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Effect of nitrogen and phosphorus on seed yield and fertility status of soil after harvest of African marigold

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Abstract
This research was conducted to investigate the Effect of nitrogen and phosphorus on seed yield and fertility status of soil after harvest of African marigold, during '*Kharif*' season 2019-2020 at Horticulture Section, College of Agriculture, Nagpur. The treatments comprised of four levels of each nitrogen 0, 80, 100, 120 kg ha^{-1} and phosphorus 0, 40, 50 and 60 kg ha^{-1}. The fertilizers applied as per the treatments to evaluate the yield and soil fertility status after harvest of African marigold. The Experiment was laid out in factorial randomized block design with three replications. The maximum number of flowers plant^{-1} (56.60 nos.), number of flowers ha^{-1} (20.15 lakh) and seed yield ha^{-1} (678.79 kg) in respect to yield parameters were recorded significantly higher in (N_3P_3) where, 100 kg N ha^{-1} applied with 50 kg P ha^{-1}. Whereas, pH of soil (7.52), EC of soil (0.486 dS m^{-1}), organic carbon (4.44 g kg^{-1}), available N in soil (354.38 kg ha^{-1}), available P in soil (23.87 kg ha^{-1}) and available K in soil (363.44 kg ha^{-1}) in respect to soil reaction and soil fertility status were also recorded higher in treatment (N_3P_3) i.e. application of 100 kg N ha^{-1} with 50 kg P ha^{-1}.

Keywords: African marigold, nitrogen, phosphorus, seed yield, soil reaction, soil fertility

Introduction
Marigold is native of central and South America especially Mexico and belongs to the family Asteraceae (Compositae). There are 33 species of genus tagetes. African marigold (*Tagetes erecta* Linn.) is hardy, erect and branched, leaves are pinnately divided and leaflets are lanceolate and serrate. Flowers are single to fully double and its colour varies from lemon yellow to golden yellow or orange and having large globular flowers. African marigold is one of the important and popular commercial flowers grown mainly for making garlands, other decorative purposes and also used for religious offering, pharmaceuticals, foods supplement and coloring agent for cosmetics. So, for its cultivation balanced fertilisation are required. Nitrogen plays a vital role in metabolic activities of plants. It is one of the very important major plant nutrients which directly affect the plant growth and flowering behaviour. It is constituent of nucleic acid, protoplasm and might have increased carbohydrates synthesis, amino acid etc. from which the phyto-harmones like auxins, gibberellins and cytokines have been synthesizes resulting plant growth (Verma and Kumar 2018) [15], whereas, phosphorus has very important role in energy storage or structural integrity. It plays a vital role in photosynthesis, respiration, energy storage and cell division. It promotes early root formation and growth. Phosphorus improves the quality of flower. It brings early seed formation by stimulating early flowering (Kumar 2015) [7]. Suitable combination of fertilizers consequently leading to increase vegetative growth, production of healthy plants having maximum number of shoots and leaves which have a good effect on quality flower production and seed yield.

Material and Methods
The present investigation was carried out during '*kharif*' season 2019-2020 at Horticulture Section, College of Agriculture, Nagpur (20^o 10' N and 79^o 19' E, 321.26 m above MSL). Nagpur is characterized by hot, dry summer and fairly cold winter. The area shows wide fluctuation of temperature. The soil of experimental site was medium black in colour with good drainage. The soil properties before start of experiment is neutral in reaction (pH 7.49), medium in salt concentration (0.47 dS m^{-1}), medium in organic carbon (3.96 g kg^{-1}), Low in available N (252.01 kg ha^{-1}), moderate in available P (19.77 kg ha^{-1}) and high in available K (340.33 kg ha^{-1}).
The experiment was laid out to study the effect of nitrogen and phosphorus on seed yield and fertility status of soil after harvest of African marigold. The research was carried out on variety African double orange.

Sixteen treatment combinations with four levels of nitrogen 0, 80, 100, 120 kg ha^{-1} and phosphorus 0, 40, 50 and 60 kg ha^{-1} were tested in factorial randomized block design with three replications. The different combinations of nitrogen and phosphorus as: T1 – 0 kg N ha^{-1} + 0 kg P ha^{-1} (N_1P_1), T2 – 0 kg N ha^{-1} + 40 kg P ha^{-1} (N_1P_2), T3 – 0 kg N ha^{-1} + 50 kg P ha^{-1} (N_1P_3), T4 – 0 kg N ha^{-1} + 60 kg P ha^{-1} (N_1P_4), T5 – 80 kg N ha^{-1} + 0 kg P ha^{-1} (N_2P_1), T6 – 80 kg N ha^{-1} + 40 kg P ha^{-1} (N_2P_2), T7 – 80 kg N ha^{-1} + 50 kg P ha^{-1} (N_2P_3), T8 – 80 kg N ha^{-1} + 60 kg P ha^{-1} (N_2P_4), T9 – 100 kg N ha^{-1} + 0 kg P ha^{-1} (N_3P_1), T10- 100 kg N ha^{-1} + 40 kg P ha^{-1} (N_3P_2), T11 -100 kg N ha^{-1} + 50 kg P ha^{-1} (N_3P_3), T12 -100 kg N ha^{-1} + 60 kg P ha^{-1} (N_3P_4), T13 – 120 kg N ha^{-1} + 0 kg P ha^{-1} (N_4P_1), T14 -120 kg N ha^{-1} + 40 kg P ha^{-1} (N_4P_2), T15 – 120 kg N ha^{-1} + 50 kg P ha^{-1} (N_4P_3) and T16 – 120 kg N ha^{-1} + 60 kg P ha^{-1} (N_4P_4). The seeds of African marigold were sown in the nursery beds in the month of July. African marigold seedlings of uniform size were transplanted 27 days after sowing at the spacing of 45 cm x 30 cm in the month of August, 2019. Half dose of nitrogen and full dose of phosphorus as per treatments were applied as a basal dose at the time of transplanting of seedlings and remaining half dose of nitrogen was given one month after transplanting and recommended dose of K were applied at the time of transplanting. Package of practices including irrigation were adopted as per recommendation.

Five plants were selected randomly from each plot for recording yield parameters i.e., number of flowers $plant^{-1}$, number of flowers ha^{-1} (Lakh), seed yield kg ha^{-1} were recorded on these randomly selected plants. A composite soil sample from the experimental site was collected before the crop was transplanted to know the nutrient status of the soil before the application of fertilizer. After the harvesting of crop, the surface soil samples were collected (0-30 cm depth) from each treatment plot using screw auger. Soil samples collected were mixed and spread on small cotton cloth bags for air drying. Then the samples were ground and sieved through 2 mm sieve. This sample was used for the estimation of pH, EC, organic carbon, available nitrogen, phosphorus and potash contents of the soil. Data were statistically analysed in FRBD (Panse and Sukhatme, 1967) [10].

Results and Discussion

Effect of nitrogen and Phosphorus on yield parameters

The data presented in table 1 revealed that the increase in individual application of nitrogen and phosphorus significantly influence the number of flowers per plant, number of flowers per hectare (Lakh) and seed yield (kg ha^{-1}) of African marigold. The increase in application of nitrogen @ 100 kg ha^{-1} recorded the maximum number of flowers per plant (50.86 nos.), number of flowers per hectare (20.09 lakh) and seed yield per hectare (665.06 kg ha^{-1}). This might be due to nitrogen increased photosynthetic activity for better vegetative and reproductive growth of the plant. Nitrogen was the main driving force behind the life processes which led to enhanced flower production. The similar observation was also noted by Sharma *et al.* (2017) [12] that, the application of nitrogen 75 kg ha^{-1} recorded maximum numbers of flowers $plant^{-1}$, Vijay *et al.*, (2015) [16] resulted that, the application of nitrogen 150 kg ha^{-1} had recorded maximum flower yield ha^{-1} in calendula and Nikam *et al.*, (2018) [9] concluded that, the application of nitrogen 200 kg ha^{-1} had recorded maximum seed yield ha^{-1} in chrysanthemum. An application of phosphorus @ 50 kg ha^{-1} recorded the maximum number of flowers per plant (48.86 nos.), number of flowers per hectare (17.42 lakh) and seed yield per hectare (628.77 kg), However, higher level of nitrogen @ 120 kg ha^{-1} and phosphorus @ 60 kg ha^{-1} were on at par. The reason for increased in yield parameters might be due to abundant availability of phosphorus in the rooting medium which affects the earlier maturation of plant that trends to develop the flower, also crop produced maximum vegetative growth, reproductive growth resulted in production of maximum number of flowers. Similar result reported by Solanki and Ganie (2009) [13] that, the application of phosphorus 200 kg ha^{-1} produced maximum number of flowers $plant^{-1}$ in African marigold, Kumar and Moon (2014) [6] reported that, the application of 75 kg ha^{-1} phosphorus gave maximum flower yield ha^{-1} in African marigold, Aslam *et al.*, (2016) [3] concluded that, the application of 10 g/m^2 phosphorus was given maximum seed yield ha^{-1} in African marigold.

Table 1: Number of flowers $plant^{-1}$, number of flowers ha^{-1} (Lakh) and seed yield ha^{-1} (kg) of African marigold as influenced by Nitrogen and phosphorus levels.

Treatments	Number of flowers $plant^{-1}$	Number of flowers $hectare^{-1}$ (Lakh)	Seed yield $hectare^{-1}$ (kg)
Levels of Nitrogen (kg ha^{-1})			
N_1- 0 kg N ha^{-1}	32.84	12.97	459.75
N_2- 80 kg N ha^{-1}	44.57	18.44	600.63
N_3- 100 kg N ha^{-1}	50.86	20.09	665.06
N_4-120 kg N ha^{-1}	49.83	19.42	661.75
'F' test	Sig.	Sig.	Sig.
SE (m) ±	0.85	33681	8.63
CD at 5%	2.46	97277	24.9
Levels of Phosphorus (kg ha^{-1})			
P_1- 0 kg P ha^{-1}	38.20	15.09	468.04
P_2- 40 kg P ha^{-1}	40.89	15.76	571.95
P_3- 50 kg P ha^{-1}	48.86	17.42	628.77
P_4- 60 kg P ha^{-1}	47.14	16.65	608.43
'F' test	Sig.	Sig.	Sig.
SE (m) ±	0.85	33681	8.63
CD at 5%	2.46	97277	24.9
Interaction (Nitrogen X Phosphorus)			
'F' test	Sig.	Sig.	Sig.
SE (m) ±	2.08	32811	9.02
CD at 5%	6.11	98501	31.10

Combine application of nitrogen @ 100 kg ha^{-1} with phosphorus @ 50 kg ha^{-1} (Table 2) significantly increased the number of flower per plant (56.60 nos.), number of flowers per hectare (20.15 lakh) and seed yield per hectare (678.79 kg ha^{-1}) and found at par with higher level i. e. application of nitrogen @ 120 kg ha^{-1} with phosphorus 60 kg ha^{-1}. Similar results was also noted by Ahmad *et al.*, (2017) [1] that, the application of nitrogen 150 kg ha^{-1} with phosphorus 75 kg ha^{-1} recorded maximum numbers of flowers plant^{-1} in chrysanthemum, Saman and Kirad (2013) [11] noted that, the application of nitrogen 150 kg ha^{-1} and phosphorus 80 kg ha^{-1} had maximum flower yield ha^{-1} in calendula, Tembhare *et al*., (2016) [14] reported that, the application of nitrogen 200 kg ha^{-1} and phosphorus 75 kg ha^{-1} had maximum seed yield in china aster.

Table 2: Interaction effect of nitrogen and phosphorus on Number of flowers plant^{-1}, number of flowers hectare^{-1} (Lakh) and seed yield hectare^{-1} (kg) of African marigold

Treatments	Phosphorus levels														
Nitrogen levels	Number of flowers plant^{-1}					Number of flowers hectare^{-1} (Lakh)					Seed yield hectare^{-1} (kg)				
	0 kg ha^{-1}(P_1)	40 kg ha^{-1} (P_2)	50 kg ha^{-1} (P_3)	60 kg ha^{-1} (P_4)	Average	0 kg ha^{-1}(P_1)	40 kg ha^{-1} (P_2)	50 kg ha^{-1} (P_3)	60 kg ha^{-1} (P_4)	Average	0 kg ha^{-1}(P_1)	40 kg ha^{-1} (P_2)	50 kg ha^{-1} (P_3)	60 kg ha^{-1} (P_4)	Average
N_1- 0 kg N ha^{-1}	30.70	33.13	33.53	34.00	32.84	12.12	13.08	13.24	13.43	12.97	422.93	442.04	468.40	505.63	459.75
N_2- 80 kg N ha^{-1}	36.13	37.86	47.26	49.06	44.57	14.27	14.95	14.72	15.43	18.44	537.07	569.07	643.93	652.46	600.63
N_3- 100 kg N ha^{-1}	39.86	44.26	56.60	55.80	50.86	15.74	16.90	20.15	19.76	20.09	557.06	620.33	678.79	667.20	665.06
N_4-120 kg N ha^{-1}	46.13	48.33	53.40	54.40	49.83	18.22	19.09	19.91	19.75	19.42	555.11	626.39	658.98	662.41	661.75
Average	38.20	40.89	48.86	47.14		15.09	15.76	17.42	16.65		468.04	571.95	628.77	608.43	
	Interaction (N X P)					Interaction (N X P)					Interaction (N X P)				
'F' test	Sig.					Sig.					Sig.				
SE (m) ±	2.08					32811					9.02				
CD at 5%	6.11					98501					31.10				

Effect of nitrogen and Phosphorus on soil reaction and organic carbon status of soil

Effect of nitrogen and phosphorus individual and combine application have no significant effect on pH and EC of soil (Table 3,4). Whereas, available OC in soil recorded significantly maximum (4.45 g kg^{-1}) with application of nitrogen @ 120 kg ha^{-1} and recorded (4.41 g kg^{-1}) with application of phosphorus @ 60 kg ha^{-1}, whereas found at par with phosphorus @ 50 kg ha^{-1}. While combine application of nitrogen with phosphorus have no significant effect on organic carbon of soil.

Table 3: pH, EC and OC of soil as influenced by Nitrogen and phosphorus levels

Treatments	pH of soil	EC of soil (dS m^{-1})	Organic carbon of soil (g kg^{-1})
Levels of Nitrogen (kg ha^{-1})			
N_1- 0 kg N ha^{-1}	7.50	0.464	4.09
N_2- 80 kg N ha^{-1}	7.51	0.466	4.21
N_3- 100 kg N ha^{-1}	7.51	0.467	4.34
N_4-120 kg N ha^{-1}	7.52	0.468	4.45
'F' test	N.S.	N.S.	Sig.
SE (m) ±	0.019	0.020	0.02
CD at 5%	-	-	0.06
Levels of Phosphorus (kg ha^{-1})			
P_1- 0 kg P ha^{-1}	7.52	0.458	4.14
P_2- 40 kg P ha^{-1}	7.51	0.461	4.24
P_3- 50 kg P ha^{-1}	7.50	0.463	4.36
P_4- 60 kg P ha^{-1}	7.52	0.464	4.41
'F' test	N.S.	N.S.	Sig.
SE (m) ±	0.019	0.020	0.02
CD at 5%	-	-	0.06
Interaction (Nitrogen X Phosphorus)			
'F' test	N.S.	N.S.	N.S.
SE (m) ±	0.04	0.050	0.053
CD at 5%	-	-	-

Table 4: Interaction effect of nitrogen and phosphorus on Ph, EC and OC of soil

Treatments	Phosphorus levels														
Nitrogen levels	pH of soil					EC of soil (dS m^{-1})					Organic carbon of soil (g kg^{-1})				
	0 kg ha^{-1}(P_1)	40 kg ha^{-1} (P_2)	50 kg ha^{-1} (P_3)	60 kg ha^{-1} (P_4)	Average	0 kg ha^{-1}(P_1)	40 kg ha^{-1} (P_2)	50 kg ha^{-1} (P_3)	60 kg ha^{-1} (P_4)	Average	0 kg ha^{-1}(P_1)	40 kg ha^{-1} (P_2)	50 kg ha^{-1} (P_3)	60 kg ha^{-1} (P_4)	Average
N_1- 0 kg N ha^{-1}	7.49	7.50	7.50	7.49	7.50	0.448	0.460	0.460	0.490	0.464	4.08	4.09	4.09	4.11	4.09
N_2- 80 kg N ha^{-1}	7.51	7.51	7.50	7.51	7.51	0.451	0.472	0.469	0.483	0.466	4.11	4.20	4.24	4.37	4.21
N_3- 100 kg N ha^{-1}	7.53	7.51	7.52	7.52	7.51	0.477	0.482	0.486	0.490	0.467	4.18	4.33	4.44	4.38	4.34
N_4-120 kg N ha^{-1}	7.54	7.53	7.52	7.54	7.52	0.477	0.484	0.487	0.491	0.468	4.32	4.34	4.45	4.50	4.45
Average	7.52	7.51	7.50	7.52		0.458	0.461	0.463	0.464		4.14	4.24	4.36	4.41	
	Interaction (N X P)					Interaction (N X P)					Interaction (N X P)				
'F' test	N.S.					N.S.					N.S.				
SE (m) ±	0.04					0.050					0.053				
CD at 5%	-					-					-				

Effect of nitrogen and Phosphorus on residual fertility status of soil

The data revealed that the application of individual levels of nitrogen and phosphorus significantly increased the availability of nutrients in soil (Table 5, 6). The application of nitrogen @ 120 kg ha^{-1} recorded significantly maximum (327.26 kg ha^{-1}) available nitrogen in soil, while application of Phosphorus @ 60 kg ha^{-1} recorded significantly maximum (308.43 kg ha^{-1}) available nitrogen in soil, but found at par with application of nitrogen @ 100 kg ha^{-1} (324.99 kg ha^{-1}) and phosphorus @ 50 kg ha^{-1} (306.44 kg ha^{-1}). However, combine application of nitrogen @ 100 kg ha^{-1} with phosphorus @ 50 kg ha^{-1} recorded maximum (354.38 kg ha^{-1}) available nitrogen in soil and found at par with higher level i. e. nitrogen @ 120 kg ha^{-1} and phosphorus @ 60 kg ha^{-1} (350.21 kg ha^{-1}). Similar observation was noted by Joshi *et al*., (2012) that, the application of nitrogen @ 300 kg ha^{-1} with phosphorus @ 150 kg ha^{-1} increased nitrogen availability in soil under chrysanthemum cultivation.

The maximum available phosphorus in soil found significantly maximum with application of nitrogen @ 120 kg ha^{-1} recorded (23.72 kg ha^{-1}), whereas found at par with application of nitrogen @ 100 kg ha^{-1} recorded (22.70 kg ha^{-1}) while application of phosphorus @ 60 kg ha^{-1} recorded (25.05 kg ha^{-1}) and found at par with application of phosphorus @ 50 kg ha^{-1} recorded (24.69 kg ha^{-1}). However, combine application of nitrogen with phosphorus have no significant result on available P in soil. Similar results were also reported by Badole *et al*., (2016) [4] that, the increase in application of nitrogen (150 kg ha^{-1}) and phosphorus (75 kg ha^{-1}) increased phosphorus availability in soil under gaillardia cultivation.

The maximum available potassium in soil found significantly maximum with application of nitrogen @ 120 kg ha^{-1} recorded (364.71 kg ha^{-1}), and found at par with application of nitrogen @ 100 kg ha^{-1} recorded (362.56 kg ha^{-1}) similar finding reported by Navyashree *et al.*, (2017) [8] that, the application of 62.5 kg N ha^{-1} increased the availability of K_2O, while application of phosphorus @ 60 kg ha^{-1} recorded (351.94 kg ha^{-1}) and found at par with application of phosphorus @ 50 kg ha^{-1} recorded (350.21 kg ha^{-1}). Similar finding reported by Badole *et al.*, (2016) [4] that the application of 75 kg P ha^{-1} increased the availability of K in soil under Gaillardia cultivation. However, combine application of nitrogen with phosphorus have no significant result on available K in soil.

Table 5: Available NPK in soil as influenced by Nitrogen and phosphorus levels

Treatments	Available N in soil (kg ha^{-1})	Available P in soil (kg ha^{-1})	Available K in soil (kg ha^{-1})
Levels of Nitrogen (kg ha^{-1})			
N_1- 0 kg N ha^{-1}	259.67	16.52	317.42
N_2- 80 kg N ha^{-1}	303.22	20.25	354.78
N_3- 100 kg N ha^{-1}	324.99	22.70	362.56
N_4-120 kg N ha^{-1}	327.26	23.72	364.71
'F' test	Sig.	Sig.	Sig.
SE (m) ±	1.69	0.30	2.18
CD at 5%	4.89	0.87	6.40
Levels of Phosphorus (kg ha^{-1})			
P_1- 0 kg P ha^{-1}	251.52	17.56	339.79
P_2- 40 kg P ha^{-1}	264.75	22.74	345.53
P_3- 50 kg P ha^{-1}	306.44	24.69	350.21
P_4- 60 kg P ha^{-1}	308.43	25.05	351.94
'F' test	Sig.	Sig.	Sig.
SE (m) ±	1.69	0.30	2.18
CD at 5%	4.89	0.87	6.40
Interaction (Nitrogen X Phosphorus)			
'F' test	Sig.	N.S.	N.S.
SE (m) ±	4.14	5.74	3.89
CD at 5%	11.98	-	-

Table 6: Interaction effect of nitrogen and phosphorus on N, P and K status of soil

Treatments	Phosphorus levels														
Nitrogen levels	Available N in soil (kg ha^{-1})					Available P in soil (kg ha^{-1})					Available K in soil (kg ha^{-1})				
	0 kg ha^{-1}(P_1)	40 kg ha^{-1} (P_2)	50 kg ha^{-1} (P_3)	60 kg ha^{-1} (P_4)	Average	0 kg ha^{-1}(P_1)	40 kg ha^{-1} (P_2)	50 kg ha^{-1} (P_3)	60 kg ha^{-1} (P_4)	Average	0 kg ha^{-1}(P_1)	40 kg ha^{-1} (P_2)	50 kg ha^{-1} (P_3)	60 kg ha^{-1} (P_4)	Average
N_1- 0 kg N ha^{-1}	190.10	204.49	221.46	227.46	259.67	11.15	14.17	16.28	18.49	16.52	315.98	323.17	327.64	334.92	317.42
N_2- 80 kg N ha^{-1}	260.83	240.36	315.32	316.40	303.22	14.29	19.32	21.23	22.58	20.25	346.97	352.29	359.64	360.23	354.78
N_3- 100 kg N ha^{-1}	270.88	294.06	354.38	349.66	324.99	17.49	21.05	23.87	24.41	22.70	357.55	360.51	363.44	368.74	362.56
N_4-120 kg N ha^{-1}	284.28	320.11	334.44	350.21	327.26	18.34	23.43	23.71	24.75	23.72	358.66	366.17	370.15	373.87	364.71
Average	251.52	264.75	306.44	308.43		17.56	22.74	24.69	25.05		339.79	345.53	350.21	351.94	
	Interaction (N X P)					Interaction (N X P)					Interaction (N X P)				
'F' test	Sig.					N.S.					N.S.				
SE (m) ±	4.14					5.74					3.89				
CD at 5%	11.98					-					-				

Conclusion

The combine application of nitrogen @ 100 kg ha^{-1} and phosphorus @ 50 kg ha^{-1} improve the yield parameter i.e., number of flower plant^{-1}, number of flowers ha^{-1}, seed yield ha^{-1} and In case of soil reaction, organic carbon and fertility status of soil i.e., available NPK, the combine application of nitrogen @ 100 kg ha^{-1} and phosphorus 50 kg ha^{-1} increase the soil reaction, organic carbon and improves fertility status of soil.

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