACT

The field experiment was conducted during 2014-2015 at Department of Horticulture, College of Agriculture, Shivamogga, Karnataka, to know the response of Marigold (*Tagetes erecta* L.) cv. Double Orange to liquid formulations of effective microbial consortia with graded levels of NPK on nutrient content of soil and plant and total biomass. The experiment was laid out in Randomized Block Design with 15 treatments replicated thrice. Significantly higher nitrogen (1.40 %), phosphorus (0.97 %) and potassium content (2.91 %) in the plant was recorded in the treatment which received 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T₁₄), 100 % RDF + *Azotobacter* + *Bacillus megaterium* (T₉) and 100 % RDF + *Bacillus megaterium* + *Frateuria aurantia* (T₁₃), respectively. Maximum available nitrogen (229.46 kg/ha), phosphorus (157.05 kg/ha) and potassium in soil (247.52 kg/ha) was reported with the application of 100 % RDF + *Azotobacter* (T₃), 100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T₁₅) and 75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P' (T₁₀), respectively. Similarly, bacteria, fungi and actinomycets population was observed maximum under 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T₁₄) over cent percent RDF (T₁).

Keywords

Marigold, EM
Consortia, Soil, Plant,
Biomass.

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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 flowers 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'.

In India, the present area under Marigold cultivation is 55,890 hectares with a production of 5, 11,314 metric tonnes. It is cultivated commercially in most parts of India. In Karnataka, the present area under Marigold cultivation is 9,100 hectares with a production of 74,900 metric tonnes (Anon, 2014). Presently, in our country the commercial extraction of Marigold carotenoids is done in Cochin (Kerala), Hyderabad (Telangana), Satyamangal forest (Tamil Nadu) and Telagi near Harihar, Davanagere, Haveri, Kolar, Chikkmagalur district and around Bangalore (Karnataka). The contents are being regularly exported to Mexico, Peru, USA, Japan, Spain, Turkey, Poland, Italy, Australia, Canada and Africa. Consequently large area in Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra are under contract farming of Marigold for xanthophyll extraction.

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. The microbial inoculants have attained special significance in modern agriculture keeping view the increasing fertilizers cost and poor purchasing capacity of Indian farmers. Chemical fertilizers have temporary effect while biofertilizer have permanent effect without any production problem. Uses of composite biofertilizers increase the soil fertility considering the prospects of biofertilizers in the country.

Effect of liquid biofertilizers on flower crops has not been thoroughly evaluated under Indian conditions. Accordingly, the present investigation was aimed to study the response of Marigold (*Tagetes erecta* L.) cv. Double Orange to liquid formulations of EM consortia with graded levels of NPK on nutrient content of soil and plant and soil biomass under transitional tract of Karnataka.

Materials and Methods

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 gravily loam soil, having a pH of 6.40. During the experimentation period the rainfall was 790 mm and the average maximum temperature is 31.23⁰ C and minimum temperature is 18.97⁰ C 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., T₁: 100 % RDF (C), T₂: 75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K', T₃: 100 % RDF + *Azotobacter*, T₄: 75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K', T₅: 100 % RDF + *Bacillus megaterium*, T₆: 75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P', T₇: 100 % RDF + *Frateuria aurantia*, T₈: 75 % RD'N' and 'P' + *Azotobacter* + *Bacillus megaterium* + 100 % RD'K', T₉: 100 % RDF + *Azotobacter* + *Bacillus megaterium*, T₁₀: 75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P', T₁₁: 100 % RDF + *Azotobacter* + *Frateuria aurantia*, T₁₂: 75 % RD'P' and

'K' + *Bacillus megaterium* + *Fruteuria aurantia* + 100 % RD'N', T₁₃: 100 % RDF + *Bacillus megaterium* + *Fratureia aurantia*, T₁₄: 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Fratureia aurantia* and T₁₅: 100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Fratureia aurantia*. Liquid EM cultures having population of 10¹³ 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 course of study. The data recorded on flower yield and quality parameters were tabulated and subjected to statistical analysis (Sunderaraju *et al.*, 1972).

Results and Discussion

Nutrient content of plant (%)

Significantly higher nitrogen (1.40 %), phosphorus (0.97 %) and potassium content (2.91 %) in the plant was recorded in the treatment received 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Fratureia aurantia* (T₁₄), 100 % RDF + *Azotobacter* + *Bacillus megaterium* (T₉) and 100 % RDF + *Bacillus megaterium* + *Fratureia aurantia* (T₁₃),

respectively over 100 % RDF (T₁). The maximum NPK content of plants is attributed to the better availability and uptake of nutrients facilitated by biofertilizers (Table 1). Inoculation of *Azotobacter* might have resulted in better fixation of nitrogen in soil, inoculated *Bacillus megaterium* which mediated the release of phosphorus from insoluble phosphate to soluble form and *Fratureia aurantia* mobilizes the unavailable form of potassium into available and resulting in absorption of more nutrients. These results are in line with the findings of Qasim *et al.*, (2014) in *Gladiolus*. Similar observation was made by Hemavathi (1997) in *Chrysanthemum* and Renukaradya *et al.*, (2011) in *Carnation*.

Available nutrients in soil (kg/ha)

Significantly the maximum available nitrogen (229.46 kg/ha), phosphorus (157.05 kg/ha) and potassium in soil (247.52 kg/ha) was reported with the application of 100 % RDF + *Azotobacter* (T₃), 100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Fratureia aurantia* (T₁₅) and 75 % RD'N' and 'K' + *Azotobacter* + *Fratureia aurantia* + 100 % RD'P' (T₁₀), respectively compared to (T₁) 100 % RDF (Table 2). The increased in nitrogen status of soil was due to use of organic manures, especially FYM and balance use of chemical fertilizers (Shaktawat and Shekhawat, 2010). Similar trend of increased nitrogen level was reported by Chaudary *et al.*, (2012) in *Gladiolus*. The build-up of available phosphorus and potassium in the soil could be due to the organic acids which were released by increased microbial population in soil by the application of PSB and KSB. Bosali *et al.*, (2014) and Godse *et al.*, (2006) also reported that combined application of biofertilizers and inorganic (*Azotobacter* + PSB + ½ recommended doses of N + full P and K) fertilizers, increased the soil N, P and K availability compared with inorganic fertilizers alone.

Table.1 Effect of liquid formulations of EM consortia on plant nutrient status of *Tagetes erecta* L. cv. Double Orange

Treatment		Nutrient content (%)		
		Nitrogen	Phosphorus	Potassium
T₁	100 % Recommended dose of fertilizer (C)	0.26	0.25	0.93
T₂	75 % RD'N' + <i>Azotobacter</i> + 100 % RD'P' and 'K'	0.39	0.59	1.27
T₃	100 % RDF + <i>Azotobacter</i>	0.84	0.41	1.73
T₄	75 % RD'P' + <i>Bacillus megaterium</i> + 100 % RD'N' and 'K'	0.42	0.49	1.44
T₅	100 % RDF + <i>Bacillus megaterium</i>	0.43	0.55	1.74
T₆	75 % RD'K' + <i>Frateuria aurantia</i> + 100 % RD'N' and 'P'	0.57	0.63	1.42
T₇	100 % RDF + <i>Frateuria aurantia</i>	0.26	0.41	1.59
T₈	75 % RD'N' and 'P' + <i>Azotobacter</i> + <i>Bacillus megaterium</i> + 100 % RD'K'	0.52	0.74	1.80
T₉	100 % RDF + <i>Azotobacter</i> + <i>Bacillus megaterium</i>	1.12	0.97	2.51
T₁₀	75 % RD'N' and 'K' + <i>Azotobacter</i> + <i>Frateuria aurantia</i> + 100 % RD'P'	0.85	0.44	2.37
T₁₁	100 % RDF + <i>Azotobacter</i> + <i>Frateuria aurantia</i>	0.57	0.32	2.09
T₁₂	75 % RD'P' and 'K' + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i> + 100 % RD'N'	0.73	0.61	2.35
T₁₃	100 % RDF + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i>	0.72	0.53	2.91
T₁₄	75 % RDF + <i>Azotobacter</i> + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i>	1.40	0.36	2.30
T₁₅	100 % RDF + <i>Azotobacter</i> + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i>	1.01	0.76	2.89
S. Em ±		0.09	0.01	0.08
C. D. @ 5 %		0.27	0.04	0.23

Table.2 Available NPK status in soil as influenced by liquid formulations of EM consortia after harvest of *Tagetes erecta* L. cv. Double Orange

Treatment		Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
T ₁	100 % Recommended dose of fertilizer (C)	129.07	85.65	121.13
T ₂	75 % RD'N' + <i>Azotobacter</i> + 100 % RD'P' and 'K'	169.21	120.36	183.95
T ₃	100 % RDF + <i>Azotobacter</i>	229.46	132.80	134.45
T ₄	75 % RD'P' + <i>Bacillus megaterium</i> + 100 % RD'N' and 'K'	180.86	120.23	144.23
T ₅	100 % RDF + <i>Bacillus megaterium</i>	182.64	126.62	167.74
T ₆	75 % RD'K' + <i>Frateuria aurantia</i> + 100 % RD'N' and 'P'	170.32	140.24	188.28
T ₇	100 % RDF + <i>Frateuria aurantia</i>	182.63	126.21	156.16
T ₈	75 % RD'N' and 'P' + <i>Azotobacter</i> + <i>Bacillus megaterium</i> + 100 % RD'K'	166.21	151.21	188.40
T ₉	100 % RDF + <i>Azotobacter</i> + <i>Bacillus megaterium</i>	224.33	125.27	173.74
T ₁₀	75 % RD'N' and 'K' + <i>Azotobacter</i> + <i>Frateuria aurantia</i> + 100 % RD'P'	195.57	112.91	247.52
T ₁₁	100 % RDF + <i>Azotobacter</i> + <i>Frateuria aurantia</i>	225.89	118.11	213.11
T ₁₂	75 % RD'P' and 'K' + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i> + 100 % RD'N'	154.41	124.38	209.17
T ₁₃	100 % RDF + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i>	138.13	145.68	190.68
T ₁₄	75 % RDF + <i>Azotobacter</i> + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i>	225.71	150.81	224.06
T ₁₅	100 % RDF + <i>Azotobacter</i> + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i>	218.57	157.05	190.99
S. Em ±		15.33	4.17	5.88
C. D. @ 5 %		44.42	12.08	17.04

Table.3 Effect of liquid formulations of EM consortia on total microbial population of soil after harvest of *Tagetes erecta* L. cv. Double Orange

Treatment		Total bacteria (cfu/g soil)		Total fungi (cfu/g soil)		Total actinomycets (cfu/g soil)	
		10 ⁻⁵	10 ⁻⁶	10 ⁻³	10 ⁻⁴	10 ⁻²	10 ⁻³
T ₁	100 % Recommended dose of fertilizer (C)	77.57	37.69	6.67	5.33	5.00	3.67
T ₂	75 % RD‘N’ + <i>Azotobacter</i> + 100 % RD‘P’ and ‘K’	93.39	52.86	8.00	8.33	9.00	7.00
T ₃	100 % RDF + <i>Azotobacter</i>	114.07	102.45	8.00	7.67	8.67	5.33
T ₄	75 % RD‘P’ + <i>Bacillus megaterium</i> + 100 % RD‘N’ and ‘K’	94.00	78.17	13.33	12.33	6.67	7.67
T ₅	100 % RDF + <i>Bacillus megaterium</i>	78.52	44.52	9.67	8.67	10.00	8.00
T ₆	75 % RD‘K’ + <i>Frateuria aurantia</i> + 100 % RD‘N’ and ‘P’	138.92	119.44	16.33	15.00	15.00	4.33
T ₇	100 % RDF + <i>Frateuria aurantia</i>	93.24	34.63	10.33	11.33	7.67	5.67
T ₈	75 % RD‘N’ and ‘P’ + <i>Azotobacter</i> + <i>Bacillus megaterium</i> + 100 % RD‘K’	125.12	92.48	15.00	11.00	13.67	12.33
T ₉	100 % RDF + <i>Azotobacter</i> + <i>Bacillus megaterium</i>	218.19	189.28	26.67	13.33	15.67	14.33
T ₁₀	75 % RD‘N’ and ‘K’ + <i>Azotobacter</i> + <i>Frateuria aurantia</i> + 100 % RD‘P’	181.65	146.74	22.00	11.67	10.33	9.00
T ₁₁	100 % RDF + <i>Azotobacter</i> + <i>Frateuria aurantia</i>	154.33	120.88	11.67	12.67	16.00	13.00
T ₁₂	75 % RD‘P’ and ‘K’ + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i> + 100 % RD‘N’	196.15	159.98	20.33	16.67	10.33	6.67
T ₁₃	100 % RDF + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i>	205.22	148.11	24.00	18.00	21.33	12.67
T ₁₄	75 % RDF + <i>Azotobacter</i> + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i>	233.00	207.33	51.00	45.00	24.33	19.67
T ₁₅	100 % RDF + <i>Azotobacter</i> + <i>Bacillus megaterium</i> + <i>Frateuria aurantia</i>	204.67	204.00	25.00	16.67	11.67	11.00
S. Em ±		4.63	3.80	1.52	1.19	1.05	1.36
C. D. @ 5 %		13.41	11.01	4.41	3.46	3.04	3.94

Note: cfu = colony forming units

Similar findings were also reported by Chandrikapure *et al.*, (1999) who found that dual inoculation of VAM and *Azotobacter* with 50 kg N and 25 kg P per hectare increased 13.42 and 13.81 per cent soil available N and P, respectively compared to initial fertility status of soil.

Total microbial population in soil

Total bacteria

The bacterial population varied significantly due to different treatments. The higher bacterial population of 233 and 207.33 *cfu/gram* soil was observed under 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T₁₄) at 10⁻⁵ and 10⁻⁶ dilution, respectively. While, minimum number of cell count was observed in T₁ with 100% RDF (77.57 *cfu/g* soil) at 10⁻⁵ dilution and T₇ (34.63 *cfu/g* soil) at 10⁻⁶ dilution. The increase in bacterial biomass under this treatment might be due to increased microbial activity and multiplication as it was inoculated with microbial consortium. These results get support from the findings of Chaudhary *et al.*, (2012) in *Gladiolus*.

Total fungi

Treatments differed significantly with regard to total fungus population in soil (Table 3). At 10⁻³ and 10⁻⁴ dilution, the higher fungi biomass of 51 and 45 *cfu* per gram of soil, respectively was noticed with the inoculation *Azotobacter*, *Bacillus megaterium* and *Frateuria aurantia* along with 75 % RDF (T₁₄). Whereas, treatment T₁ (100 % RDF) recorded least number of fungal colonies (6.67 and 5.33 *cfu/g* soil) at 10⁻³ and 10⁻⁴ dilution (Table 3).

Total actinomycetes

Significantly the higher actinomycetes biomass of 24.33 and 19.67 *cfu* per gram of

soil at 10⁻² and 10⁻³ dilution was reported with the application of 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T₁₄). However, the treatment T₁ (100 % RDF) recorded lowest number (Table 3) of colonies of 5 and 3.67 *cfu/gram* of soil at 10⁻² and 10⁻³ dilution, respectively.

References

- Alam, A. U., Cough, I. R. and Creger, C. R., 1968, Fatty acid composition of the xanthophyll esters of *Tagetes erecta* petals. *Lipids*, 3: 183.
- Anonymus, 2014, Indian Horticulture Database, National Horticulture Board, Gurgaon. pp. 286.
- Bosali, M., Kumar, P. and Kumar, S., 2014, Impact of integrated nutrient management on post-harvest and corm characters of *Gladiolus* cv. Novalux. *Ann. Hort.*, 7(2): 109-114.
- Chandrikapure, K. R., Sadawarte, K. T., Panchabh, D. M. and Selke, B. D., 1999, Effect of bio inoculants and graded doses of nitrogen on growth and flower yield of Marigold (*Tagetes erecta* L.). *Orissa J. Hort.*, 27(2): 31-34.
- Chaudhari, N., Swaroop, K., Janakiram, T., Biswas, D. R. and Singh, G., 2012, Response of INM on *Gladiolus* for corm attributing characters and soil fertility. *J. Orn. Hort.*, 15(1&2): 47-52.
- Godse, S. B., Golliwar, V. J., Chopde, N., Bramhankar, K. S. and Kore, M. S., 2006, Effects of organic manures and biofertilizers with reduced doses of inorganic fertilizers on growth, yield and quality of *Gladiolus*. *J. Soil. Crop.*, 16(2): 445-449.
- Hemavathi, M., 1997, Effect of organic manures and biofertilizers on growth and productivity of *Chrysanthemum*. *M. Sc. Thesis*, Uni. Agric. Sci., Bangalore, Karnataka (India).
- Qasim, M., Younis, A., Zahir, Z. A., Riaz, A., Raza, H. and Tariq, U., 2014, Microbial

inoculation increases the nutrient uptake efficiency for quality production of *Gladiolus grandiflorus* L. *Pak. J. Agri. Sci.*, 51(4): 875-880.

- Renukaradya, S., Pradeepkumar, C. M., Santhosha, H. M., Dronachari, M. and Shashikumar, R. S., 2011, Effect of integrated system of plant nutrition management on growth, yield and flower quality of Carnation (*Dianthus caryophyllus* L.) under green house. *The Asian J. Hort.*, 6(1): 106-112.
- Scott, M. I., Ascarelli, I. and Olson, G., 1968, Studies on egg-yolk pigmentation.

Poultry Sci., 47: 863.

- Shaktawat, R. P. S. and Shekawat, P. S., 2010, Soil fertility status as affected with and without farm yard manure in *Kharif* crops and fertilizers levels in Barley (*Hordeum vulgare* L.). *Indian J. Agric. Sci.*, 80(9): 791-794.
- Sunderaraju, N., Nagaraju, S., Venkataramu, M. N. and Jagannath, M. R., 1972, *Design and analysis of field experiments*. Misc. Series No. 22, Uni. Agric. Sci., Bangalore, Karnataka (India).

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