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Effect of integrated nutrient management on growth, flowering behaviour and yield of African marigold (*Tagetes erecta* L.) cv. African Giant Double Orange

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ABSTRACT

A field experiment was carried out to study the effect of integrated nutrient management on growth, flowering behaviour and yield of marigold (*Tagetes erecta* L.) at the main experiment station, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad, during 2004 and 2005 in Randomized Block Design. There were thirteen treatments involving two biofertilizers, viz., *Azotobacter* and phosphorus solubilizing bacteria (PSB) and two levels of nitrogen and phosphorus, viz., (50% and 100%), farm yard manure (FYM) and control (recommended dose of NPK., *i.e.*, 200:100:100 kg/ha). One month old seedlings were transplanted at a spacing of 40 x 30 cm. Results revealed that combined application of *Azotobacter* and PSB with FYM and 50% recommended dose of nitrogen and phosphorus significantly improved growth, flowering behavior and yield during both years (2004 and 2005). Application of *Azotobacter* + PSB + FYM @ 30 ha^{-1} + nitrogen @ 100 ha^{-1} and phosphorus @ 50 kg/ha was found to be best for growth, flowering behaviour and yield of cv. African Giant Double Orange.

Key words: Integrated Nutrient Management, biofertilizers, *Tagetes erecta* L.

INTRODUCTION

Marigold (*Tagetes erecta* L.) is one of the most popular and commercial flowering annual cultivated in different parts of the country. It has great demand for garland, cut flowers and decorative purposes at various kinds of religious and social functions. Nutrients play an important role in growth and development of marigold crop. Continuous and indiscriminate use of chemical fertilizers alters the soil fertility, leading to soil pollution and ultimately poor crop yield. It is therefore, necessary to restrict their use. However, considering recent concept of integrated nutrient management system, which has currently a special significance in crop production to address the sustainability problem and is being practiced in several crops. Integration of biofertilizers and organic manures reduce the consumption of inorganic fertilizers and increase the quality and quantity of flower. Efficacy of the inorganic fertilizers was increased when they are combined with organic manures. Application of farmyard manure (FYM) increased the population of micro-flora mainly *Azotobacter* (Gupta *et al*, 1999). The combined application of *Azotobacter* and phosphorus solubilizing bacteria along with 75% nitrogen was found to be most effective in increasing the flower yield of marigold (Gupta *et al*., 1999). Keeping in view the above facts, this experiment was carried out to study the effect of integrated nutrient management on growth, flowering behaviour and yield of marigold cv. African Giant Double Orange in relation to reduced dose of nitrogen and phosphorus.

MATERIAL AND METHODS

An experiment was conducted during summer season of 2004 and 2005 at main experiment station (Horticulture), Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumargang), Faizabad in Randomized Block Design. There were 13 treatments involving two biofertilizers viz., *Azotobacter* and phosphorus solubilizing bacteria (PSB) and two levels of nitrogen and phosphorus viz., 50% and100%; farm yard manure (FYM) alone and in combination and control (recommended dose of NPK). The treatments were recommended dose of NPK

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@ 200:100:100 kg/ha (T_1), PSB @ 2 kg/ha (T_2), *Azotobacter* @ 2 kg/ha (T_3), PSB + *Azotobacter* (T_4), FYM @ 30 t/ha (T_5), PSB + 50% P + 100% N and K (T_6), PSB + 50% P + 100% N and K + FYM (T_7), *Azotobacter* + 50% N + 100% P and K (T_8), *Azotobacter* + 50% N + 100% P and K + FYM (T_9), PSB + *Azotobacter* + 50% N and P + 100% K (T_{10}), PSB + *Azotobacter* + 50% N and P + 100% K + FYM (T_{11}), PSB + *Azotobacter* + 100% NPK + FYM (T_{12}) and PSB + *Azotobacter* + 100% NPK (T_{13}). *Azotobacter* @ 2 kg/ha was applied through seedlings root treatments for few minutes before transplanting while PSB @ 2 kg/ha was applied through soil treatment at the time of transplanting. The data recorded on various parameters of growth, flowering behaviour, yield attributes and flower yield were subjected to statistical analysis (Panse and Sukhatme, 1989).

RESULTS AND DISCUSSION

Growth parameters

All the growth parameters were influenced significantly due to various treatments of integrated nutrient management during both experimental years. The data recorded (Table 1A and 1B) on plant height at bud initiation stage revealed that maximum values (99.30 and 102.23 cm) were observed with the application of PSB + *Azotobacter* + full NPK + FYM (T_{12}) and it was found to be significantly superior over all other treatments followed by T_{11} treatment during 2004 and 2005. However, maximum values regarding other growth parameters like stem diameter (2.91 and 3.23 cm), plant spread (3420.03 and 3502.52 cm), number of primary branches plant^{-1} (13.59 and 15.69), number of leaves plant^{-1} (180.13 and 184.11) and leaf area (189.89 and 194.54 cm^2) were recorded with the application of PSB + *Azotobacter* + full K + FYM + half N and P (T_{11}). Results clearly showed that the combined application of PSB, *Azotobacter* and FYM along with half nitrogen and phosphorus proved to be beneficial for robust growth of plant as compared to other treatments. This might be due to nitrogen and phosphorus fertilization in combination of bioinoculants (*Azotobacter* and PSB) and FYM proved to be beneficial to fix the atmospheric nitrogen and solubilize fixed phosphorus in soil and it also secrete growth substances like auxins, which stimulated the plant metabolic activities and photosynthetic efficacy leading better growth and development of plant. Above results are in conformity with the findings of Kulkarni (1990) in aster, Chandrikapure *et al,* (1999) in marigold and Kumar *et al.* (2003) in aster.

Flowering parameters

Data presented in Table 1a and 1b, on flowering parameters showed significant response to different treatments of integrated nutrient management. With respect to days taken for bud initiation, first flower opening and flowering span, the application of PSB + *Azotobacter* + 50% N and P + full K + FYM (T_{11}) recorded minimum number of days for bud initiation (48.20 and 45.12 days) and first flower opening (9.30 and 11.65 days) and marked increase in flowering span of marigold (41.39 and 45.79

Table 1a. Effect of INM on plant growth and flowering behaviour of African marigold cv. African Giant Double Orange

Treatment	Plant height (cm)		Stem diameter (cm)		Plant spread (cm)		Number of main branches per plant		Number of leaves per plant		Leaf area (cm^2)		Days taken to bud initiation	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
T_1	69.09	70.23	1.55	1.87	1705.81	1705.83	7.89	9.99	147.89	151.47	156.64	161.29	52.60	57.56
T_2	65.87	69.45	1.58	1.90	1795.23	1800.57	6.24	8.34	145.34	149.32	125.03	134.41	50.50	53.26
T_3	67.97	72.23	1.77	2.09	1815.34	1820.68	7.83	9.93	161.34	165.25	132.15	142.56	52.30	51.23
T_4	68.46	73.23	1.70	2.02	1905.05	1879.56	7.19	9.29	160.16	164.14	129.75	152.56	51.70	53.00
T_5	75.04	80.56	1.80	2.12	2005.17	2023.32	8.74	10.84	140.56	144.54	139.10	143.75	49.70	51.45
T_6	70.56	75.43	1.72	2.04	1997.02	2004.36	6.25	8.36	145.08	149.06	131.40	136.05	50.09	49.12
T_7	71.55	77.12	1.67	1.99	2110.91	2116.25	8.14	10.24	158.95	162.93	145.16	149.81	51.40	52.42
T_8	72.45	77.23	1.79	2.11	2223.14	2356.23	8.10	10.20	169.89	173.87	150.31	154.96	51.72	56.23
T_9	76.46	81.87	2.41	2.73	2800.56	2754.98	9.13	11.23	172.86	176.04	158.64	163.29	51.80	55.79
T_{10}	78.56	83.56	1.89	2.21	2010.39	2065.13	10.27	12.37	171.77	175.68	184.74	189.39	49.60	45.65
T_{11}	88.47	90.54	2.91	3.23	3420.03	3502.52	13.59	15.69	180.13	184.11	189.89	194.54	48.20	45.12
T_{12}	99.30	102.23	2.61	2.93	3210.27	3323.56	8.23	10.33	169.24	173.22	173.06	177.71	49.23	49.06
T_{13}	80.30	85.46	2.52	2.84	2870.23	2956.54	7.27	9.53	153.54	157.52	165.71	170.36	51.50	55.45
SEm±	2.59	2.70	0.07	0.08	107.99	73.80	0.32	0.33	3.89	5.9	5.60	4.77	0.69	1.69
CD (*P=0.05*)	7.55	7.89	0.21	0.24	315.21	215.44	0.93	0.96	11.37	17.23	16.36	13.92	2.02	4.92

days) and it was significantly superior over application of NPK alone, FYM and biofertilizers during both the years. This might be due to early completion of vegetative growth and changing of vegetative primordia to reproductive primordia, probably due to the secretion growth promoting substances like auxins, gibberellins, vitamins and organic acids (Rossaria and Basera, 1975), which promoted faster vegetative growth and ultimately induced early flower bud initiation and prolonged flowering span. Similar observations have been recorded by Chandrikapure *et al.* (1999) and Gupta *et al* (1999) in marigold.

Yield and yield parameters

It is evident from Table 2 that the integration of organic manures and biofertilizers with inorganic fertilizers showed significant response towards yield attributes and yield of African marigold. The flower stalk length (10.34 cm in 2004 and 12.46 in 2005), flower diameter (7.10 cm in 2004 and 8.54 cm in 2005), fresh weight of flower (8.18 g in 2004 and 8.33 g in 2005) and number of flowers per plant (28.93 in 2004 and 29.44 in 2005) were highest under treatment T_{11} followed by T_{12}, whereas minimum values with respect to above mentioned parameters were recorded in T_1, T_2 and T_3 treatments. The significant increase in these parameters might be due to high nitrogen and phosphorus assimilation from FYM and 50% nitrogen and phosphorus in association with more nitrogen fixing and phosphorus solubilizing proficiency and secretion of hormones by the cultures. These findings corroborate with that of Yadav *et al* (2000) in marigold and Shashidara and Gopinath (2002) in calendula.

Inoculation with combined culture of *Azotobacter* and PSB along with FYM and various doses of nitrogen and phosphorus exhibited yield and shelf life of flower as compared to application of inorganic fertilizers, organic manures and biofertilizers alone during 2004 and 2005. Among all treatments, application of *Azotobacter* + PSB + FYM +50% N and P + full K (T_{11}) recorded maximum flower yield per hectare (196.66 and 212.72 q/ha) and shelf life (7.12 and 7.69 days), followed by *Azotobacter* + PSB + FYM + full NPK and further it was significantly superior over all the treatments during both the years. The effect of combined application of *Azotobacter* + PSB culture in association with nitrogen and phosphorus with or without FYM was observed to be better than the application of culture inoculation alone/combination. This increase in yield might be due to active and rapid multiplication of bacteria especially in rhizospher creating favorable condition for nitrogen fixation and phosphorus solubilization at higher rate through nitrogen supply by nitrogenous fertilizers and supply of other nutrients, bacterial secretion, hormone production and supply of antibacterial and antifungal compounds, which were favourable for growth and ultimately increased yield. The flower yield increase in combination treatments of *Azotobacter* + PSB + FYM + 50% nitrogen and phosphorus + full potassium might be due to robust growth and maximum increase in flowering span, flower diameter and flower number. Similar observations have been reported by Kumar *et al* (2003) in aster, Gupta *et al* (1999), Chandrikapure *et al* (1999) and Syamal *et al* (2006) in marigold.

Table 2. Effect of INM on yield attributes and yield of African marigold cv. African Giant Double Orange

Treatment	Flower stalk length (cm)		Flower diameter (cm)		Fresh weight of flower (g)		Number of flowers per plant		Flower yield (q/ha)		Shelf life (days)	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
T_1	7.17	11.41	4.58	6.16	5.55	5.70	19.83	22.02	91.63	104.60	3.65	4.22
T_2	6.17	8.20	4.60	6.63	5.88	6.00	16.33	18.03	79.95	90.49	6.20	6.77
T_3	7.87	9.99	5.09	6.65	5.62	5.92	19.85	21.28	92.98	104.86	5.43	6.00
T_4	6.47	8.59	5.40	6.95	6.37	6.28	18.95	21.61	100.49	112.98	3.89	4.46
T_5	7.77	9.89	5.45	7.09	6.77	6.96	20.22	20.65	114.24	119.58	4.89	5.46
T_6	8.12	8.29	5.49	7.16	7.23	6.95	20.43	22.14	132.50	127.26	4.23	4.80
T_7	7.29	9.41	5.52	7.49	6.56	6.54	24.85	25.94	135.96	143.28	5.42	5.99
T_8	6.74	8.86	6.13	7.66	7.24	6.93	20.32	21.92	130.81	126.63	6.96	7.53
T_9	7.24	9.36	6.15	7.77	8.09	7.60	21.43	24.14	144.60	153.99	5.98	6.55
T_{10}	9.27	11.39	6.41	7.80	7.72	7.57	22.99	23.09	138.63	145.90	6.00	6.57
T_{11}	10.34	12.46	7.10	8.54	8.18	8.33	28.93	29.44	196.66	212.72	7.12	7.69
T_{12}	9.28	10.40	6.88	7.93	7.77	7.71	27.60	28.77	166.40	184.95	6.90	7.47
T_{13}	8.14	10.24	6.68	7.88	7.03	6.55	20.57	21.44	120.58	120.57	5.23	5.80
SEm±	0.22	0.31	0.53	0.35	0.19	0.43	0.77	0.88	5.74	8.75	0.23	0.16
CD (*P=0.05*)	0.65	0.91	1.57	1.03	0.56	1.23	2.25	2.57	16.78	25.55	0.67	0.47

Table 3. Economics of flower production through integrated nutrient management

Treatment	Flower yield (q/ha)		Gross income (Rs./ha)		Cost of cultivation (Rs./ha)		Net income (Rs./ha)		B:C ratio	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
T_1	91.63	104.60	73304.00	83680.00	38494.71	40356.25	34809.29	43323.75	0.90	1.07
T_2	79.95	90.49	63960.00	72392.00	32762.00	34251.00	31198.00	38141.00	0.95	1.11
T_3	92.98	104.86	74384.00	83888.00	32762.00	34251.00	41622 .00	49637.00	1.27	1.45
T_4	100.49	112.98	80392.00	90384.00	32874.00	34363.00	47518.00	56021.00	1.45	1.63
T_5	114.24	119.58	91392.00	95664.00	39382.00	42554.00	52010.00	53110.00	1.32	1.25
T_6	132.50	127.26	106000.00	101808.00	37379.48	39200.30	68620.52	62607.70	1.84	1.60
T_7	135.96	143.28	108768.00	114624.00	44111.48	47615.30	64656.52	67008.70	1.47	1.41
T_8	130.81	126.63	104648.00	101304.00	37369.94	39156.85	67278.06	62147.15	1.80	1.59
T_9	144.60	153.99	115680.00	123192.00	44101.94	47571.85	71578.06	75620.15	1.62	1.59
T_{10}	138.63	145.90	110904.00	116720.00	36254.71	38000.90	74649.29	78719.10	2.06	2.07
T_{11}	196.66	212.72	157328.00	170176.00	42986.71	46415.90	114241.29	123760.10	2.66	2.67
T_{12}	166.40	184.95	133120.00	147960.00	45450.71	48995.25	87669.29	98964.75	1.93	2.02
T_{13}	120.58	120.57	96464.00	96456.00	38718.71	40580.25	57745.29	55875.75	1.49	1.38

Maximum gross income (Rs.1,57,328 and 1,70,176), net income (Rs.1,14,241.29 and Rs.1,23,760.10) and cost:benefit ratio (2.66 and 2.67) was achieved with the application of *Azotobacter* + PSB + FYM + 50% N and P + full K (T_{11}), while maximum cost of cultivation (Rs.45,450.71 and 48,995.25) was observed with the application of PSB + *Azotobacter* + 100% NPK + FYM (T_{12}) (Table 3). It is also worth mentioning that inoculation of biofertilizers along with farmyard manure and 50% nitrogen and phosphorus help in achieving significant flower yield as compared to all the combinations of biofertilizers, organic manure and inorganic fertilizers. Thus, reducing the 50% dose of nitrogen and phosphorus by the integration of biofertilizers (*Azotobacter* and phosphorus solubilizing bacteria) and organic manure (farmyard manure) is advantageous.

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