

Original Research Article

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Effect of Integrated Nutrient Management on Growth and Flowering of African Marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda

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ABSTRACT

A field experiment was conducted to study the effect of integrated nutrient management on marigold cv. Pusa Narangi Gainda at College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, during 2016-17. Results revealed that treatment T₇ (75% NPK + FYM + AZO + PSB) was found to be significantly good for both vegetative and floral parameters. It recorded maximum plant height (84.85 cm), maximum number of primary and secondary branches (10.03 and 26.55, respectively), maximum stem girth (4.57 cm), earliest bud initiation and flowering (31.89 days and 46.25 days, respectively) and maximum number of flowers per plant (34.40). Minimum days to 50% flowering (50.51 days), 100% flowering (54.57 days) and maximum flower diameter (4.87 cm) were found in treatment T₅ (75% NPK + FYM + PSB). Flowering duration (46.22 days) and shelf life (70.67 hours) was superior with application of treatment T₆ (75% NPK + FYM + AZO) whereas treatment T₃ (AZO + 75% N + 100% P & K) reported maximum fresh weight and dry weight (5.73 g and 1.50 g, respectively). Application of 75% NPK (75:150:150 kg NPK /ha) in combinations with FYM (10t/ha) and biofertilizers (Azospirillum and PSB @ 5 kg/ha) resulted in highest yield (15.53 t/ha) with maximum net return (Rs. 1,90,794/ha) and highest benefit cost ratio of 2.57.

Keywords

African marigold, NPK, FYM, Flower diameter, Azospirillum and PSB

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Introduction

Marigold, a member of the family *Asteraceae*, is native to Central and South America especially Mexico (Kaplan, 1960). Cultivated genera include *Tagetes erecta* and *Tagetes patula*, commonly referred to as African

marigold and French marigold, respectively. African marigold is one of the most important loose flower crops grown commercially in many parts of the country. Flowers of marigold are used in garland-making, wreaths, as religious offering, in hall decoration, etc. It is in great demand as loose flower throughout

the year. Among the various factors affecting the growth and flowering of marigold, balanced nutrition right from the beginning is very important. Though, the research over conventional nutritional requirement (NPK) in African marigold has been standardized, but farmers, for getting more quantity of flowers, add chemical fertilizers unscrupulously, which has led to enormous level of chemical build up in the ecosystem. Continuous application of imbalanced and excessive nutrients has led to decline in nutrient-use efficiency making fertilizer consumption uneconomical and producing adverse effects on atmosphere and ground water quality, causing health hazards. Integrated Nutrient Management (INM) provides an excellent opportunity to overcome all the imbalances beside sustaining soil health and enhancing crop production. The use of organic manures and bio-fertilizers along with balanced use of chemical fertilizers is known to improve the physio-chemical and biological properties of soil, besides improving the efficiency of applied fertilizers (Verma *et al.*, 2011). Hence, keeping the importance of new age farming in mind, the present investigation was conducted to know the effect of INM in African marigold.

Materials and Methods

The present investigation was conducted at the garden of the Department of Floriculture and Landscaping, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, during 2016-17 under open field condition. The experimental land was divided into small plots of size 1.4 m × 1m. One month old seedlings of African marigold cv. Pusa Narangi Gaiinda having uniform size and vigor were transplanted at a spacing of 30 cm × 40 cm. The treatments comprised of various combination of RDF (100:200:200 kg NPK/ha), FYM (10t/ha), bio-fertilizers (*Azospirillum* and PSB both @ 5 kg/ha) were applied as, T₁-100% NPK

(control), T₂-PSB @ 5kg/ha+75% P + 100% N & K, T₃-AZO @ 5kg/ha+75% N +100% P & K, T₄-75% NPK + FYM @ 10t/ha, T₅- 75% NPK +FYM @ 10t/ha + PSB @ 5kg/ha, T₆-75% NPK + FYM @ 10t/ha + AZO @ 5kg/ha, T₇-75% NPK + FYM @ 10t/ha + AZO@ 5kg/ha+ PSB @ 5kg/ha, T₈-PSB @ 5kg/ha+ AZO@ 5kg/ha+ 75% P&N +100% K. The experiment was laid out in randomized block design with eight treatments and three replications. All recommended package of practices were followed to raise a good crop. Data on various vegetative and flowering attributes *viz.*, plant height (cm), number of primary and secondary branches and stem girth (cm), length of primary branches (cm), leaf area (cm²), days to bud initiation, days to flowering, days to 50% and 100% flowering, numbers of flowers per plant, flower diameter (cm), flowering duration (days), fresh weight and dry weight of flowers (g), shelf life of flowers (days), flower yield per plant (g), per plot (kg) and per hectare (t) were recorded and analysed statistically.

Results and Discussion

Effect of INM on vegetative parameters of African marigold

The application of 75% of recommended dose of NPK along with FYM and bio-inoculants had a significant effect on vegetative parameters of marigold (Table 1). The treatment T₇ (75% NPK + FYM @ 10t/ha + AZO @ 5kg/ha + PSB @ 5kg/ha) recorded maximum plant height (84.85 cm), maximum number of primary and secondary branches (10.03 and 29.55 respectively) and maximum stem girth (4.57 cm). However, minimum plant height and stem girth was observed under T₂ (PSB @ 5kg/ha + 75% P + 100% N & K) while T₄ (75% NPK + FYM @ 10t/ha) recorded minimum number of primary and secondary branches. Beneficial effect of biofertilizers and FYM in combination with

75% recommended dose of inorganic fertiliser might have resulted in the accumulation of more N in soil and more N uptake by the plants which might have resulted in maximum plant height. Similar findings have been reported by Majumdar *et al.*, (2014) in gladiolus, Airadevi *et al.*, (2012) in garland chrysanthemum; Gotmare *et al.*, (2007) and Patel *et al.*, (2017) in marigold. Maximum number of primary branches may be due to the effect of optimum level of NPK, biofertilizers and FYM which leads to increased level of nutrients to plant which might have enhanced the cell division and cell elongation and increase in metabolic activities in the plants. Further, it might have resulted in breaking of apical dominance and thus sprouting of axillary buds leading to more number of primary branches per plant. Similar findings have also been reported by Gotmare *et al.*, (2007), Kumar *et al.*, (2009) and Mittal *et al.*, (2010) in marigold. Increase in stem girth and more number of secondary branches may be due to the effect of biofertilizers which produce the growth promoting substances such as IAA, gibberellins which enhances the soil fertility with balanced dose of inorganic fertilizers which ultimately influences increase growth and development. Similar findings were observed by Mittal *et al.*, (2010), Gotmare *et al.*, (2007) and Kumar *et al.*, (2009) in marigold. Length of primary branches was highest (50.82 cm) under T₁ (RDF) which was at par with T₇ (75%NPK+FYM+AZO+PSB) and T₆ (75%NPK+FYM+AZO). It may be due to immediate availability of nutrients to plants through chemical fertilizer. Increase in length of primary branches in treatments involving reduced doses of chemical fertilizers along with organic fertilizers might be attributed to the beneficial effect of biofertilizers which enhanced the process of cell division and cell elongation, which in turn might have encouraged the increase in length of primary branches. Similar findings have been reported

by Gotmare *et al.*, (2007) in marigold. Maximum leaf area (30.25 cm²) was observed in T₈ (PSB +AZO+75% P&N+100% K) whereas it was found to be minimum in T₄ (75% NPK+FYM). This might be due to influence of *Azospirillum* which fixes the additional dose of nitrogen from the atmosphere, the chief constituent of protein essential for formation of protoplasm, which enhances the cell division and cell enlargement. PSB solubilize the fixed phosphorus in soil and helps in secretion of growth substances like auxins which enhances the better growth and development of plant. It is in conformity with the findings of Kumar *et al.*, (2009) in African marigold and Naik *et al.*, (2014) in carnation.

Effect of INM on floral parameters of African marigold

The different treatment combination of inorganic and organic fertilizers had significantly influenced the floral parameters (Table 2). Earliest bud initiation, earliest flowering (31.89 days and 46.25 days, respectively) and maximum number of flowers per plant (34.40) were recorded under treatment T₇ (75% NPK + FYM @ 10t/ha + AZO @ 5kg/ha+ PSB @ 5kg/ha). However, maximum delay in bud initiation and flowering was recorded in plants treated with T₈ (PSB @ 5kg/ha+ AZO @ 5kg/ha+ 75% P&N +100% K) while minimum number of flowers per plant was recorded in T₃ (AZO+75%N+100% P&K). Early bud initiation and flowering may be due to combined application of inorganic and organic fertilizers which led to amplification of nutrients especially nitrogen, phosphorus and potassium from FYM as well as recommended dose of inorganic fertilizers which prompted the translocation of phytohormones to shoots resulting in early bud initiation. *Azospirillum* and PSB might have indirect role which makes the nutrient readily available along with

the presence of plant growth promoting substances which might have led to early flowering through better uptake of nutrients, thereby, plant completed its vegetative growth soon, resulting in early flowering.

These findings are in conformity with the findings of Kumar *et al.*, (2011) in gladiolus, Naik *et al.*, (2014) in carnation and Khanna *et al.*, (2016) in china aster. Highest number of flowers per plant might be due to the indirect effect of the more number of branches developed by the influence of inorganic fertilizers along with organic manures and biofertilizers like PSB and *Azospirillum*. More number of branches resulted in more photosynthesis due to more number of leaves with enhanced food accumulation which might have resulted in better growth and subsequently higher number of flowers per plant. Similar findings have been reported by Kumar *et al.*, (2009) in African marigold and Verma *et al.*, (2011) in chrysanthemum.

Application of T₅ (75% NPK + FYM + PSB) recorded minimum days to 50% and 100% flowering (50.51 days and 54.57 days, respectively) and maximum flower diameter

(4.87 cm) while maximum delay in 50% and 100% flowering was recorded under T₈ (PSB +AZO + 75% P&N + 100% K) and minimum flower diameter under T₆ (75% NPK + FYM + AZO). Earliness in 50 % and 100 % flowering might be due to combined effect of biofertilizers and inorganic fertilizers which led to altered C: N ratio which helped in balanced management of vegetative and reproductive phases and promote early flowering.

Ultimately they resulted in better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. Similar findings have been reported by Thumar *et al.*, (2013) in marigold and Naik *et al.*, (2014) in carnation. Increased flower diameter might be due to combined effect of organic and inorganic fertilizers. PSB possess the ability to bring sparingly insoluble inorganic or organic phosphates into soluble form by secreting organic acids which can also contribute to improving flower diameter. Similar findings were reported by Kumar *et al.*, (2009), Thumar *et al.*, (2013) and Patel *et al.*, (2017) in African marigold.

Table.1 Effect of integrated nutrient management on vegetative parameters of African marigold cv. Pusa Narangi Gainda

Treatments	Plant height (cm)	Number of primary branches	Length of primary branches (cm)	Number of secondary branches	Leaf area (cm ²)	Stem girth (cm)
T ₁	82.39	9.20	50.82	24.88	25.00	4.32
T ₂	75.32	8.13	45.16	25.22	24.84	3.47
T ₃	76.46	8.37	46.77	24.22	25.04	3.63
T ₄	77.47	7.93	45.88	24.11	24.28	3.77
T ₅	78.00	9.73	45.47	25.99	27.18	4.36
T ₆	80.33	8.83	49.03	25.55	26.57	4.25
T ₇	84.85	10.03	49.40	26.55	29.17	4.57
T ₈	78.17	8.50	47.62	24.55	30.00	4.10
SEm±	1.46	0.21	1.38	0.72	0.73	0.08
CD (5%)	4.44	0.65	4.20	2.21	2.20	0.24

Table.2 Effect of integrated nutrient management on floral parameters of African marigold cv. Pusa Narangi Gainda

Treatments	Days to bud initiation	Days to flowering	Days to 50 percent flowering	Days to 100 percent flowering	Flower diameter (cm)	Number of flowers/plant	Flowering duration (days)	Fresh weight of flower (g)	Dry weight of flower (g)	Shelf life (hours)
T ₁	32.97	47.05	51.53	56.01	4.50	29.73	44.04	4.35	1.19	59.00
T ₂	34.63	50.63	55.09	59.07	4.17	29.60	43.11	5.04	1.16	58.33
T ₃	33.04	50.09	54.45	58.54	4.37	28.07	45.33	5.73	1.50	60.67
T ₄	34.44	50.89	55.36	59.76	4.30	31.17	45.00	4.96	1.07	62.33
T ₅	33.89	46.92	50.51	54.57	4.87	32.07	43.82	4.58	1.12	64.00
T ₆	34.07	48.45	52.77	56.77	4.10	32.63	46.22	5.55	1.36	70.67
T ₇	31.89	46.25	51.22	55.33	4.67	34.40	45.66	5.25	1.23	68.00
T ₈	35.08	51.01	55.82	59.78	4.80	29.10	43.44	4.33	1.03	69.33
SEm±	0.56	0.60	0.57	1.30	0.08	0.61	0.52	0.16	0.04	1.29
CD (5%)	1.27	1.83	1.73	3.95	0.26	1.81	1.59	0.49	0.13	3.93

Table.3 Effect of integrated nutrient management on yield and economics of African marigold cv. Pusa Narangi Gainda

Treatments	Flower yield/plant (g)	Flower yield/plot (kg)	Flower yield/ ha (t)	Total cost of production (Rs.)	Gross return (Rs.)	Net return (Rs.)	Benefit : Cost
T ₁	127.19	1.91	13.62	1,08,358.00	2,72,448.00	1,64,090.00	2.51
T ₂	125.38	1.88	13.43	1,06,539.00	2,68,557.00	1,62,017.00	2.52
T ₃	128.10	1.92	13.72	1,08,642.00	2,74,390.00	1,65,748.00	2.53
T ₄	127.67	1.92	13.67	1,20,206.00	2,73,462.00	1,53,256.00	2.27
T ₅	136.50	2.05	14.62	1,20,806.00	2,92,383.00	1,71,577.00	2.42
T ₆	142.48	2.14	15.26	120,806.00	3,05,185.00	1,84,379.00	2.53
T ₇	145.03	2.18	15.53	1,21,406.00	3,12,200.00	1,90,794.00	2.57
T ₈	128.10	1.92	13.72	1,06,813.00	2,71,540.00	1,64,727.00	2.54
SEm±	4.554	0.07	0.49				
CD (5%)	13.78	0.20	1.47				

Maximum flowering duration (46.22 days) and longest shelf life (70.67 hrs.) was reported in plants treated with T₆ (75% NPK + FYM + *Azospirillum*) while they were minimum in T₂ (PSB + 75% P + 100% N&K). Maximum flowering duration may be due to combined application of inorganic fertilizers along with organic and biofertilizers. It might be ascribed to easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinins to the axillary buds resulting in breakage of apical dominance.

Ultimately they resulted in better sink for faster mobilization of photosynthates. Similar findings have been reported by Palagni *et al.*, (2013) in chrysanthemum and Chaudhary *et al.*, (2013) in gladiolus.

Increased shelf life may be due to optimum food nutrient availability from different organic and inorganic sources which might have resulted in greater development of water conducting tissue with high level of water retention in the cells of flowers thereby lowering the desiccation. Similar findings have been reported by Khanna *et al.*, (2016) in china aster and Verma *et al.*, (2011) chrysanthemum. The fresh and dry weight of flowers were found to be maximum (5.73 g and 1.50 g, respectively) under T₃ (AZO+75% N+100% P&K) while they were minimum in treatment T₈ (PSB+AZO+75% P&N+100% K).

This might be due to the presence of ammonium from two different sources *viz.*, *Azospirillum* and chemical fertilizer which might have participated in higher protein synthesis and thus improved the vegetative growth, dry matter accumulation and partitioning of nutrients towards the developing flower buds. Similar findings have been reported by Kumar *et al.*, (2009) in African marigold and Sarwa *et al.*, (2014) in petunia.

Effect of INM on yield of African marigold flowers

Maximum flower yield per plant, per plot and per hectare (145.03 g, 2.18 kg and 15.53 t, respectively) was obtained in T₇ (75% NPK + FYM + AZO + PSB) whereas minimum results for these parameters were found in T₂ (PSB + 75% P + 100% N&K). It might be due to the fact that bio-fertilizers enhance growth promoting substances such as IAA, gibberellins like substances, vitamins, riboflavins etc. which might have enhanced the soil fertility. Bio-fertilizer when applied with organic and inorganic fertilizers has increased the availability of essential plant nutrients which might have enhanced root and shoot development thereby increasing the growth and yield. Thereafter it might have influenced the reproductive phase and induced flowering which resulted in increased number of flower yield per plant, per plot and per hectare. Similar findings has been reported by Mittal *et al.*, (2010), Thumar *et al.*, (2013) and Patel *et al.*, (2017) in African marigold and Airadevi *et al.*, (2012) in garland chrysanthemum.

Effect of INM on economics of African marigold flowers

The cost of production of marigold in the present investigation ranged from Rs. 1,06,539 (T₂) to Rs. 1,21,406 in T₇ whereas the net return varied from Rs. 1,62,017 (T₂) to Rs.1,90,794 (T₇). The maximum benefit cost ratio (2.57) was obtained in T₇ (75% NPK+FYM+AZO+PSB) which might be due to production of maximum number of quality flower under this treatment, fetching better price thus increasing net return as compared to other treatments.

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