RESEARCH ARTICLE

RESPONSE OF MARIGOLD (*TAGETES ERECTA* L.) CV. DOUBLE ORANGE TO LIQUID FORMULATIONS OF EM CONSORTIA WITH GRADED LEVELS OF NPK ON FLOWER YIELD, QUALITY AND XANTHOPHYLLS YIELD

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Abstract: The present investigation entitled "response of Marigold (*Tagetes erecta* L.) cv. Double Orange to liquid formulations of effective microbial consortia with graded levels of NPK on flower yield and quality traits" was carried out at Department of Horticulture, College of Agriculture, Shivamogga, Karnataka, during 2014-15. The experiment was laid out in Randomized Block Design with 15 treatments replicated thrice. Studies showed significant effect on flower weight (8.37 g), flower diameter (8.04 cm), number of petals per flower (323.12), number of flowers per plant (91.34), flower yield per plant (572.86 g), flower yield per plot (20.62 kg) and flower yield per hectare (12.70 t) was recorded in the treatment which received 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia* (T_{14}). Petal meal yield per kilogram of fresh flower (90.84 g), petal meal yield per hectare (1156.40 kg), xanthophyll content (42.21 g) per kilogram of petal meal and xanthophyll yield per hectare (48.61 kg) were also recorded maximum with the same treatment *i.e.,* T_{14} (75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*) compared to cent per cent RDF.

Keywords: Marigold, EM consortia, Flower yield, Quality, Xanthophyll

INTRODUCTION

Marigold (*Tagetes erecta* L.) occupying a prominent place in ornamental horticulture, is one of the commercially exploited flower crops 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. 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 flower yield and quality traits under transitional tract of Karnataka.

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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 period the rainfall was 790 mm and the average maximum temperature is 31.23^0 C and minimum temperature is 18.97^0 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.*, 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' 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* + *Fruteuria 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 course of study. The data recorded on flower yield and quality parameters were tabulated and subjected to statistical analysis (Sunderaraju *et al.*, 1972).

RESULT AND DISCUSSION

The plants inoculated with *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* + 75 % RDF (T_{14}) registered significantly more number of flowers (91.34) per plant and it was on par with T_9 (85.06). The treatment consisting of 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}) gave significantly maximum flower yield per plant (572.86 g) and it was on par with T_3 (570.00 g) and T_2 (541.53 g). The plants supplied with 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}) produced maximum flower yield (20.62 kg) per plot and per hectare (12.70 t) which was found on par with T_3 (19.16 kg and 11.80 t, respectively). Which resulted in 32.15 and 22.78 % increase in flower yield in T_{14} and $T_{3,}$ respectively over 100 % RDF (T_1) (Table 1). Whereas, 100 % RDF (T_1) recorded least number of flowers (55.65), flower yield per plant (441.13 g), per plot (15.60 kg) and per hectare (9.61 t). The possible reason for better performance of yield attributes and higher yield could be due to the regular supply of nutrients leads to more vegetative growth leading to increase in photosynthetic area, which in turn resulted in more synthesis and accumulation of dry matter in the flower (Bosali *et al*., 2014). Moreover, presence of growth promoting substances such as auxin, gibberllins and cytokinin due to presence of biofertilizers would have also contributed in development and accumulation of sink resulting in better growth and subsequently higher number of flowers per plant and higher flower yield per hectare. The results are in agreement with the earlier findings of Thumhar *et al*., 2013 and Jadhav *et al*., 2014 in Marigold, Patanwar *et al*., 2014 in Chrysanthemum, Kirar *et al.*, 2014 in China aster and Sheergojri *et al.*, 2014 in Gladiolus.

Treatments varied significantly with respect to quality parameters (Table 2). The plants treated with 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}) registered maximum flower weight of 8.37 g, which was significantly higher than all other treatments and it was on par with T_{11} (8.04 g), T_3 (7.77 g) and T_9 (7.69 g). The flower diameter was recorded maximum (8.04 cm) when the plants were supplied with 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* (T_{14}) followed by T_3, T_{11}, T_{10}, T_5, T_9, T_{15}, T_2 and T_4 (7.64, 7.58, 7.57, 7.56, 7.45, 7.45, 7.43 and 7.43 cm, respectively). However, the above treatments were found on par with each other. The treatment T_{14} (75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*) produced significantly highest number of petals per flower (323.12) and it was on par with T_9 (315.51), T_{15} (309.30) and T_3 (300.10). Whereas, T_1 (100 % RDF) recorded minimum flower weight (6.44 g), flower diameter (6.61 cm) and number of petals per flower (231.73). The possible reason for increased quality might be due to better physical condition of soil and increased population of microflora, thereby enhanced availability of nutrient through mineralization process. Moreover, biofertilizers produce the growth stimulating substances *viz*., auxin, gibberellins and cytokinins which contribute towards vigorous growth of the plant. This in turn increases photosynthesis and enhances food accumulation and also diversion of photosynthates towards sink resulting in better quality flowers. The earlier study of Panchal *et al*. (2010) and Swaroop (2011) also confirms these findings in Marigold, Kirar *et al*. (2014) in China aster, and Singh (2007) and Chaudhari *et al.* (2010) in Rose.

Different treatments significantly influenced on the petal meal yield and xanthophylls yield. The treatment T_{14} which received 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* recorded maximum petal meal yield (90.84 g/kg) and it was found statistically on par with T_9, T_3, T_{10}, T_5 and T_8 (87.42, 86.31, 84.56, 83.95 and 83.86 g/kg, respectively). The maximum petal meal yield of 1156.40 kg per hectare was recorded in the treatment T_{14} (75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia*) and it was on par with T_9 (1031.37 kg/ha). Significantly higher xanthophyll content (42.21 g/kg) was recorded in the treatment T_{14} supplied with 75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurantia* which was closely followed by (40.92 g/kg) 100 % RDF + *Azotobacter* + *Bacillus megaterium* (T_9) and on par with each other. Inoculation of *Azotobacter*, *Bacillus megaterium* and *Frateuria aurantia* along with 75 % RDF (T_{14}) produced higher xanthophyll yield of 48.61 kg/ha, which was significantly superior over rest of the treatments followed by T_9 (42.17 kg/ha). This resulted in 265.21 and 216.82 % increase in xanthophyll yield in T_{14} and T_9, respectively compared to T_1 (100 % RDF). The treatments T_1 with 100 % RDF reported

Table 1. Effect of liquid formulations of EM consortia on yield and its attributes of *Tagetes erecta* L. cv. Double Orange

Treatment		No. of flowers/ plant	Flower yield/ plant (g)	Flower yield/plot (kg)	Flower yield/ ha (t)
T_1	100 % Recommended dose of fertilizer (C)	55.65	441.13	15.60	9.61
T_2	75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K'	76.01	541.53	18.89	11.64
T_3	100 % RDF + *Azotobacter*	79.07	570.00	19.16	11.80
T_4	75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K'	67.46	510.26	17.56	10.81
T_5	100 % RDF + *Bacillus megatherium*	60.91	482.80	18.10	11.15
T_6	75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P'	68.66	507.26	18.39	11.33
T_7	100 % RDF + *Frateuria aurentia*	60.99	508.20	17.81	10.97
T_8	75 % RD'N' and 'P' + *Azotobacter* + *Bacillus megaterium* + 100 % RD'K'	72.16	479.40	17.35	10.69
T_9	100 % RDF+ *Azotobacter* + *Bacillus megatherium*	85.06	532.00	19.12	11.78
T_{10}	75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P'	74.67	529.46	18.58	11.44
T_{11}	100 % RDF+ *Azotobacter* + *Frateuria aurentia*	71.93	483.40	17.43	10.73
T_{12}	75 % RD'P' and 'K' + *Bacillus megaterium* + *Frateuria aurantia* + 100 % RD'N'	64.83	489.73	17.70	10.90
T_{13}	100 % RDF + *Bacillus megaterium* + *Frateuria aurentia*	77.87	500.04	18.12	11.16
T_{14}	75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*	91.34	572.86	20.62	12.70
T_{15}	100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*	65.26	475.65	17.43	10.74
S. Em ±		3.72	11.00	0.50	0.31
C. D. @ 5 %		10.79	31.88	1.47	0.90

Table 2. Effect of liquid formulations of EM consortia on quality traits of *Tagetes erecta* L. cv. Double Orange

Treatment		Flower Weight (g)	Flower diameter (cm)	Number of petals per flower	Petal meal yield (g/kg)	Petal meal yield (kg/ha)	Xanthophyll yield (g/kg)	Xanthophyll yield (kg/ha)
T_1	100 % Recommended dose of fertilizer (C)	6.44	6.61	252.99	71.61	713.82	18.54	13.31
T_2	75 % RD'N' + *Azotobacter* + 100 % RD'P' and 'K'	7.07	7.43	288.38	82.05	956.92	19.44	18.67
T_3	100 % RDF + *Azotobacter*	7.77	7.64	300.10	86.31	1023.04	21.48	21.69
T_4	75 % RD'P' + *Bacillus megaterium* + 100 % RD'N' and 'K'	6.87	7.43	278.37	77.27	837.55	37.09	30.99
T_5	100 % RDF + *Bacillus megatherium*	6.62	7.56	282.88	83.95	937.30	31.38	29.59
T_6	75 % RD'K' + *Frateuria aurantia* + 100 % RD'N' and 'P'	7.12	7.27	270.07	81.66	925.98	33.08	30.78
T_7	100 % RDF + *Frateuria aurentia*	7.29	7.30	295.99	74.18	786.65	24.84	19.66
T_8	75 % RD'N' and 'P' + *Azotobacter* + *Bacillus megaterium* + 100 % RD'K'	6.86	7.28	263.26	83.86	898.00	27.93	24.98
T_9	100 % RDF + *Azotobacter* + *Bacillus megatherium*	7.69	7.45	315.51	87.42	1031.37	40.92	42.17
T_{10}	75 % RD'N' and 'K' + *Azotobacter* + *Frateuria aurantia* + 100 % RD'P'	7.15	7.57	273.07	84.56	968.43	28.53	27.71

T_{11}	100 % RDF + *Azotobacter* + *Frateuria aurentia*	8.04	7.58	278.17	80.95	870.27	19.75	17.32
T_{12}	75 % RD'P' and 'K' + *Bacillus megaterium* + *Frateuria aurantia* + 100 % RD'N'	7.07	7.38	280.18	78.58	855.97	23.57	20.35
T_{13}	100 % RDF + *Bacillus megaterium* + *Frateuria aurentia*	7.25	7.26	293.69	82.10	919.22	36.70	33.68
T_{14}	75 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*	8.37	8.04	323.12	90.84	1156.40	42.21	48.61
T_{15}	100 % RDF + *Azotobacter* + *Bacillus megaterium* + *Frateuria aurentia*	7.25	7.45	309.30	82.87	893.99	27.04	23.93
S. Em ±		0.24	0.20	8.40	2.66	43.05	1.57	1.69
C. D. @ 5 %		0.69	0.60	24.34	7.70	124.72	4.55	4.91

minimum petal meal yield (71.61 g/kg), petal meal yield (713.82 kg) per hectare, xanthophyll yield (18.54 g) per kg petal meal and per hectare (13.31 kg). The difference in xanthophyll yield may be attributed to variation in flower yield and petal meal yield per hectare. The difference in the petal meal yield per hectare in the treatments may be attributed to the corresponding differences in yield components *viz*., individual flower weight, number of petals per flower, flower yield per plant and per hectare and petal meal yield per kilogram of fresh flower weight. The present results are in conformity with the research findings of Anuradha *et al*. (1990) and Naik (2003) in Marigold and Roelants (1973) in Carnation, who also observed higher number of petals per flower as well as petal meal yield and higher carotenioid contents.

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