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Effect of nitrogen and phosphorus on growth and flowering of calendula

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Abstract
A field experiment was conducted at Horticulture section, College of Agriculture, Nagpur (Maharashtra), India during *Rabi* season of the year 2018-2019 to know the response of nitrogen and phosphorus on growth and flowering of calendula. The experiment was laid out in Factorial Randomized Block Design with three replication and sixteen treatment combinations, which comprised of four levels of nitrogen (0, 75, 100 and 125 kg ha^{-1}) and phosphorus (0, 25, 50 and 75 kg ha^{-1}). The results revealed that nitrogen and phosphorus levels significantly influenced the growth and flowering of calendula. Growth parameters *viz.*, plant height (62.33 cm), stem diameter (0.76 cm), leaves plant^{-1} (177.36), leaf area (73.66 cm^2), branches plant^{-1} (37.60) and plant spread at 50 % flowering (45.56 cm) were recorded significantly maximum with nitrogen 100 kg and phosphorus 50 kg ha^{-1}. As regards flowering parameters *viz.*, minimum days for first flower bud initiation, days for opening of first flower, days for 50 per cent flowering and flowering span were recorded with individual application of nitrogen 100 kg and phosphorus 50 kg ha^{-1}.

Keywords: Calendula, nitrogen, phosphorus, growth, flowering

Introduction
Calendula is very important ornamental plant which growing as winter annual for landscaping. It belongs to family *Compositae*. It is also known as pot marigold. The name calendula has latin origin. The name is derived from the word 'calendae' meaning first day of month. It is originated in South Europe. The plant prefers sunny situations and well drained rich soil. It can be grown as a winter seasonal at the places having mild climates. Calendulas are considered by many gardening experts as among the easiest and most versatile flowers to grow in a garden, especially because they tolerate most soils. As a cut flower, calendula is very useful for flower arrangement in flat bowls. Due to flatness of the flowers, they are not easily mixed with any other flowers. They serve the purpose of useful fillers in the flower bouquets and arrangement. The plants are very popular for growing in beds as well as pot plants. As cut flower and also grown in window boxes. Since, florets close at night they are not suitable for night decorations.

Nutrients play an important role in the improvement of vegetative growth and flowering in calendula. At present, due to lack of scientific knowledge, growers are not able to boost the productivity of calendula. In view of this fact and overriding need was felt to conduct research on the effect of nitrogen and phosphorus to achieve the maximum benefit. Hence, this study was conducted to optimizes the effect of nitrogen and phosphorus on growth and flowering of calendula.

Material and Methods
A field experiment was carried out at farm of Horticulture Section, College of Agriculture, Nagpur during *rabi* season of the year 2018-2019. The experiment was laid out in Factorial Randomized Block Design with 16 treatment combinations comprised with four different levels of nitrogen (0, 75, 100 and 125 kg ha^{-1}) and four different levels of phosphorus (0, 25, 50 and 75 kg ha^{-1}). The experiment comprised with sixteen treatments *viz.*, T_1 – 0 kg N/ha + 0 kg P/ha (N_0P_0), T_2 – 0 kg N/ha + 25 kg P/ha (N_0P_1), T_3 – 0 kg N/ha + 50 kg P/ha (N_0P_2), T_4 – 0 kg N/ha + 75 kg P/ha (N_0P_3), T_5 – 75 kg N/ha + 0 kg P/ha (N_1P_0), T_6 – 75 kg N/ha + 25 kg P/ha (N_1P_1), T_7 – 75 kg N/ha + 50 kg P/ha (N_1P_2), T_8 – 75kg N/ha + 75 kg P/ha (N_1P_3), T_9 – 100 kg N/ha + 0 kg P/ha (N_2P_0), T_{10} – 100 kg N/ha + 25 kg P/ha (N_2P_1), T_{11} – 100 kg N/ha + 50 kg P/ha (N_2P_2), T_{12} – 100 kg N/ha + 75 kg P/ha (N_2P_3), T_{13} – 125 kg N/ha + 0 kg P/ha (N_3P_0), T_{14} – 125 kg N/ha + 25 kg P/ha (N_3P_1), T_{15} – 125 kg N/ha + 50 kg P/ha (N_3P_2), T_{16} – 125 kg N/ha + 75 kg P/ha (N_3P_3). The field was prepared by ploughing and harrowing.

Flat beds of size 1.2 x 3.0 m were prepared and transplanting of 25 days old well developed and healthy seedling of calendula was done at spacing 30 cm x 30 cm.

Observations were recorded on plant height (cm), leaves plant^{-1}, branches plant^{-1} at 15 days interval, stem diameter (cm), leaf area (cm^2) and plant spread (cm) at 50 % flowering stage, flowering parameters *viz.*, days for first flower bud initiation from the date of transplanting (days), opening of first flower (days), 50 per cent flowering (days) were recorded at flowering time and flowering span (days)from first harvest to last harvest collected data were statistically analyzed as per method suggested by Panse and Sukhatme, (1967) [4].

Results and Discussion

Growth Parameter

Effect of nitrogen

The data presented in table 1 revealed that the application of nitrogen significantly influenced the growth parameters. Plant height (58.25 cm), stem diameter (0.76 cm), leaves plant^{-1} (177.36), leaf area (73.66 cm^2), branches plant^{-1} (37.60) and plant spread at 50 % flowering (45.56 cm) were recorded significantly maximum with the application of 100 kg nitrogen ha^{-1} which were at par with 125 kg nitrogen ha^{-1} at 90 DAT. Whereas, Plant height (53.55 cm), stem diameter (0.37 cm), leaves plant^{-1} (118.51), leaf area (52.23 cm^2), branches plant^{-1} (28.53) and plant spread at 50 % flowering (33.50 cm) were recorded minimum in control treatment. The increase in growth parameters by increasing the dose of nitrogen might be due to the fact that, nitrogen is a constituent of protein which is responsible for the formation of protoplasm, thus affecting cell division and cell enlargement and ultimately better growth. The results are in the close conformity with the result of Vijay Kumar *et al* (2015) [2]. They recorded that an application of nitrogen at 150 kg ha^{-1} had recorded maximum plant height, number of leaves, number of branches and plant spread in calendula. Gaikwad *et al*. (2004) [1] stated that an application of nitrogen at 150 kg ha^{-1} had recorded maximum stem diameter and leaf area in China aster.

Effect of phosphorus

The data presented in table 1 revealed that the application of phosphorus significantly influenced the growth parameters. Plant height (59.62 cm), stem diameter (0.61 cm), leaves plant^{-1} (154.0), leaf area (64.18 cm^2), branches plant^{-1} (34.85) and plant spread at 50 % flowering (40.52 cm) were recorded significantly maximum with the application of 50 kg phosphorus ha^{-1} at 90 DAT. Whereas, Plant height (535.14 cm), stem diameter (0.42 cm), leaves plant^{-1} (126.58), leaf area (52.14 cm^2), branches plant^{-1} (28.55) and plant spread at 50 % flowering (35.68 cm) were recorded minimum in control treatment. The increase in growth parameters by increasing the dose of phosphorus might be due to the role of phosphorus in structural component as in phospholipids and in absorbing and translocation of food material. The results are in the close conformity with the result of Vijay Kumar *et al* (2015) [2]. They recorded that an application of phosphorus at 50 kg ha^{-1} had recorded maximum plant height, number of leaves, number of branches and plant spread in calendula. Wani *et al*. (2013) [5] stated that an application of phosphorus at 50 kg ha^{-1} had recorded maximum stem diameter and leaf area in China aster.

Interaction effect

The data presented in table 1 indicated that the interaction effect of nitrogen and phosphorus on growth parameters was found to be significant. Plant height (62.33 cm), leaves plant^{-1} (177.36), leaf area (73.66 cm^2), branches plant^{-1} (37.60) and plant spread at 50 % flowering (45.56 cm) were recorded significantly maximum in treatment combination of nitrogen 100 kg and phosphorus 50 kg ha^{-1}.whereas, Plant height (51.76 cm), leaves plant^{-1} (106.16), leaf area (47.90 cm^2), branches plant^{-1} (24.31) and plant spread at 50 % flowering (32.23 cm) were recorded minimum in control treatment.

This might be due to the effect of nitrogen and phosphorus the synergistic effects of most of essential growth of plant in calendula. The findings are in conformity with the results of Kumar *et al*. (2015) [2] in calendula. They revealed that an application of nitrogen at 100 kg ha^{-1} in combination with phosphorus at 50 kg ha^{-1} recorded maximum growth parameters in calendula.

Table 1: Effect of nitrogen and phosphorus on growth parameters of calendula

Treatments	Plant height (cm) at 90 DAT	Stem diameter (cm)	Leaves plant^{-1} at 90 DAT	Leaf area (cm^2)	Branches plant^{-1} at 90 DAT	Plant spread (cm)
Nitrogen levels (N)						
N_0- 0 kg N ha^{-1}	53.55	0.37	118.51	52.23	28.53	33.50
N_1- 75 kg N ha^{-1}	57.84	0.45	131.54	54.37	30.64	35.74
N_2- 100 kg N ha^{-1}	58.25	0.63	157.63	65.09	34.98	42.06
N_3- 125 kg N ha^{-1}	57.94	0.62	156.23	64.16	32.82	40.13
SE (m) ±	0.35	0.02	2.54	0.89	0.33	0.56
CD at 5%	1.02	0.07	7.35	2.57	0.96	1.63
Phosphorus levels (P)						
P_0- 0 kg P ha^{-1}	55.14	0.42	126.58	52.14	28.55	35.68
P_1- 25 kg P ha^{-1}	55.68	0.47	136.94	57.02	30.13	36.25
P_2- 50 kg P ha^{-1}	59.62	0.61	154.08	64.18	34.85	40.52
P_3- 75 kg P ha^{-1}	57.13	0.58	146.41	62.52	33.64	38.98
SE (m) ±	0.35	0.02	2.54	0.89	0.33	0.56
CD at 5%	1.02	0.07	7.35	2.57	0.96	1.63
Interaction effect (NxP)						
N_0P_0	51.76	0.31	106.16	47.90	24.31	32.23
N_0P_1	52.50	0.37	115.96	52.93	27.93	33.23
N_0P_2	55.59	0.41	129.66	54.33	31.43	34.70
N_0P_3	54.36	0.40	122.66	53.78	30.46	33.83
N_1P_0	56.16	0.35	125.86	51.80	27.23	34.83
N_1P_1	57.66	0.45	132.00	53.93	30.10	35.23
N_1P_2	59.30	0.52	134.66	56.63	33.46	36.56

N_1P_3	58.25	0.50	133.66	55.13	31.76	36.33
N_2P_0	56.79	0.52	138.00	53.93	32.95	40.43
N_2P_1	58.11	0.54	155.53	62.70	33.25	41.00
N_2P_2	62.33	0.76	177.36	73.66	37.60	45.56
N_2P_3	55.76	0.71	159.66	70.06	36.15	41.26
N_3P_0	55.86	0.50	136.33	54.03	28.91	35.23
N_3P_1	54.45	0.53	144.30	58.53	29.25	35.53
N_3P_2	61.28	0.74	174.66	72.10	36.92	45.26
N_3P_3	60.16	0.72	169.66	71.10	36.20	44.50
SE (m) ±	0.86	0.06	5.24	2.18	0.81	1.38
CD at 5%	2.04	-	14.7	5.14	1.92	2.26

Table 2: Effect of nitrogen and phosphorus on flowering parameters of calendula

Treatments	Days for first flower bud initiation (days)	Days for opening of first flower (days)	Days for 50 per cent flowering (days)	Flowering span (days)
Nitrogen levels (N)				
N_0- 0 kg N ha^{-1}	62.29	7.71	80.19	62.70
N_1- 75 kg N ha^{-1}	53.36	5.93	77.42	65.02
N_2- 100 kg N ha^{-1}	45.26	4.96	67.88	72.23
N_3- 125 kg N ha^{-1}	47.16	5.06	68.29	71.94
SE (m) ±	0.98	0.19	1.47	1.01
CD at 5%	2.84	0.55	4.26	2.93
Phosphorus levels (P)				
P_0- 0 kg P ha^{-1}	55.33	6.53	78.36	65.13
P_1-25 kg P ha^{-1}	53.04	6.41	76.66	67.01
P_2-50 kg P ha^{-1}	49.79	4.99	66.14	71.05
P_3-75 kg P ha^{-1}	50.40	5.74	72.64	68.70
SE (m)±	0.98	0.19	1.47	1.01
CD at 5%	2.84	0.55	4.26	2.93

Flowering parameters

Effect of nitrogen

The data presented in table 2 revealed that the application of nitrogen significantly influenced the flowering parameters. days for first flower bud initiation (45.26 days), days for opening of first flower (4.96 days), days for 50 per cent flowering (67.88 days) and flowering span (72.23 days) were recorded early with an application of 100 kg nitrogen ha^{-1} which were at par with 125 kg nitrogen ha^{-1} . Whereas, days required for first flower bud initiation (62.29 days), days for opening of first flower (7.71 days), days for 50 per cent flowering (80.19 days) and flowering span (62.70 days) were recorded late in control treatment. The flowering parameters are early with 100 kg nitrogen ha^{-1}. The possible reason that highest number of days taken for flower bud opening with control may be due to the promotion of less vegetative growth by no nitrogen and results in the delaying in bud initiation. The results are in the close conformity with the result of Mili and Sable (2003) [3] in calendula.

Effect of phosphorus

The data presented in table 2 revealed that the application of phosphorus significantly influenced the flowering parameters. days for first flower bud initiation (49.79 days), days for opening of first flower (4.99 days), days for 50 per cent flowering (66.14 days) and flowering span (71.05 days) were recorded early with an application of 100 kg nitrogen ha^{-1} which were at par with 125 kg nitrogen ha^{-1}. Whereas, days required for first flower bud initiation (55.33 days), days for opening of first flower (6.53 days), days for 50 per cent flowering (78.36 days) and flowering span (65.13 days) were recorded late in control treatment. The flowering parameters are early with 50 kg phosphorus ha^{-1}. The possible reason that at with increasing dose phosphorus increases vegetative and reproductive growth results in early flower bud initiation. The results are in the close conformity with the result of Mili and Sable (2003) [3] in calendula.

Interaction effect

The data presented in table 2 indicated that the interaction effect of nitrogen and phosphorus on flowering parameters was found to be non significant.

Conclusion

The maximum vegetative growth *viz.* plant height, stem diameter, leaves $plant^{-1}$, leaf area, branches $plant^{-1}$ and plant spread were found with the individual application of N_2 (100 kg N ha^{-1}) and P_2 (50 kg P ha^{-1}). Significantly maximum plant height, leaves $plant^{-1}$, leaf area, branches $plant^{-1}$ and plant spread were observed in the treatment combination of N_2 P_2 (100 kg N ha^{-1} and 50 kg P ha^{-1}). The interaction effect of nitrogen and phosphorus levels on stem diameter was found non significant.

As regards flowering parameters *viz*., days for first flower bud initiation from the date of transplanting, days for opening of first flower, days for 50 per cent flowering and flowering span were found earlier with an individual application of N_2 (100 kg N ha^{-1}) and P_2 (50 kg P ha^{-1}). The interaction effect of nitrogen and phosphorus levels with respect to flowering parameters i.e. days for opening of first flower, days for 50 per cent flowering and flowering span were found non significant.

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