

Research Article

Effect of NPK, Biofertilizers and Plant Spacings on Growth and Yield of African Marigold (*Tagetes erecta* Linn.)Manoj Kumar Rolaniya*¹, S.K. Khandelwal¹, Sunita koodi¹, Saroj R. Sepat², and A. Choudhary³¹Department of Horticulture, Sri Karan Narendra Agriculture University, Jobner, Rajasthan – 303329, India²Defence Research and Development organization, New Delhi – 110054, India³Department of Floriculture and Landscaping, CH&F, Jhalrapatan, Jhalawar, Rajasthan -326023, India**Abstract**

A field experiment was conducted during winter season of 2014-15 to study the effect of NPK, biofertilizers and plant spacings on growth and yield of African marigold. Application of 100% RDF of NPK + Azotobacter + PSB gave significantly higher values of plant height (82.75 cm), number of primary branches per plant (16.18 cm), plant spread of 68.54 cm in E-W direction to 62.22 cm in N-S direction, duration of flowering (68.01 days), chlorophyll content in leaves (2.56 mg/g), flower yield (184.13 q/ha) and took minimum days to appearance of first flower (54.11). The spacing registered significantly linear reduction in plant height from closest spacing at 45 x 45 cm (78.55 cm), appearance of first flower (60.51 days), duration of flowering (58.51 days) and maximum primary branches per plant (16.55).

Maximum plant spread E-W (60.15 cm) and N-S (56.85 cm), chlorophyll content in leaves (2.55 mg/g) and maximum flower yield ha (126.73 q) were observed in wider spacing i.e. 60×60 cm followed by 60×45 cm.

Keywords: African marigold, NPK, biofertilizers and plant spacing

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Introduction

African marigold (*Tagetes erecta* L.) belongs to family Asteraceae is a very popular commercial flower crop as loose flower in India because of its wider adaptability to various soils and climatic conditions, easy cultivation, profuse flowering habit, short duration to produce marketable flowers and good keeping quality. It is an established fact that nutrition plays an important role in the improvement of growth and yield of marigold. Nutrients directly affect the vegetative growth and yield of crop. Adequate supply of nutrients especially N, P and K are often considered important for realizing the maximum yield of any crop.

Nitrogen is the chief constituent of several important elements like protein, nucleic acid and amino acids occurring in the plants. An adequate supply of nitrogen is associated with higher photosynthetic activity, vigorous vegetative growth, dark green color and carbohydrate utilization. It is unequivocal that nitrogen is an essential element required by all the plants, however it is found to be deficient in most of the Indian soils (Arakeri *et al.*, 1956) [1] especially in soils of Rajasthan. Phosphorus is also a major nutrient required by the crops. It is indispensable constituent of nucleic acid, phospholipids and several enzymes. The most essential function of phosphorus in a plant is energy storage and transfer for proper metabolism. Potassium is not a constituent of any plant tissue or compounds but it is involved in the synthesis of amino acids. It imparts vigor and disease resistance to plants. It also regulates water loss from the plant by maintaining the balance between anabolism, respiration and transpiration. Bio-fertilizers play an important role in increasing availability of nutrients and productivity in sustainable manner. Azotobacter is a free-living bacterium which may add 25-30 kg nitrogen/ha/year in a field of non-legume crop under favorable conditions and also secretes some growth promoting substances. Spacing plays an important role for manipulating plant growth, flowering behavior and seed yield. Inter row and intra row spacing and balanced supply of nutrients are important for obtaining higher yield of good quality seeds (Sunitha *et al.*, 2007) [2]. Therefore, the present study was undertaken with the objectives; to find out the optimum spacing between plants and to see the effect of NPK and biofertilizers on growth and yield of African marigold.

Materials and Methods

Present study was carried out at the experimental farm of Department of Horticulture, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) during *rabi* season, 2014-15. Jobner is situated 45 km west of the Jaipur at 75°28' East longitude and 26°05' North latitude at an altitude of 427 meters above mean sea level. The climate of this region is typically semi-arid characterized by aridity of the atmosphere, scarcity of water with extremity of temperature both during summer and winter. The maximum temperature touches around 45.5°C during May and June, while in December and January it falls below 1°C. The average rainfall varies between 400-500 mm, most of which is received during rainy season from July to September. To ascertain physico-chemical characteristics of soils, soil samples were collected from different spots of the experimental field before sowing up to 30 cm depth and a representative homogeneous sample was prepared after drying, mixing, grinding and sieving all the soil samples together. The sample was analyzed for various chemical and physical characteristics of soil. The treatments consists of seven levels of fertility and three levels of biofertilizers, thereby making 21 treatment combinations, which were replicated thrice in the randomized block design with factorial approach. Randomization of treatments was done with the help of random number table (Fisher, 1950) [3]. Five week old seedlings, having 5-7 true leaves and almost uniform in size and vigour were transplanted at different spacings, i.e. 45x45cm, 60x45cm and 60x60 cm in the plots of 3.60x1.8 sq meter size in the evening hours. Before transplanting, the seedlings were treated with biofertilizers (Azotobacter and PSB) according to the treatments for 30 minutes. For preparation of biofertilizer solution, 30 g of jaggery was boiled in half liter of water and then cooled; 50 g of culture was mixed in jaggery solution. The roots of seedlings were thoroughly dipped in the culture solution to inoculate with Azotobacter and PSB for 30 minutes and transplanted immediately. Light irrigation was applied immediately after transplanting of seedlings. Full dose of phosphorus through single super phosphate and potash through muriate of potash were applied just before transplanting of seedlings according to the treatment combinations. Nitrogen through urea was applied in two split doses, i.e. first ½ dose of total nitrogen was applied at the time of transplanting of seedlings and remaining dose was applied at 30 days after transplanting as top dressing. Five plants were selected randomly from each plot and tagged for recording the observations.

The observations on plant height, number of primary branches, plant spread, chlorophyll content, duration of flowering, days taken to appearance of first flower and yield /ha were recorded. Total chlorophyll content in leaves was estimated at 60 days after transplanting with the method as recommended by Arnon (1949) [4]. Fifty milligram bits of leaves were weighed for each treatment and were rapidly crushed and homogenized with 5 ml of 80 per cent acetone in mortar with the help of pestle. The homogenate was centrifuged at 2000 rpm for 10 minutes and the volume was made up to 10 ml. The optical density was read at 645 nm and 663 nm using 80 per cent acetone as blank on spectrophotometer. Total chlorophyll content in leaves was calculated by the following formula:

$$\text{Total chlorophyll (mg/g)} = \frac{20.2 (A_{645}) + 8.02 (A_{663})}{1000 \times W} \times V$$

A = Absorbance at specific wave lengths, V = Final volume of chlorophyll extract in 80% acetone solution, W = Fresh weight of bits of leaves extracted.

In order to evaluate the effect of different treatments on vegetative growth and yield characters, the data were statistically analyzed using "Analysis of variance test". The critical difference at 5% level of significance was calculated to find out the significance of different treatments over each other (Panse and Sukhatme, 1989) [5].

Results and Discussion

Vegetative parameters

Growth characters differed significantly for the various levels of NPK, biofertilizers and plant spacings (**Table 1**). Maximum plant height (82.75 cm), number of primary branches per plant (16.18 cm), chlorophyll content in leaves (2.56 mg/g) and plant spread of 68.54 cm in E-W direction and 62.22 cm in N-S direction were recorded with the application of 100% RDF of NPK + Azotobacter + PSB, while the minimum plant height (53.81cm), number of primary branches per plant (8.97), chlorophyll content in leaves (2.32 mg/g) and plant spread of 43.95 cm in E-W direction and 42.74 cm in N-S direction were recorded with control. The positive effect of nutrients supplied through

NPK fertilizers on vegetative growth parameters could be described to its effectiveness in providing a balanced nutritional environment favourable both in soil rhizosphere and in plant system (Baboo and Singh, 2003) [6]. Azotobacter and PSB in combined inoculation mutually benefitted each other by supplying essential nutrients for their proper activity. Hence, their combined inoculation in this experiment produced better effect on growth parameters. These findings are in conformity with the findings of Kumar *et al.* (2006) [7] and Syamal *et al.* (2006) [8] in marigold and Praneetha *et al.* (2007) [9] in tuberose. Maximum plant height (78.55 cm) was recorded with closest spacing i.e. 45x45 cm, whereas the maximum number of primary branches per plant (16.55), plant spread E-W (60.15 cm) and N-S (56.85 cm) and chlorophyll content in leaves (2.55 mg/g) were observed in wider spacing of 60x60 cm. Minimum plant height (63.45 cm) was recorded with 60 x 60 cm spacing, whereas the minimum chlorophyll content in leaves (2.36 mg/g) and number of primary branches per plant (10.45), plant spread E-W (55.91 cm) and N-S (53.12 cm) were recorded with 45x45 cm spacing. More plant height at closer spacing might be due to heavy competition between plants for light, which resulted in elongation of main stem and also might be due to the fact that the plants tend to grow vertically when they are crowded owing to shadowing effect of the plants on one another. The results are in conformity with the findings of Balachandra *et al.* (2004) [10] in ageratum and Srivastava *et al.* (2005) [11] in marigold. The increased number of primary branches and plant spread may be attributed to the availability of more space for growth of roots and shoots as well as utilization of more nutrients by the plants and less competition among the plants for available resources in wider spacing. These results are in accordance with the findings of Sunitha *et al.* (2007) [2] and Singh *et al.* (2008) [12] in marigold.

Table 1 Effect of NPK, biofertilizers and plant spacing on vegetative characters of African marigold

Treatment	Plant height (cm)	Number of primary branches per plant	Plant spread (cm)		Chlorophyll content (mg/g)
			E-W	N-S	
Fertility levels					
Control	53.81	8.97	43.95	42.74	2.32
50% RDF of NPK	61.11	10.99	50.14	47.96	2.40
50 % RDF of NPK + Azotobacter + PSB	66.58	12.32	54.94	52.86	2.45
75 % RDF of NPK	71.50	13.56	59.46	57.18	2.51
75 % RDF of NPK + Azotobacter + PSB	75.92	14.69	63.82	61.38	2.54
100 % RDF of NPK	79.29	15.48	66.55	61.66	2.55
100 % RDF of NPK + Azotobacter + PSB	82.75	16.18	68.54	62.22	2.56
SEm+	1.53	0.35	1.57	1.56	0.05
CD at 5%	4.38	0.99	4.49	4.47	0.15
Spacing					
D ₁ (45 x 45 cm)	78.55	10.45	55.91	53.12	2.36
D ₂ (60 x 45 cm)	68.41	12.51	58.54	55.45	2.52
D ₃ (60 x 60 cm)	63.45	16.55	60.15	56.85	2.55
SEm+	1.00	0.23	1.03	1.02	0.03
CD at 5%	2.87	0.65	2.94	2.93	0.10

Floral parameters

Yield characters also differed significantly for the various levels of NPK, biofertilizers and plant spacings (**Table 2**). Minimum days taken to appearance of first flower (54.11), maximum duration of flowering (68.01 days) and highest flower yield per ha (184.13 q) were observed with 100% RDF of NPK + Azotobacter + PSB, whereas maximum days taken to appearance of first flower (59.67), minimum duration of flowering (48.02 days) and minimum flower yield per ha (64.83q) were observed in control. Plants sown at 60x60cm spacing took minimum days to appearance of first flower (52.52 days), had longest duration of flowering (62.11) and produced maximum flower yield per ha (126.73q), whereas maximum days taken to appearance of first flower (60.51), minimum duration of flowering (58.51 days) and lowest flower yield per ha (110.39q) were observed at 45 x 45 cm. The positive effect of nutrients supplied through NPK fertilizers and inoculation of biofertilizers on flowering behaviour might be ascribed the fact that nitrogen accelerate the development of reproductive phases, increases the protein synthesis and hence promotes the earlier floral primordial development in marigold (Acharya and Dashora, 2004) [13]. Phosphorus is a component of many

energy rich compounds in plant and also increases entire root growth and helps in uptake of other nutrients resulting in increase in yield (Singh *et al.*, 2015) [14]. Potassium increases the rate of photosynthesis (Lauchli and Pfluger, 1978) [15] and mobilization of sucrose to the shoots which have positive influence on flower initiation (Stockman *et al.*, 1983) [16]. These findings are in close agreement with finding of Sharma *et al.* (2006) in chrysanthemum [17]. Azotobacter and PSB are reported to produce growth promoting substances and other acids like acetic, formic, glycolic, fumaric and succinic, which were positively correlated with growth and flowering and helps in branching and development of side buds thus increased early flowering (Wange and Patil, 1994) [18]. The results are in consonance with Mittal *et al.* (2010) [19] in marigold. It might be due to more leaf area; ultimately increased photosynthetic activity and accumulation of carbohydrates in the flowers, Deshmane *et.al* (2012) [20] in marigold.

Table 2 Effect of NPK, biofertilizers and plant spacing on yield parameters of African marigold

Treatments	Days taken to appearance of first flower	Duration of flowering (days)	Yield/ha (q)
Fertility levels			
Control	59.67	48.02	64.53
50% RDF of NPK	56.77	53.24	88.33
50 % RDF of NPK + Azotobacter + PSB	56.05	57.72	112.73
75 % RDF of NPK	55.25	62.01	139.59
75 % RDF of NPK + Azotobacter + PSB	54.63	66.23	158.40
100 % RDF of NPK	54.52	67.26	172.55
100 % RDF of NPK + Azotobacter + PSB	54.11	68.01	184.13
SEm+	1.32	1.41	3.22
CD at 5%	3.78	4.02	9.21
Spacing			
D ₁ (45 x 45 cm)	60.51	58.51	110.39
D ₂ (60 x 45 cm)	54.54	60.45	157.29
D ₃ (60 x 60 cm)	52.52	62.11	126.73
SEm+	0.87	0.92	2.11
CD at 5%	2.47	2.63	6.03

Conclusion

On the basis of results obtained in present investigation, it may be concluded that application of NPK, biofertilizers and plant spacings enhanced the growth and flower yield in marigold. A comparison of various treatments taken for study revealed that application of 100 % RDF of NPK + Azotobacter + PSB ha⁻¹ registered a significant higher values of growth and flower yield in marigold. Also concluded that 60x45 cm significantly higher values of flower yield.

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