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RESPONSE OF AFRICAN MARIGOLD TO DIFFERENT LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM UNDER MID-HILL CONDITIONS OF HIMACHAL PRADESH

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ABSTRACT
The present investigation entitled "Effect of NPK on growth and yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda" was carried out during the years 2017 and 2018. Study aimed to ascertain the effect of different levels of NPK on plant nutrient contents, their uptake, growth and yield of African marigold. The experiment was laid out in randomized block design with seven treatments comprising different levels of NPK with four replications. The maximum plant height and number of branches along with nutrient contents and uptake by plant was recorded under T7 (150 % recommended dose of NPK) and minimum was recorded under T1 (control). Treatment T6 (125 % recommended dose of NPK) proved to be the best in respect of flower yield and related parameters *viz*., first flower opening (63.70 days), flower duration (65.20 days), flower weight (7.17 g), flower diameter (6.95 cm) number of flowers per plant (25.83) and flower yield (133.43 q/ha).

INTRODUCTION

Marigold (*Tagetes erecta* L.), which occupies a prominent place in ornamental horticulture, is one of the commercially exploited flower crops belonging to the family Asteraceae. It is mainly cultivated in the states of Madhya Pradesh, Maharashtra, Gujarat, Haryana, Tamil Nadu, Rajasthan, West Bengal, Karnataka, Himachal Pradesh and Delhi. The uses of marigold are many fold, often referred to as, "versatile crop with golden harvest." Flower is used for religious offering, decoration, pharmaceuticals, foods supplement and coloring agent for cosmetics (Priyanka *et al*., 2013). The flowers are also used for extracting lutein which is a common yellow/orange food colour. Marigold dye is also used in textile, pharmaceutical industries, food supplements, cosmetics *etc*. as they offer several advantages over synthetic dyes from natural point of view, safety and eco friendly in nature (Hemla Naik *et al*., 2004). The orange colored marigolds are good sources of carotenoid pigments which are widely used as dietary supplement in poultry industry to enhance the intensity of yolk pigmentation. It is one of the most valuable medicinal plants. Incorporation of marigold wastes with soil significantly reduces the nematode population. Marigold holds a number one position among the flower crops of the state. But, due to sub optimal use of fertilizers, improper management of soil and water resources and inadequate crop management practices *i.e.* weed control and plant protection measures, marigold yield in the state (15.77 thousand metric tons) is lower than the national average of 603.18 thousand metric tons (Anonymous, 2016). Out of the various factors influencing the growth and flowering of the marigold, balanced nutrition is the main factor. Nutrients directly affect the vegetative growth and yield of crop. Adequate supply of nutrients is often considered important for realizing the maximum yield of any crop, maintenance of soil health and to sustain the crop productivity. Among nutrients nitrogen, phosphorus and potassium are of much importance and to fulfill the requirement of plants they are supplied from outside in the form of fertilizers. The balanced doses of nitrogen, phosphorus and potassium play a key role in the increment of the vegetative growth, favorable for the synthesis of peptide bonds, protein and carbohydrates metabolism, necessary for the plant growth and flower development (Boodly and Meyer, 1965). The present study has been proposed to investigate the effect of different levels of NPK on soil and plant nutrients along with effect on growth and yield attributes of African marigold. Research work on these aspects is meager; hence the present experiment was taken up to achieve the maximum productivity of marigold flowers, especially in mid-hill conditions of Himachal Pradesh.

MATERIALS AND METHODS

The present investigation was carried out in the experimental farm of Department of Soil Science and Water Management, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during the year 2017 and 2018. The experiment was laid out in a randomized block design (RBD) at a spacing of 30 cm × 30 cm with four replications comprising 7

treatments *viz*., T1 - Control (without fertilizer application), T2 - 25 % recommended dose of NPK, T3 - 50 % recommended dose of NPK, T4 - 75 % recommended dose of NPK, T5 - 100 % recommended dose of NPK, T6 - 125 % recommended dose of NPK, T7 - 150 % recommended dose of NPK. The chemical fertilizers in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) were applied in different quantities as per the treatment. Half dose of nitrogen along with full doses of phosphorus and potassium (25, 50, 75, 100, 125 and 150 % of 15:15:20 N: P_2O_5: K_2O g m^{-2}) were incorporated in soil after bed formation and before the transplanting of seedlings. The remaining half dose of nitrogen (25, 50, 75, 100, 125 and 150 % of 15 g N m^{-2}), for respective treatments, was given after 30 days of transplanting. Farmyard manure (FYM) was applied at the rate of 5 kg per square meter to all the plots uniformly and incorporated into the soil before planting of marigold seedlings. Five plants were randomly selected in the net plot area and tagged with a label in each treatment after 25 days of transplanting. The observations recorded were plant height, number of branches per plant, days to first flower opening, duration of flowering, fresh weight of individual flower head, average flower diameter, flower yield per hectare, leaf nutrient content and their uptake by plants. Plant samples were taken at harvesting stages and were oven dried at 60ºC up to constant weight and powdered, which was utilized for analysis of various elements. Well ground leaf samples of known weight were digested in diacid mixture prepared by mixing concentrated HNO_3 and $HClO_4$ in the ratio of 4:1 observing all relevant precautions as laid down by Piper (1966) for estimating Phosphorus and Potassium whereas for Nitrogen, digestion was carried out using concentrated H_2SO_4 and digestion mixture (Potassium sulphate 400 parts, copper sulphate 20 parts, mercuric oxide 3 parts and selenium powder 1 part) as suggested by Jackson (1973). The N, P and K content in plants were determined by Microkjeldhal method (Jackson, 1973), Vando-molybdate phosphoric yellow color method (Jackson, 1973) and Flame photometer method (Jackson, 1973) respectively. The data were subjected to statistical analysis of variance as described by Panse and Sukhatme (2000) for using RBD.

RESULTS AND DISCUSSION

Effect of NPK on vegetative growth

The plant height was significantly enhanced by the application of different levels of NPK fertilizers at 30, 60 and 90 days after transplanting (DAT) during both the years of experimentation (Table 1). The pooled data pertaining to plant height revealed that soil receiving 150 % NPK (T7) recorded maximum plant height at 30 DAT (35.3 cm) which was statistically at par with treatment T6 (33.6 cm) and the lowest (27.7 cm) was recorded under treatment T1. Similarly the maximum plant height (57.8 cm and 84.1 cm) at 60 and 90 DAT was also recorded under T7 which was statistically at par with T6 (55.6 cm and 81.8 cm) and the lowest (46.8 cm and 73.3 cm) was in T1 at both the stages *i*.e. 60 and 90 DAT . The increase in plant height with increasing levels of fertilizer application might be due to greater nutrient (NPK) uptake by plants from soil which finally

Table 1: Effect of NPK on plant height (cm) of African marigold

Treatment	Plant height								
	30 DAT			60 DAT			90 DAT		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T1 (Control)	26.7	28.8	27.7	44.9	48.7	46.8	73	73.6	73.3
T2 (25% RDN)	27.9	29.4	28.6	48	49.2	48.6	73.8	74.9	74.4
T3 (50% RDN)	30	31.4	30.7	50.1	52.2	51.1	75.3	76.5	75.9
T4 (75% RDN)	30.9	31.9	31.4	51.7	53.2	52.5	77.6	79.3	78.4
T5 (100% RDN)	31.5	32.3	31.9	53.8	56.2	55	79.1	82	80.5
T6 (125% RDN)	33	34.1	33.6	54	57.2	55.6	80.7	83	81.8
T7 (150% RDN)	34.7	35.9	35.3	56.5	59.2	57.8	82	84.1	83.1
Mean	30.7	32		51.3	53.7		77.3	79	
C.D(0.05)	4.61	3.34		3.94	4.13		2.32	3.59	
T	2.91			2.74			2.76		
Y	NS			1.46			1.47		
T × Y	NS			NS			NS		

Table 2: Effect of NPK on number of branches per plant of African marigold

Treatment	Number of branches per plant								
	30 DAT			60 DAT			90 DAT		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T1 (Control)	4.15	4.97	4.56	9.1	9.3	9.2	13.55	13.6	13.57
T2 (25% RDN)	4.95	5.01	4.98	10	10.62	10.31	14.8	14.95	14.87
T3 (50% RDN)	4.99	5.35	5.17	10.93	11.4	11.16	15.45	15.75	15.6
T4 (75% RDN)	5.1	5.77	5.43	11.83	12.32	12.08	15.87	15.97	15.92
T5 (100% RDN)	5.87	6.45	6.16	12.6	13.1	12.85	16.32	16.5	16.41
T6 (125% RDN)	6.03	6.85	6.44	13.19	13.7	13.45	17.02	17.17	17.1
T7 (150% RDN)	6.95	7.25	7.1	13.58	14	13.79	17.97	18.1	18.03
Mean	5.43	5.95		11.6	12.06		15.85	16	
C.D(0.05)	1.17	1.2		1.06	1.11		0.94	1.15	
T	0.87			1.31			1.28		
Y	0.46			NS			NS		
T × Y	NS			NS			NS		

Table 3: Effect of NPK on first flower opening (days), duration of flowering (days) and average flower weight (g) of African marigold

Treatment	First flower opening			Duration of flowering			Flower weight		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T1 (Control)	84	74.2	79.1	48.8	51.4	50.1	5.12	5.77	5.48
T2 (25% RDN)	81.1	73.5	77.3	52.7	53.3	53	5.52	5.9	5.71
T3 (50% RDN)	74.1	70.2	72.2	54.5	57.7	56.1	6.05	6.17	6.11
T4 (75% RDN)	74	69.1	71.6	57.9	62.1	60	6.22	6.29	6.25
T5 (100% RDN)	70	65.2	67.6	60	64	62	6.98	7.03	7.01
T6 (125% RDN)	65.3	62.1	63.7	64.1	66.2	65.2	7.13	7.21	7.17
T7 (150% RDN)	66	64.4	65.2	62.7	63.9	63.3	7	7.13	7.06
Mean	73.5	68.4		57.3	59.8		6.3	6.5	
C.D(0.05)	1.78	1.1		0.99	2.26		0.28	0.76	
T	1.53			1.51			0.58		
Y	0.82			0.81			NS		
T × Y	2.17			NS			NS		

Table 4: Effect of NPK on average flower diameter (cm), number of flowers per plant and flower yield (q/ha) of African marigold

Treatment	Flower diameter			Number of flowers			Flower yield		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T1 (Control)	4.69	5.02	4.86	15.87	19.07	17.47	59.3	76.58	67.94
T2 (25% RDN)	5.01	5.29	5.15	17.17	19.86	18.52	68.26	81.4	74.83
T3 (50% RDN)	5.15	5.59	5.37	18.44	21.08	19.76	80.34	92.1	86.22
T4 (75% RDN)	5.93	6.13	6.03	21.65	24.13	22.89	96.8	108.43	102.61
T5 (100% RDN)	6.45	6.78	6.61	22.75	26.05	24.4	114.38	131.19	122.79
T6 (125% RDN)	6.82	7.09	6.95	24.29	27.37	25.83	124.77	142.1	133.43
T7 (150% RDN)	6.2	6.34	6.27	23	26.65	24.82	116.14	136.57	126.35
Mean	5.75	6.03		20.45	23.46		94.28	109.77	
C.D(0.05)	0.32	0.58		1.6	4.04		9.28	12.59	
T	0.56			2.27			8		
Y	NS			1.21			4.28		
T × Y	NS			NS			NS		

Table 5: Effect of NPK on leaf nitrogen, phosphorus and potassium content (%) of African marigold

Treatment	Nitrogen			Phosphorus			Potassium		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T1 (Control)	1.95	1.96	1.95	0.27	0.28	0.28	1.63	1.57	1.6
T2 (25% RDN)	2.08	2.11	2.09	0.4	0.42	0.41	1.95	1.94	1.95
T3 (50% RDN)	2.13	2.17	2.15	0.52	0.53	0.52	2.09	2.11	2.1
T4 (75% RDN)	2.19	2.2	2.19	0.55	0.54	0.54	2.17	2.23	2.2
T5 (100% RDN)	2.23	2.24	2.24	0.56	0.56	0.56	2.28	2.32	2.3
T6 (125% RDN)	2.27	2.29	2.28	0.58	0.58	0.58	2.34	2.41	2.38
T7 (150% RDN)	2.3	2.31	2.31	0.6	0.61	0.61	2.4	2.44	2.42
Mean	2.17	2.18		0.5	0.5		2.12	2.14	
C.D(0.05)	NS	NS		NS	NS		0.18	0.28	
T	NS			NS			0.17		
Y	NS			NS			NS		
T × Y	NS			NS			NS		

Table 6: Effect of NPK on nitrogen, phosphorus and potassium uptake (kg/ ha) by plant of marigold

Treatment	N uptake			P uptake			K uptake		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T1 (Control)	67.22	72.46	69.84	9.15	10.65	9.9	61.04	66.68	63.86
T2 (25% RDN)	76.51	83.1	79.8	14.99	17.45	16.22	80.09	86.04	83.07
T3 (50% RDN)	85.02	90.16	87.59	20.64	23.29	21.96	90.17	95.27	92.72
T4 (75% RDN)	93.9	98.52	96.21	25.18	27.19	26.18	103.64	110.88	107.26
T5 (100% RDN)	105.37	111.2	108.29	28.68	32.14	30.41	119.43	128.23	123.83
T6 (125% RDN)	112.79	119.4	116.09	31.89	34.23	33.06	130.84	140.77	135.8
T7 (150% RDN)	122.14	131.22	126.68	35.39	39.12	37.26	142.09	152.96	147.52
Mean	94.71	100.87		23.7	26.3		103.9	111.55	
C.D(0.05)	4.83	4.99		3.3	3.53		7.96	7.47	
T	3.33			2.57			5.21		
Y	1.78			1.37			2.79		
T × Y	NS			NS			NS		

involved in the cell division, cell enlargement and promotion of protein synthesis which ultimately enhance the stem length. The increase in plant height due to NPK application is in close proximity with the findings of Kumar *et al*. (2010) and Pal and Ghosh (2010) in African marigold.

The pooled data pertaining to number of branches at 30, 60 and 90 DAT is presented in Table 2. The highest number of branches (7.10) at 30 DAT was recorded under T7 and lowest (4.56) was in T1. The highest number of branches (13.79) were recorded under T7 which was statistically at par with T6 (13.45) and T5 (12.85) and lowest (9.20) under T1 at 60 DAT. Similarly at 90 DAT highest number of branches (18.03) were recorded under T7 which was statistically at par with T6 (17.10) and lowest (13.57) was under T1. The increase in number of branches at all the growth stages might be due to the fact that all the three nutrients (N, P and K) have major role in vegetative growth of plant such as nitrogen supply to the roots is found to stimulate the production and export of cytokinins to the shoots (Wagner and Michael, 1971). The increased levels of cytokinins in plants might have caused the lateral buds to sprout giving more number of lateral branches. Potash fertilization might have improved plant growth in number of branches virtue of vital role in carbohydrate metabolism, enzyme activation and osmotic regulation. Results are in confirmation with the findings of Mansur (2006), Dinesh (2015) and Rajput (2015) who reported increase in number of branches with increasing doses of fertilizers in gaillardia, dahlia and marigold, respectively.

Effect of NPK on flowering characters and yield attributes of African marigold

Perusal of data presented in Table 3 revealed that there was significant impact of various treatments with respect to days taken for first flower opening. Pooled data revealed that the minimum days required for first flower opening (63.7 days) were recorded under T6 and maximum (79.1 days) under T1. This might be due to accumulation of carbohydrates over and above burn up through respiration could have resulted in slightly early flower bud differentiation and eventual initiation of flowering. The delay in flowering at still higher level of NPK might be due to the competition between vegetative and reproductive phases which was a consequence of promotion of vegetative phase by higher nitrogen. Present findings are in accordance of observations made by Bhat and Shepherd (2006) and Rajbeer *et al*. (2009). Nitrogen, phosphorus and potassium were found to have a positive role in increasing flowering duration. Increase in flower duration was observed with increasing doses of fertilizer application in Table 3. The maximum duration of flowering (65.2 days) was noted with the application of 125 % RDN (T6), while the minimum duration of flowering (50.1 days) was observed with T1. These findings are in close confirmation with the findings of Polara (2005) and Kishore *et al*. (2010) in marigold.

Significant differences were observed among different treatments for fresh weight of individual flower head (Table 3). The perusal of pooled data indicated that the highest flower weight (7.17 g) was recorded under T6 which was statistically at par with T5 (7.01 g) and T7 (7.06 g), whereas T1 (control) registered minimum flower weight (5.48 g). Supply of nutrients at higher level might have accelerated the photosynthetic activities of plants and thus more assimilates have been available to the flowers resulting in increased flower weight. The findings are in close proximity with the findings of Singh *et al*. (2008) and Sharma *et al*. (2010) in marigold. Significant differences were observed in the average flower diameter due to the application of nitrogen, phosphorus and potassium in different doses. Pooled data (Table 4) revealed that the maximum diameter was recorded under T6 (6.95cm) which was statistically at par with T5 (6.61 cm) and minimum (4.86 cm) was under T1. The influence of NPK on flower diameter was very significant because, nutrients play an important role in transport of metabolites for growth and development which in turn is responsible for more uptake of nutrients and increase in flower size. Similar results were found by Sharma *et al*. (2010) and Naik (2015) in marigold.

Increase in number of flowers per plant was observed with increasing doses of fertilizer application. The pooled data on number of flowers at the time of harvest has been presented in Table 4. Significantly highest number of flowers (25.83) was recorded under T6 which was statistically at par with T7 (24.82) and T5 (24.40). Results obtained indicates that the application of nutrients increase the number of flowers per plant upto 125 % RDN. Beyond this dosage, number of flowers observed to decrease. This could be due to the fact that excess dose of nitrogen might have contributed for more vegetative growth for longer period and lower level of nitrogen might have produced less vegetative growth and might have helped in increasing number of flowers. The results are in Naik (2015) and Singh *et al*. (2008) in marigold. The pooled data on yield per hectare taken at the time of harvest has been presented in Table 4. Significantly highest yield (133.43 q ha^{-1}) was recorded under T6 which was statistically at par with T7 (126.35 q ha-1). The increased number, size and weight of flowers resulted in increased flower yield. The increase in flower yield might be attributed to improvement in growth of plant and increase in the number of lateral branches which in turn led to higher production. Similar results were obtained by Naik (2015) and Bhat and Shepherd (2006).

Effect of NPK on nutrient content and their uptake by African marigold plants

The data on leaf nitrogen, phosphorus and potassium at harvest as influenced by different treatments is enumerated in Table 5. An examination of pooled data indicated that the nitrogen and phosphorus content in leaves at harvest varied from 1.95 % to 2.31 % and 0.28 % to 0.61 % respectively. Pooled data revealed that highest K content (2.42 %) was recorded under T7 which was statistically at par with T6 (2.38 %) and T5 (2.30 %). The lowest K content (1.60 %) was recorded under T1. Results obtained revealed that the potassium content in leaves increased with the increasing dose of NPK fertilizers. This might be due to increase in available potassium in soil which in turn resulted in higher nutrient absorbance in plants. Similar results were obtained by Jamod (2001) and Polara *et al*. (2014) in marigold.

N, P and K uptake by marigold plant increased significantly with increase in NPK levels. A scrutiny of data in Table 6 revealed that maximum N uptake (126.68 kg ha^{-1}) was recorded under T7 and minimum (69.84 kg ha^{-1}) was under T1. Pooled data revealed that the highest P uptake (37.26 kg ha^{-1}) was

recorded under T7 and lowest (9.90 kg ha^{-1}) was under T1. The highest K uptake (147.52 kg ha^{-1}) was recorded under T7 and the lowest (63.86 kg ha^{-1}) was recorded under T1 (control). At higher level of N, P and K fertilizer application, the availability of nutrients to marigold was high, which in turn resulted in higher vegetative growth and nutrient content in plants which directed contributed total N, P and K uptake in plants. Similar results were demonstrated by Joshi (2002) in chrysanthemum, Baboo and Singh (2003) and Polara *et al*. (2014) in marigold.

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