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Effect of nitrogen and phosphorus nutrition on growth, flowering, flower yield and chlorophyll content of different varieties of African marigold (*Tagetes erecta* L.)

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Abstract

A field experiment was conducted to study the effect of N and P_2O_5 nutrition on growth, flowering, yield and chlorophyll content of different varieties of African marigold on the medium black calcareous soil during two consecutive years. The treatments consisted of all combination of three levels of nitrogen (100, 150 and 200 kg N ha^{-1}) and three levels of phosphorus (50, 100 and 150 kg P_2O_5 ha^{-1}) with three varieties of African marigold *viz*., Local Orange (V_1), Pusa Basanti (V_2) and Pusa Narangi (V_3). The growth parameters like plant height, number of primary and secondary branches as well as leaf area exhibited increasing trend with increase in nitrogen level which were highest at N_3 (200 kg N ha^{-1}). The phosphorus application failed to influence the growth of plant except plant spread. The maximum total chlorophyll content, 1.452 and 1.431 mg g^{-1}, respectively was found due to addition of nitrogen and phosphorus. The higher number of flowers, diameter of flower, number of ray florets per flower and flower yield was recorded at higher level of each nutrient *i.e.* N_3 (200 kg N ha^{-1}), and P_3 (150 kg P_2O_5 ha^{-1}). Number of days to first flower was advanced with increasing levels of N. Variety Pusa Narangi produced the biggest flower diameter (6.20 cm), highest number of flowers per plant (56.34), flower yield (183.0 quintal ha^{-1}), leaf area (13.89 cm^2) and total chlorophyll content (1.432 mg g^{-1}) in leaves. The interaction effect of N and P was found significant for plant spread at 60 DAT and at the end of harvest season. The combination N_3P_3 (200 kg N ha^{-1} and 150 kg P_2O_5 ha^{-1}) recorded maximum plant spread (42.87 and 56.65 cm) at 60 DAT and at the end of harvest season, respectively. Treatment combination N_2P_3 (150 kg N ha^{-1} and 150 kg P_2O_5 ha^{-1}) recorded significantly larger flower diameter (7.79 cm).

Key words: African marigold, chlorophyll content, flower yield, nitrogen, phosphorus, variety

Introduction

African marigold (*Tagetes erecta* L.), a member of the family Asteraceae, is a potential commercial flower that is gaining popularity on account of its easy culture, wide adaptability and increasing demand in the Indian subcontinent. Marigold is grown as an ornamental crop for its flowers which are sold in the market as loose flowers in bulk, as specialty cut flowers or for making garlands. It is also one of the most important natural sources of xanthophylls for use as natural food additive to brighten egg yolkes and poultry skin (Bosma *et al*., 2003). Moreover, it is also being used effectively to dye fabrics commercially, where its ethanol-based flower extracts produce different colour on fabrics (Vankar *et al*., 2009). Proper combinational of fertilizers plays a vital role in production of vigorous plants having maximum number of shoots and leaves, which have positive impact on quality flower production and prolonged flowering period (Ahmad *et al*., 2011). Optimum cultural practices are necessary for quality flower production. Among essential nutrients, nitrogen and phosphorus are most important for plant growth and flowering. These also play a key role in the production of higher flower and seed yield of ornamentals (Mohanty *et al*., 2002). These also enhance the vegetative growth and assist the plant during the blooming period to mobilize the process of flower opening. Flowering can be increased with increased levels of N and P application (Arora and Singh, 1980). In marigold, plant vigour was decreased as the season progressed which was attributed to nitrogen deficiency. On the other hand, improper nutrition, which leads to nutrient imbalance in plants, is major obstacle to the yield of many flowering annuals. The nutrient supply should be adjusted to the specific requirements of plant during various stages of growth to achieve the maximum flower production (Mengel, 1969). Different varieties and plant species have different nutrient requirements and when inappropriate nutrient elements and dosage are used for plant nutrition, some nutritional disorders may occur. A nutritional disorder is a malfunction in the physiology of a plant resulting in abnormal growth caused by either a deficiency or excess of mineral elements (Resh, 1991). Alongwith the the effect of fertilizer dose on yield and quality of marigold flower, the adoption of suitable high yielding varieties also play an important role to maximize flower yield per unit area (Mehta *et al*., 1995; Joshi and Barad, 2002 and Sehrawat *et al*., 2003). Therefore, this study was conducted to standardize the nitrogen and phosphorus requirements and best variety of marigold for optimum growth and higher production of quality flowers.

Materials and methods

Field experiments were conducted on African marigold at Fruit Research Station, Department of Horticulture, Junagadh Agricultural University, Junagadh (21°50' N latitude and 70°50' E longitudes at an elevation of 60 m above mean sea level) during *Rabi* seasons for two consecutive years. A composite soil sample from experimental plot was collected before commencement of the experiment and initial characteristics of the soil were pH 7.8, EC 0.30 dSm^{-1}, organic carbon 0.57%, available nitrogen 145.5 kg ha^{-1}, phosphorus 23.2 kg ha^{-1} and potassium 253.0 kg ha^{-1}. The experiment was laid out in Factorial Randomized Block Design with twenty seven treatment combinations and replicated three times. The treatments consisted of three levels of nitrogen (100, 150 and 200 kg ha^{-1}) and three levels of phosphorus (50, 100 and 150 kg P_2O_5 ha^{-1}) with three varieties of African marigold *viz*., Local Orange (V_1), Pusa Basanti (V_2) and Pusa Narangi (V_3). The seeds of Pusa Narangi and Pusa Basanti variety were procured from seed production unit of Indian Agricultural Research Institute, New Delhi and local variety seeds from instructional farm of Horticulture Department of College of Agriculture, Junagadh. Seeds of these three varieties were sown in nursery raised bed and thirty days old, uniform and healthy seedlings were transplanted at 45 x 45 cm spacing on 20th October in both the years of experiment. Immediately after transplanting, a light irrigation was given for better establishment of seedlings in the field. Farmyard manure (FYM) was applied at the rate of 10 tones per hectare to all the plots uniformally and incorporated into the soil at the time of field preparation. Fertilizer application was done as per the treatment allocation. In all cases, half the dose of nitrogen in the form of urea (46% N) was applied as basal application and remaining half dose at 30 DAT. The entire dose of phosphorus as single superphosphate (18% P_2O_5) was applied at the time of transplanting. Potassium was applied uniformally to all the plots at the rate of 90 kg per hectare in the form of muriate of potash (60% K_2O) at transplanting. The fertilizers were applied with 'broadcasting' and 'incorporation' method for basal application whereas; top dressing of urea was carried out by 'ring' method. Data were recorded at 60 DAT and end of harvest season for plant height, number of primary and secondary branches and plant spread. Leaf area and total chlorophyll content of leaves (Arnon, 1949) were recorded at full bloom stage. Number of flowers per plant and fresh flower yield was recorded by summing of all picking. Data were analyzed statistically in each year and pooled as per method given by Panse and Sukhatme (1985).

Results and discussion

Effect on growth parameters: Data presented in Table 1 indicated increasing trend in plant growth parameters with increasing levels of nitrogen at 60 DAT and at end of harvest season. The significantly highest plant height (53.97 and 81.71 cm), number of primary branches (5.96 and 6.52), number of secondary branches (16.34 and 17.64) per plant and plant spread (38.79 and 53.10 cm) were recorded in 200 kg N ha^{-1} treatment at 60 DAT and at the end of harvest season, respectively, while lowest dose of nitrogen (100 kg ha^{-1}) showed least value for plant growth parameters at both the stages. This might be due to the positive role of nitrogen in cell division as well as in protein synthesis, which ultimately enhanced quick and better vegetative growth. These results are in conformity with the findings of earlier workers in which they recorded the highest plant height under highest level of nitrogen in marigold (Jamod, 2001; Joshi and Barad, 2002; Sehrawat *et al.*, 2003). Significant improvement in number of branches per plant was reported by Avari (1993) in same crop with application of 200 kg N ha^{-1}. Maximum leaf area (14.75 cm^2) and total leaf chlorophyll content (1.452 mg g^{-1}) were recorded with 200 kg N ha^{-1} (N_3). Phosphorus application affected plant spread and total leaf chlorophyll content while other plant growth parameters remained unaffected. This indicates that phosphorus requirements of marigold for plant growth can be satisfied with 150 kg P_2O_5 ha^{-1}. Among different varieties, plant height and plant spread were not influenced at both the stages whereas number of primary (6.29) and secondary branches (16.80) per plant at the end of harvest season, leaf area (13.89 cm^2) as well as chlorophyll content (1.432 mg g^{-1}) recorded highest in Pusa Narangi variety, respectively while local variety (V_1) recorded lowest value for the same. This might be due to variation in the genetic structure and capabilities of the cutivars. The results are in concurrence with those reported by previous

Table 1. Effect of nitrogen and phosphorus on growth parameters and total chlorophyll content of different varieties of African marigold (two years pooled data)

Treatments	Plant height (cm)		Primary branches		Secondary branches		Plant spread (cm)		Leaf area (cm^2)	Total leaf chlorophyll content (mg g^{-1})
	60 DAT	At final harvest	60 DAT	At final harvest	60 DAT	At final harvest	60 DAT	At final harvest		
N- Nitrogen (kg ha^{-1})										
100 (N_1)	49.87	76.79	5.19	5.83	14.19	15.22	33.86	50.01	11.60	1.243
150 (N_2)	51.58	78.99	5.68	6.29	15.41	16.32	36.43	52.17	12.88	1.365
200 (N_3)	53.97	81.71	5.96	6.52	16.34	17.64	38.79	53.10	14.75	1.452
S.Em. ±	0.55	0.65	0.06	0.05	0.14	0.14	0.56	0.50	0.23	0.009
C.D. at 5 %	1.56	1.84	0.18	0.15	0.40	0.39	1.58	1.42	0.64	0.026
P- Phosphorus (kg ha^{-1})										
50 (P_1)	50.92	78.52	5.60	6.18	15.16	16.21	34.10	50.15	12.66	1.277
100 (P_2)	52.09	78.79	5.62	6.21	15.19	16.32	36.07	51.80	13.20	1.352
150 (P_3)	52.41	80.19	5.62	6.25	15.60	16.64	38.90	53.32	13.38	1.431
S.Em. ±	0.55	0.65	0.06	0.05	0.14	0.14	0.56	0.50	0.23	0.009
C.D. at 5 %	NS	NS	NS	NS	NS	NS	1.58	1.42	NS	0.026
V- Variety										
Local Orange (V_1)	50.85	78.26	5.50	6.10	14.89	15.93	35.53	50.84	12.29	1.264
Pusa Basanti (V_2)	52.16	79.77	5.59	6.24	15.44	16.44	36.50	51.87	13.05	1.364
Pusa Narangi(V_3)	52.41	79.46	5.75	6.29	15.62	16.80	37.05	52.56	13.89	1.432
S.Em. ±	0.55	0.65	0.06	0.05	0.14	0.14	0.56	0.50	0.23	0.009
C.D. at 5 %	NS	NS	0.18	0.15	0.40	0.39	NS	NS	0.64	0.026
C.V. %	8.83	6.83	9.42	7.21	7.63	6.99	12.78	8.04	14.44	5.63

DAT- Days after transplanting

workers on African marigold (Mehta *et al.*, 1995; Singh *et al.*, 2003; Khanvilkar *et al.*, 2003).

Effect on flowering, flower quality and yield parameters: The commencement of flowering in marigold was significantly delayed by the application of nitrogen (Table 2). The earliest flowering (54.98 days) was observed with 100 kg N ha^{-1}. This can be attributed to the effect of nitrogen in prolongation of vegetative growth of plants. The phosphorus levels failed to influence the earliness of flowering. Variety Pusa Narangi produced earliest flowering (55.04 days) which was statistically at par with variety Pusa Basanti. Application of nitrogen and phosphorus at higher level significantly increased the duration of flowering (50.07 and 49.58 days, respectively). The variety Pusa Basanti recorded longest (49.82 days) duration of flowering followed by variety Pusa Narangi. In present case, the nitrogen at higher levels might have favoured the amino acid metabolism at the expense of carbohydrate metabolism resulting in delayed days to first flowering. These results are in close accordance with those reported by Arora and Khanna (1986), who observed delay in flowering with increasing nitrogen application rates from 0 to 40 g m^{-2}. Similar results were obtained by Mohanty *et al.* (2002) and Sehrawat *et al.* (2003) in marigold.

It is evident from the data (Table 2) that diameter of flower was significantly influenced by N, P_2O_5 and variety. Application of nitrogen and phosphorus each at 150 kg ha^{-1} produced highest flower diameter (6.41 and 6.73 cm, respectively). Variety Pusa Narangi produced the highest flower diameter (6.20 cm) which was at par with variety Pusa Basanti. Similar results were also obtained by Sharma *et al.* (1996) and Singh *et al.* (2003). Addition of nitrogen at 200 kg N ha^{-1} significantly increased the number of ray florets per flower (156.9). The number of ray florets can be considered as good indicators of flower quality. The wider the ratio of ray: disc florets, the higher the quality of flower in terms of doubleness. Anuradha *et al.* (1990) also reported significant increase in number of ray florets per flower with increasing N application from 0 to 90 kg ha^{-1} in marigold. Resembling trend was also observed with phosphorus application where 150 kg P_2O_5 ha^{-1} gave significantly higher number of ray florets (153.9) as compared to 50 and 100 kg P_2O_5 ha^{-1}. The variety Pusa Narangi produced significantly the highest (149.4) number of ray florets which was at par with variety Pusa Basanti (147.9).

Addition of nitrogen at 200 kg N ha^{-1} produced significantly highest number of flowers per plant (59.54) as well as recorded significantly the highest flower yield (200.4 quintal ha^{-1}). The phosphorus though failed to cause significant influence on production of number of flowers per plant; however maximum flower yield (180.0 quintal ha^{-1}) was recorded at 150 kg P_2O_5 ha^{-1}. The flower act as a sink for assimilates produced in other plant parts (source). An abundant supply of nitrogen at higher level might have accelerated the photosynthetic activities of plants and, thus, more assimilates might have been available to the flowers resulting in increased flower weight per plant as well as the yield. Application of 200 kg N ha^{-1} significantly increased the yield parameters in African marigold (Jamod, 2001; Joshi and Barad, 2002). The variety Pusa Narangi produced significantly higher number of flowers per plant as well as flower yield (56.34 and 183.0 quintal ha^{-1}), respectively as compared to other varieties.

Interaction effect: Among the various parameters studied, the

Table 2. Effect of nitrogen and phosphorus on flowering, flower quality and yield parameters of different varieties of African marigold (two years pooled data)

Treatments	Days to first flowering	Duration of flowering (days)	Flower diameter (cm)	Ray florets	Flowers per plant	Flower yield (quintal ha^{-1})
N- Nitrogen (kg ha^{-1})						
100 (N1)	54.98	46.17	5.46	135.2	48.30	138.0
150 (N_2)	56.34	47.41	6.41	149.7	53.40	175.0
200 (N_3)	57.23	50.07	6.07	156.9	59.54	200.4
S.Em. ±	0.37	0.56	0.08	1.4	0.54	2.4
C.D. at 5 %	1.05	1.58	0.23	4.0	1.52	6.6
P- Phosphorus (kg ha^{-1})						
50 (P_1)	55.73	45.90	5.32	140.6	52.97	164.0
100 (P_2)	56.11	48.18	5.90	147.2	53.69	169.5
150 (P_3)	56.72	49.58	6.73	153.9	54.58	180.0
S.Em. ±	0.37	0.56	0.08	1.4	0.54	2.4
C.D. at 5 %	NS	1.58	0.23	4.0	NS	6.6
V- Variety						
Local Orange (V_1)	57.50	46.80	5.56	144.5	51.44	160.1
Pusa Basanti (V_2)	56.01	49.82	6.18	147.9	53.45	170.3
Pusa Narangi(V_3)	55.04	47.03	6.20	149.4	56.34	183.0
S.Em. ±	0.37	0.56	0.08	1.4	0.54	2.4
C.D. at 5 %	1.05	1.58	0.23	4.0	1.52	6.6
C.V. %	5.49	9.73	11.36	8.0	8.31	11.4

Table 3. Interaction effect of nitrogen and phosphorus on plant spread and flower diameter of African marigold

Interaction	Plant spread (cm)						Flower diameter (cm)		
	At 60 DAT			At final harvest					
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
N_1	30.86	34.91	35.81	46.97	51.75	51.30	4.69	5.48	6.23
N_2	34.98	36.28	38.03	52.36	52.14	52.02	5.29	6.15	7.79
N_3	36.47	37.03	42.87	51.13	51.50	56.65	5.97	6.07	6.17
S.Em. ±		0.97			0.87			0.14	
C.D. at 5 %		2.74			2.45			0.40	

interaction effects of nitrogen and phosphorus was observed significant only in plant spread and flowers diameter. Remaining all parameters showed non-significant interaction effects. The data (Table 3) indicate that plant spread was significantly influenced by interaction effect of nitrogen and phosphorus in all the stages of growth. The combination N_3P_3 (200 kg N ha^{-1} and 150 kg P_2O_5 ha^{-1}) recorded significantly the maximum plant spread 56.65 and 42.87 cm at 60 DAT and at end of final harvest, respectively. Interactions between nutrients occur when the supply of one nutrient affects the absorption, distribution or functions of another nutrient. Thus, depending upon nutrients supply, interactions between nutrients can either induce deficiencies or toxicities and can modify the growth response (Robson and Pitman, 1983). In case of flower diameter, the treatment combination N_2P_3 (150 kg N ha^{-1} and 150 kg P_2O_5 ha^{-1}) recorded significantly the highest flower diameter (7.79 cm) while, the lowest 4.69 cm flower diameter was observed in N_1P_1 treatment combination. Hameed and Sekar (1999) reported maximum flower diameter with 150 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1} in marigold. Anuradha *et al.* (1990) obtained significantly highest flower yield at 90 kg each of N and P_2O_5 ha^{-1} in marigold.

It can be concluded that the growth, flower quality and yield of all the varieties increased with increasing level of nitrogen and phosphorus, however, flowering was delayed with increasing levels of nitrogen. Variety Pusa Narangi produced maximum yield with high quality flowers when fertilized with 200 kg nitrogen and 150 kg phosphorus per hectare in medium black soil of South Saurashtra agro climatic condition.

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