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EFFECT OF NITROGEN AND PHOSPHORUS ON NUTRIENT CONTENT AND UPTAKE IN DIFFERENT VARIETIES OF AFRICAN MARIGOLD (*TAGETES ERECTA* L.)

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ABSTRACT

The experiment on effects of nitrogen and phosphorus nutrition on African marigold was conducted to ascertain nutrient content and uptake by different varieties. The results revealed that NPK content and uptake of plant was significantly increased in proportion to the supply of their respective element (N at 200 and P at 150 kg ha^{-1}) at all stages of growth except, K content was not influenced by different P rates. The content and uptake of nutrients was decreased with age of plant. The variety Pusa Narangi (V_3) uptake maximum amount of NPK at 90 DAT (full bloom stage) i.e. 72.24, 19.56 and 98.51 kg ha^{-1}, respectively by followed by Pusa Basanti (V_2). The highest phosphorus uptake was recorded with the treatment combination $N_3P_3V_3$ (24.96 and 20.54 kg ha^{-1} at 90 DAT and final harvest stage) which was at par with $N_3P_3V_2$ and $N_2P_3V_2$.

INTRODUCTION

The African marigold (*Tagetes erecta* L.) is hardy flower crops grown throughout the India. It is extensively used on various religious and social functions. It has got considerable choice among the gardeners and flower growers on account of its ease in cultivation, wide adaptability in varying soil and climatic conditions. Flowers are used for making garlands and 'veni'. Sustainable flower production requires optimal fertilizer management to attain a high ornamental value of plant and to reduce production costs (Zhang *et al.*, 2012). Nutrient status of the plants can be a pointer to the response of plant to the fertilization and internal content of the nutrients determine the fertilizer requirements. Nitrogen applied as fertilizer is the main sources used to meet the N requirements of plant growth (Konnerup and Brix, 2010). When used properly, at the correct application rates and at the right time, N contributes to optimal growth. Excessive N fertilization has an adverse effect making leaves a darker green and delaying flowering (Singh *et al.*, 2002 and Gadagi *et al.*, 2004). Phosphorus is also important elements for plant growth and yields. Lack of P nutrition resulted in a low basal root fresh weight and a shorter stem length (Filippelli, 2008; Niedziela *et al.*, 2008 and Joshi *et al.*, 2012). Information about nutrient requirements for marigold production and cultural practices are necessary if fertilizer application rates and the nitrogen and phosphorus ratio are to be optimized. It is critical for growers to know how nutrient uptake relates to marigold flower yield. Therefore, the present experiment was undertaken with an objective to find out the effect of N and P on nutrient content and uptake by different varieties of African marigold.

MATERIALS AND METHODS

A field trial was conducted on medium black calcareous soil of Fruit Research Station, Department of Horticulture, Junagadh Agricultural University, Junagadh during *Rabi* season of two consecutive years, to study the effect of nitrogen and phosphorus on nutrient content and uptake in different varieties of African marigold (*Tagetes erecta* L.). A composite soil sample was taken from the experimental field before the commencement of the experiment from 0-15 and 15-30 cm depth to record physico-chemical properties of the soil. The soil of experimental plot was clayey in texture, calcareous in nature and slightly alkaline in reaction. The soil was moderate in organic carbon, low in available N and P_2O_5 and medium in available K_2O. The experiment was laid out in Factorial Randomized Block Design with twenty seven treatment combinations, replicated three times. The treatments consisted of three levels of N (100, 150 and 200 kg ha^{-1}) and three levels of P (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). Thirty days old, uniform and healthy seedlings were transplanted at 45 x 45 cm spacing on 20th October in both years of experiment. Farmyard manure (FYM) was applied at the rate of 10 tones per hectare to all the plots uniformly and incorporated into the soil before planting of marigold seedlings. Fertilizer application was done as per the treatment allocation. In all cases, half the dose of nitrogen was applied as basal dose at the time of transplanting and remaining half dose was applied one month after transplanting. The entire dose of phosphorus as per the treatments was applied as basal

dose at the time of transplanting. Potassium was applied uniformly to all the plots at the rate of 90 kg per hectare in the form of Muriate of Potash before transplanting. Nitrogen in the form of Urea and phosphorus in the form of Single Superphosphate (SSP) was used. The fertilizers were applied with 'broadcasting' and 'incorporation' method for basal application whereas; top dressing of urea was carried out by 'ring' method. Plant samples were taken at different stages of growth and were oven dried at 60°C up to constant weight and powdered, which was utilized for analysis of various elements. The nitrogen content was determined with micro Kjeldhal's method, P was determined by Vanadomolybdo phosphate yellow colour method and potash by Flame Photometer Method (Jackson, 1967). The data were subjected to statistical analysis of variance according to the method described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Effect of nitrogen on nutrient content and uptake

The N, P and K contents of the plant increased significantly in proportion to the supply of respective levels of nitrogen and phosphorus at 60, 90 DAT and at final harvest (Table 1). Nitrogen, phosphorus and potash content in the plant was decreased with age and increased with increasing nitrogen doses. Application of nitrogen at 200 kg ha^{-1} (N_3) recorded significantly higher NPK content as compared to lower level of nitrogen (N_1 and N_2) at 60 DAT. However, phosphorus content was remained at par with N_2 (150 kg N ha^{-1}) level of nitrogen at 90 days. While, the lowest NPK content was recorded at 100 kg N ha^{-1} (N_1). Similar trend was observed in nitrogen content at 90 DAT. At final harvest stage, each increase in nitrogen level had increased the nutrient content of plant and significantly the highest nitrogen (1.29 %), phosphorus (0.388 %) and potash (1.82 %) content was recorded when nitrogen was applied at 200 kg ha^{-1} (N_3). As per Table 2, the nutrient uptake by plant increased significantly at all the growth stages and that too increasing magnitude as nitrogen application rates increased from N_1 to N_3. Nutrient uptake was maximum under the highest level of nitrogen (200 kg N ha^{-1}) and decreased with the decrease in nitrogen level at 60, 90 DAT and at final harvest stage. A gradual increase of nutrient contents and uptake was recorded with increasing the N fertilizer rate in chrysanthemum (Joshi *et al.*, 2012). This might be due to the fact that both nitrogen and phosphorus improve the K nutrition and enhance the uptake of K by the plant. One peak rate of uptake was observed in respect to nitrogen, phosphorus and potash at peak flowering stage followed by a decline at final harvest stage (Konnerup and Brix, 2010). This reduction could be attributed to the translocation of sugars and nutrients from the leaf and stem to the developing flower parts (Gadagi *et al.*, 2004). This effect of nitrogen can be attributed to the increased root growth due to nitrogen supply. In the responsive zone, increasing nitrogen supply enhances both shoot and root growth. The roots become finer (higher branching) and the surface area increases (Marschner, 1995). With an increase in root surface area as well as volume at a higher level of nitrogen (200 kg ha^{-1}) might have been increased due to greater foliage area. By increasing the photosynthetic activities and cell formation process, nitrogen application at 200 kg N ha^{-1} increased the dry matter content of plant as determined by the dry weight of plant, thereby resulting in greater uptake of nutrients. Anuradha *et al.* (1988) showed that content and uptake of N and P_2O_5 at 30, 60 and 90 DAT increased significantly with increasing levels of nitrogen from zero to 90 kg ha^{-1}. Jamod (2001) also reported that nitrogen content of marigold leaves was increased significantly with increasing the levels of nitrogen (50 to 200 kg ha^{-1}) at 60 and 90 DAT but the reduction was observed in leaf N content at 90 DAT as compared to 60 DAT. These results are also in conformity with Ingawale (1979), Tolman *et al.* (1990) and Yadav *et al.* (1999) in marigold; and Singh *et al.* (2002) in gladiolus.

Effect of phosphorus on nutrient content and uptake

In table 1 the nitrogen and phosphorus content of plant was

Table 1: Effect of nitrogen and phosphorus on nutrient content in different varieties of African marigold (two year pooled data)

Treatments	Nitrogen content (%)			Phosphorus content (%)			Potash content (%)		
	60 DAT	90 DAT	Harvest	60 DAT	90 DAT	Harvest	60 DAT	90 DAT	Harvest
Nitrogen									
N_1	2.56	1.66	1.16	0.673	0.449	0.330	3.13	2.23	1.52
N_2	2.76	1.74	1.20	0.737	0.485	0.364	3.28	2.35	1.69
N_3	2.98	1.86	1.29	0.752	0.490	0.388	3.45	2.55	1.82
SEm ±	0.03	0.01	0.01	0.009	0.004	0.004	0.03	0.03	0.03
CD at 5%	0.08	0.04	0.04	0.024	0.012	0.012	0.09	0.08	0.07
Phosphorus									
P_1	2.70	1.71	1.18	0.634	0.424	0.311	3.22	2.33	1.66
P_2	2.74	1.74	1.20	0.745	0.487	0.373	3.28	2.37	1.67
P_3	2.86	1.81	1.27	0.784	0.511	0.398	3.34	2.43	1.70
SEm ±	0.03	0.01	0.01	0.009	0.004	0.004	0.03	0.03	0.03
CD at 5%	0.08	0.04	0.04	0.024	0.012	0.012	NS	NS	NS
Variety									
V_1	2.73	1.72	1.19	0.713	0.470	0.356	3.25	2.34	1.63
V_2	2.76	1.76	1.23	0.723	0.473	0.359	3.28	2.37	1.68
V_3	2.82	1.78	1.24	0.726	0.480	0.366	3.32	2.42	1.72
SEm ±	0.03	0.01	0.01	0.009	0.004	0.004	0.03	0.03	0.03
CD at 5%	NS	0.04	0.04	NS	NS	NS	NS	NS	NS
CV%	8.42	6.17	8.88	9.96	7.27	9.56	8.46	10.10	12.89

DAT- Days after transplanting

Table 2: Effect of nitrogen and phosphorus on nutrient uptake in different varieties of African marigold (two year pooled data)

Treatments	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potash uptake (kg ha^{-1})		
	60 DAT	90 DAT	Harvest	60 DAT	90 DAT	Harvest	60 DAT	90 DAT	Harvest
Nitrogen									
N_1	53.67	53.82	50.93	14.12	14.59	14.55	65.38	72.05	66.89
N_2	59.02	70.66	54.67	15.76	19.76	16.60	69.95	95.45	76.85
N_3	66.32	78.08	60.51	16.85	20.66	18.19	76.75	107.17	86.65
SEm ±	0.86	0.93	0.75	0.27	0.27	0.23	0.98	1.53	1.03
CD at 5 %	2.41	2.60	2.12	0.76	0.76	0.65	2.77	4.29	2.90
Phosphorus									
P_1	56.63	60.60	51.15	13.30	15.01	13.50	67.53	82.62	72.29
P_2	58.61	66.64	54.85	15.94	18.68	17.06	70.14	90.79	76.12
P_3	63.77	75.33	60.10	17.48	21.32	18.80	74.41	101.27	81.98
SEm ±	0.86	0.93	0.75	0.27	0.27	0.23	0.98	1.53	1.03
CD at 5%	2.41	2.60	2.12	0.76	0.76	0.65	2.77	4.29	2.90
Variety									
V_1	57.06	62.01	51.81	14.94	17.09	15.71	67.86	84.13	72.75
V_2	59.55	68.31	56.16	15.67	18.35	16.44	70.80	92.04	77.10
V_3	62.41	72.24	58.14	16.12	19.56	17.20	73.42	98.51	80.54
SEm ±	0.86	0.93	0.75	0.27	0.27	0.23	0.98	1.53	1.03
CD at 5%	2.41	2.60	2.12	0.76	0.76	0.65	2.77	4.29	2.90
CV%	11.85	11.33	11.23	14.30	12.13	11.65	11.50	13.79	11.09

Table 3: Interaction effect of phosphorus and variety on phosphorus uptake at 90 DAT

	Phosphorus uptake (kg ha^{-1})		
	V_1	V_2	V_3
P_1	13.05	14.82	17.15
P_2	17.73	18.72	19.60
P_3	20.50	21.52	21.94
SEm ±	0.47		
CD at 5 %	1.31		

significantly ($P<0.05$) affected due to phosphorus levels at different growth stages (60, 90 DAT and final harvest). Nutrients content in plant was decreased with age and increased with increasing phosphorus levels. Potash content of plant was not significantly affected due to different phosphorus levels at all the growth stages. The phosphorus at 150 kg P_2O_5 ha^{-1} (P_3) resulted significantly the highest nitrogen and phosphorus content of 2.86 and 0.784 per cent over P_2 and P_1 levels of phosphorus at 60 DAT, respectively. The respective increases were 6.04 and 23.65 per cent over P_1 (50 kg P_2O_5 ha^{-1}) level of phosphorus as per Table 1. Similar trend was recorded in nitrogen and phosphorus content of plant at 90 DAT and at final harvest stage and respective increases in nitrogen and phosphorus content were 5.38 and 20.50 per cent (90 DAT) and 7.83 and 28.01 per cent (at final harvest). Addition of phosphorus to the crop significantly influenced the nutrient uptake at 60, 90 DAT and at final harvest stage. Application of phosphorus at 150 kg P_2O_5 ha^{-1} (P_3) resulted in significant increase in nutrient uptake during all the growth stages. The per cent increase in nitrogen, phosphorus and potash uptake due to application of 150 kg P_2O_5 ha^{-1} (P_3) at final harvest was 17.50, 39.27 and 13.41 over lower level of phosphorus, respectively. Ristvey *et al*. (2007) showed that application of N and P at high rates increased plant nutrient contents and nutrient uptake efficiency in azalea. Joshi *et al*. (2012) revealed that phosphorus at higher level might have increased the absorption of NPK due to increased root density. Further, by exacerbating the photosynthetic activities of plants, phosphorus at higher level resulted in greater plant dry weight. Thus, the increased in absorption of N, P and K with greater dry matter accumulation with higher level of phosphorus ultimately resulted in greater N and P uptake in chrysanthemum. Similar results were found by Ingawale (1979), Anuradha *et al*. (1988), Parkash *et al*. (2002), Singh *et al*. (2002), Filippelli (2008); and Kumar and Misra (2011).

Effect of variety on nutrient content and uptake

The phosphorus and potash content of plant was not affected in different varieties at different growth stages while, nitrogen

Table 4: Interaction effect of nitrogen, phosphorus and variety on phosphorus uptake at 90 DAT and at final harvest

	Phosphorus uptake (kg ha^{-1}) 90 DAT								
	P_1			P_2			P_3		
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
N_1	10.17	11.58	13.41	11.26	15.00	16.02	17.36	18.32	18.23
N_2	13.99	15.68	19.45	21.43	19.89	20.42	21.56	22.78	22.62
N_3	15.00	17.20	18.58	20.50	21.29	22.36	22.57	23.45	24.96
SEm ±	0.81								
CD at 5%	2.27								
Final harvest									
N_1	10.13	11.73	12.55	12.18	15.23	16.60	17.55	17.41	17.57
N_2	11.98	13.35	15.31	18.43	16.82	17.31	18.47	18.96	18.81
N_3	14.55	15.72	16.14	18.49	18.49	19.95	19.57	20.28	20.54
SEm ±	0.70								
CD at 5%	1.95								

content was found significant ($p < 0.05$) at 90 DAT and at final harvest stage. Nitrogen content was significantly maximum (1.78 and 1.24 per cent) in variety Pusa Narangi (V_3) that was 3.16 and 4.59 per cent higher than Local Orange (V_1) variety at 90 DAT and at final harvest, respectively. However, there was no significant difference between variety Pusa Narangi (V_3) and Pusa Basanti (V_2) for nitrogen content of plant at both the growth stages. Nutrient uptake by plant was affected significantly in different varieties at different growths stages. Variety Pusa Narangi (V_3) registered significantly the highest (62.41 kg ha^{-1}) nitrogen uptake at 60 DAT. While, in variety Local Orange (V_1) uptake was only 57.06 kg N ha^{-1} at 60 DAT. Similarly, at 90 DAT and final harvest, variety Pusa Narangi (V_3) recorded maximum uptake of 72.24 kg N ha^{-1} (90 DAT) and 58.14 kg N ha^{-1} (at final harvest) which was followed by variety Pusa Basanti (V_2). The highest uptake of phosphorus and potash (16.12 and 73.42 kg ha^{-1}) was recorded by variety Pusa Narangi (V_3) but it was statistically at par with Pusa Basanti (V_2) at 60 DAT, respectively. The increase in phosphorus and potash uptake by Pusa Narangi (V_3) variety was to the tune of 10.09 and 10.72 per cent over V_1 (Local Orange) variety, respectively. At 90 DAT and final harvest, variety Pusa Narangi (V_3) registered significantly higher plant phosphorus and potash uptake of 19.56 and 98.51 kg ha^{-1} (90 DAT) and of 17.20 and 80.54 kg ha^{-1} (final harvest), respectively. This might be due to Pusa Narangi variety produced the higher dry matter production, so it take more uptake. The highest uptake rate of macro nutrients occurred at the full-bloom stage, implying that top dressing may be necessary at the flowering stage in order to delay senescence of the flower in petunias (Zhang *et al*., 2012). This result is in conformity with Pilanali and Kaplan (1999) and Joshi *et al*. (2012) in chrysanthemum.

Interaction effect

The interaction effect of phosphorus and variety (P × V) manifested its significant influence on phosphorus uptake at 90 DAT (Table 3). The significantly highest phosphorus uptake was observed with treatment combination P_3V_3 (21.94 kg ha^{-1}) and it was found at par with P_3V_2 treatment combination. The lowest uptake of phosphorus was registered with treatment combination P_1V_1.

The higher level of interaction effect of nitrogen, phosphorus and variety (N × P × V) was significant to cause variation in plant phosphorus uptake at 90 DAT and at final harvest (Table 4). At 90 DAT, significantly highest uptake of phosphorus was recorded with the treatment combination $N_3P_3V_3$ (24.96 kg ha^{-1}), which was found at par with $N_3P_3V_2$ and $N_2P_3V_2$ treatment combinations. The treatment combination $N_1P_1V_1$ registered significantly lowest phosphorus uptake (10.17 kg ha^{-1}) and was at par with $N_1P_1V_2$ and $N_1P_2V_1$. The increase in plant phosphorus uptake due to $N_3P_3V_3$ was about 2.45 fold over that with $N_1P_1V_1$ at 90 DAT. At final harvest stage, treatment combination $N_3P_3V_3$ recorded significantly highest uptake of phosphorus (20.54 kg ha^{-1}) but it was statistically at par with $N_3P_3V_2$, $N_3P_2V_3$, $N_3P_3V_1$, $N_2P_3V_2$ and $N_2P_3V_3$. Whereas, the lowest phosphorus uptake (10.13 kg ha^{-1}) was observed under $N_1P_1V_1$ treatment combination and it was found at par with $N_2P_1V_1$ and $N_1P_1V_2$ at final harvest. The increase in phosphorus uptake due to $N_3P_3V_3$ was to about 1.97 fold over $N_1P_1V_1$. This might be due to the synergistic effect of both nitrogen and phosphorus on dry weight, which improved the phosphorus nutrition and enhanced the uptake of phosphorus by the plants (Singh *et al*., 2002). This may also be due to that higher dose of phosphorus applied in soil so higher available phosphorus and finally variety Pusa Narangi uptake more phosphorus. The results are in close agreement with finding of El-Jaoual and Cox (1998), Chadha (2002) and Zhang *et al*. (2012).

It can be concluded that the application of N and P at higher level significantly increased nutrient content and uptake of marigold variety in proportion to the supply of their respective element at all the stages of growth. However, potash content was not influenced by different phosphorus application rates. The nutrients content and uptake was found maximum in Pusa Narangi variety followed by Pusa Basanti.

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