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Effect of Varying Levels of Fertilizer and Plant Geometry on Growth, Flowering and Yield of Calendula (*Calendula officinalis* L.)

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ABSTRACT

A field experiment was conducted during *Rabi* season of the year 2021-22 to know the effect of varying levels of fertilizers and plant geometry on growth, flowering and yield of calendula. The experiment was laid out in Factorial Randomized Block Design with two factors *i.e.* first one is inorganic fertilizers with four different levels *viz*., F_1 (120:45:45) (N:P:K Kg/ha); F_2 (96:36:36) (N:P:K Kg/ha); F_3 (80:30:30) (N:P:K Kg/ha); F_4 (64:24:24) (N:P:K kg/ha) and second is three levels of plant geometry *i.e.* S_1 (30 x 20 cm^2); S_2 (30 x 30 cm^2); S_3 (40 x 30 cm^2) which were subjected to twelve treatments and replicated thrice in each plot size of 1.2 x 1.5 m^2. The results divulged that growth attributes *i.e.* plant height (47.42 cm), number of leaves/plant (134.60) and branches/plant (14.01), was found maximum under F_1 (120:45:45 N: P: K Kg/ha). Among different spacing levels maximum flower diameter (7.13 cm), number of flowers/plant (84.00) and weight of flowers/plant (123.68 g) and maximum seed yield/plant (12.85 g) were augmented significantly under wider spacing *i.e*. S_3 (40 X 30 cm^2). Minimal days to 1st flowering (46.04 days) and earliest 50 % flowering (56.21d), utmost number of flowers/plot (1794.51), and weight of flowers/plot (3100.28 g), and 164.20 q/ha and yield attributes such as highest seed yield/plot (282.49 g) and per ha (15.40 q/ha) resulted with closer spacing of treatment S_1 (30 x 20 cm^2). In case of interaction number of flowers/plot (2025.42), and weight of flowers/plot (3513.50 g) and 194.75 q/ha, seed yield/plot (313.60 g) and 7.77 q/ha were noted significant under treatment combination of F_1S_1 (120:45:45 N:P:K Kg/ha + 30 X 20 cm^2).

Key Words: Calendula, Fertilizers, Plant Geometry, Growth Attributes, Flowering ,Yield.

INTRODUCTION

Calendula (*Calendula officinalis* L.) is one of the cultivated seasonal flowers, belongs to Asteraceae family. It is a tetraploid plant with 32 chromosomes (2n=4x=32) (Nora *et al*, 2013).

Fertilizers are chemical substances supplied to the crops to increase their productivity. Nitrogen has a greater influence on plant growth, quality and yield than any other element and its application enhances vegetative growth (Kashif *et al,* 2014). The fertilizers include the essential nutrients required by the plants, including nitrogen, potassium and phosphorus. Proper plant geometry plays an important role in increasing the growth, yield and quality of flower crops. Space available for individual plants primarily depends upon the light interception, rooting pattern and moisture extraction pattern. The present study was conducted to study the effect of varying levels of fertilizer and plant geometry on plant growth, flowering and yield of calendula.

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MATERIALS AND METHODS

The present investigation was carried out at the field of KVK Ajirma, during *Rabi* season of the year 2021-22. The experiment was laid out in Factorial Randomized Block Design with two factors *i.e.* first one is inorganic fertilizers with four different levels *viz*., F_1 (120:45:45) (N:P:K Kg/ha); F_2 (96:36:36) (N:P:K Kg/ha); F_3 (80:30:30) (N:P:K Kg/ha); F_4 (64:24:24) (N:P:K Kg/ha) and second is three levels of plant geometry *i.e.* S_1 (30 x 20 cm^2); S_2 (30 x 30 cm^2); S_3 (40 x 30 cm^2) which were subjected to twelve treatments and replicated thrice with 36 Number of plots and plot size of 1.2 x 1.5 m^2.

Physio-chemical analysis of the soil was done before the start of the experiment. The 25 days old well established, healthy and diseased free seedling of calendula var Bon Bon yellow having 3-4 fully opened leaves were transplanted in the main research plot with full dose of phosphorus, potassium and 1/3rd nitrogen as basal dose at the time of transplanting. The remaining 2/3rd nitrogen were applied as top dressing at 30 and 60 days after transplanting. The experimental field was kept free from weed by periodic hand weeding. Protective irrigations were given as and when required during crop growth period. Weeding was done with the help of hand hoe after 25-30 & 55-60 days of planting. Earthing-up was done at 30 and 60 DAT. The observations were recorded on various vegetative; floral and yield attributes of calendula and statistical data were analysed as per the method of analysis of variance.

RESULTS AND DISCUSSION

Growth parameters

Effect of varying levels of fertilizer

The highest Plant height (47.42 cm), number of leaves/plant (134.60), number of branches/ plant (14.01) and spread of plant (cm) in both the direction *i.e.* (North - South) (51.69 cm) and (East - West) (44.57 cm) were significantly influenced by the application of fertilizers (Table 1) maximum growth of all the vegetative parameters were noted under higher dose of fertilization *viz*., F_1 (120:45:45 N:P:K Kg/ha). Whereas, least vegetative growth was recorded in F_4 (64:24:24 N:P:K Kg/ha). The increase in growth parameters by increasing the dose of fertilizers might be due to the constituent of proteins which is responsible for the formation of protoplasm, thus affecting cell division along with enlargement of cells resulting in better growth. The results were in close conformity with the result of Kumar *et al* (2015) in calendula; Gaikwad *et al* (2004) in China aster.

Effect of plant geometry

Statistically significant results were obtained for growth parameters as it was clear (Table 1) that highest spread of plant (North - South) (49.88 cm) and (East - West) (42.78 cm), number of leaves/ plant (132.58) and branches per plant (11.62) were recorded under wider spacing *i.e*. S_3 (40 X 30 cm^2), followed by S_2 (30 x 30 cm^2). These parameters recorded significant with wider spacing, might be due to availability of more space and light for plant growth, which ultimately turned into producing more vigorous growth of plant under this treatment. Similar findings were reported by Chaturvedi *et al* (2010) and Tiwari *et al* (2010) in African marigold and Kumar and Singh (2011); Berimavandi *et al* (2011) in calendula. Conversely**,** the closer spacing of 30 x 20 cm^2 recorded with maximum plant height (45.44 cm). An increase in the plant height under closer spacing in calendula was also reported by Srivastava *et al* (2002); Kumar *et al* (2011); Kumar *et al* (2017); Meena *et al* (2015). The increase in plant height at the closer spacing was mainly due to the fact that closely spaced plants tend to grow vertically for more light, air and space, therefore height of the plant increases with reduce in spacing.

Interaction effect of varying levels of fertilizer and plant geometry

Combination of fertilizers and plant geometry (Table 1) at different levels responded significantly and resulted with maximum plant height (54.90 cm) under F_1S_1 (120:45:45 N:P:K Kg/ha + 30 X 20 cm^2). Under these treatments plant height

Table 1. Effect of varying levels of fertilizer, plant geometry and their interaction on vegetative and floral attributes

Treatments	Plant height (cm) at 90 DAT	Number of leaves/plants at 90 DAT	Number of branches/ plants at 90 DAT	Plant spread (North-South)	Plant spread (East-West)	Days taken to 1st flower	Days to 50% flowering	Flower diameter (cm)	Flower longevity (Days)	Flowering duration (Days)
F1	47.42	134.60	14.01	51.69	44.57	43.87	54.62	7.90	15.05	72.76
F2	42.15	130.31	11.10	50.74	41.51	47.15	59.29	7.08	13.27	68.00
F3	41.74	124.06	10.01	46.25	39.26	48.33	61.29	6.98	12.26	66.59
F4	37.92	119.57	9.22	44.85	36.25	54.48	62.22	5.78	11.11	60.28
SEm±	0.83	0.54	0.31	0.74	0.73	0.77	0.57	0.09	0.30	0.75
CD(0.05)	2.45	1.58	0.92	2.17	2.15	2.28	1.68	0.26	0.89	2.19
S1	45.44	123.31	9.88	46.55	36.51	46.04	56.21	6.83	11.84	64.20
S2	41.26	125.53	10.61	48.71	40.32	51.09	58.93	6.84	12.88	66.11
S3	40.22	132.58	11.62	49.88	42.78	52.57	62.94	7.13	14.05	66.20
SEm±	0.72	0.46	0.27	0.64	0.63	0.67	0.49	0.078	0.26	0.64
CD(0.05)	2.12	1.37	0.80	1.88	1.86	1.97	1.46	0.22	0.77	1.90
F1S1	54.90	130.85	10.64	41.21	41.49	41.41	46.37	8.44	16.75	69.29
F1S2	46.07	131.69	10.43	54.55	42.14	48.58	58.36	6.72	12.54	76.48
F1S3	41.28	141.26	15.42	59.30	48.01	41.62	59.14	8.53	15.85	72.52
F2S1	47.33	128.74	11.01	56.16	43.37	50.15	56.80	6.71	10.40	66.89
F2S2	40.16	129.82	10.80	49.52	41.53	40.89	61.67	6.63	14.83	70.56
F2S3	38.96	132.38	11.48	46.53	39.63	50.40	59.42	7.89	14.59	66.56
F3S1	41.42	121.34	10.82	46.18	42.22	48.46	58.48	7.01	11.47	60.44
F3S2	41.22	119.27	10.87	48.04	40.81	52.53	58.81	7.15	11.87	70.00
F3S3	42.57	131.56	10.67	44.53	40.24	61.31	66.57	6.76	13.44	69.33
F4S1	38.10	112.29	10.23	42.67	35.64	44.14	63.18	5.13	8.74	60.17
F4S2	37.59	121.33	10.35	42.73	36.81	62.35	56.87	5.05	12.27	64.31
F4S3	38.07	125.10	10.57	49.15	43.25	56.97	66.62	7.16	12.33	56.38
SEm±	1.45	0.94	0.55	1.28	1.27	1.35	1.00	0.16	0.53	1.30
CD(0.05)	4.25	2.74	1.60	3.76	3.73	3.95	2.93	0.46	1.55	3.81

Table 2. Effect of varying levels of fertilizer, plant geometry and their interaction on floral and yield attributes

Treatments	Number of flowers per plant	Number of flowers per plot	Number of flowers per ha (Lakhs)	Flower weight per plant (g)	Flower weight per plot (g)	Flower weight per ha (q/ha)	Seed yield per plant (g)	Seed yield per plot (g)	Seed yield (q/ ha)
F1	87.48	1721.97	100.54	130.47	2713.15	153.28	13.60	256.30	14.27
F2	77.56	1577.49	84.57	110.22	2362.46	130.68	12.75	231.59	12.83
F3	76.29	1463.74	82.18	107.39	2340.37	128.04	11.26	196.25	10.89
F4	75.87	1403.07	82.22	106.74	2202.72	106.55	10.01	189.65	10.03
SEm±	1.11	24.26	1.32	1.84	42.42	2.04	0.18	3.53	0.19
CD(0.05)	3.25	71.17	3.88	5.39	124.42	5.99	0.53	10.35	0.56
S1	74.33	1794.51	102.73	104.92	3100.28	164.20	10.87	282.49	15.40
S2	79.57	1580.10	88.77	112.53	2216.07	115.87	12.01	208.36	11.51
S3	84.00	1250.10	70.63	123.68	1897.67	111.90	12.85	164.49	9.11
SEm±	0.96	21.01	1.14	1.59	36.74	1.77	0.16	3.06	0.17
CD(0.05)	2.82	61.64	3.36	4.66	107.75	5.19	0.46	8.96	0.49
F1S1	81.00	2025.42	127.19	117.45	3513.50	194.75	11.20	313.60	17.77
F1S2	86.70	1725.00	95.83	125.31	2466.20	141.23	14.10	253.80	13.88
F1S3	94.75	1415.50	78.60	148.65	2159.75	123.85	15.50	201.50	11.16
F2S1	71.80	1966.97	95.83	102.25	3025.14	164.73	12.14	303.78	16.83
F2S2	75.82	1505.00	87.61	105.18	2154.03	121.18	12.89	219.13	12.16
F2S3	85.07	1260.50	70.27	123.23	1908.21	106.14	13.22	171.86	9.50
F3S1	75.50	1731.23	94.26	103.70	2904.69	174.12	10.22	245.28	13.61
F3S2	76.90	1525.00	84.72	108.05	2330.21	100.65	11.01	180.18	10.00
F3S3	76.48	1189.00	67.56	110.42	1786.22	109.34	12.56	163.28	9.05
F4S1	69.03	1454.40	93.66	96.26	2957.81	123.18	9.90	267.30	13.37
F4S2	78.87	1565.40	86.94	111.57	1913.84	100.43	10.02	180.34	10.00
F4S3	79.70	1135.40	66.07	112.40	1736.50	98.21	10.11	121.32	6.72
SEm±	1.93	42.04	2.30	3.18	73.48	3.54	0.32	6.11	0.33
CD(0.05)	5.65	123.29	6.73	9.33	215.50	10.38	0.93	17.93	0.98

grew vertically more upright due to less space and higher uptake of nutrients. The similar results had been reported by Kumar and Singh (2011). Though, plant spread (North - South) (59.30 cm) (East - West) (48.01 cm), number of branches per plant (15.42) and leaves/plant (141.26) were noted significantly maximum with F_1S_3 (120:45:45 N:P:K Kg/ha + 40 x 30 cm^2). Assimilation of more space and higher nutrients (N:P:K) under these treatment combinations were able to get more sunlight, space management and better utilization of available resources for overall plant growth which resulted into vigorous vegetative growth of plants. The treatment combination F_4S_1 (64:24:24 N:P:K Kg/ ha + 30 x 20 cm^2) was significantly inferior to remaining treatment combinations.

Flowering parameters

Effect of varying levels of fertilizer

Different levels of fertilizer application resulted with significant result as least days taken to commencement of 1st flower (43.87) and earliest 50 % flowering (54.62) were found under F_1(120:45:45 N:P:K Kg/ha) (Table 1). While, floral parameters such as, flower diameter (7.90 cm), stalk length (8.56 cm), flower longevity (15.05), flowering duration (72.76), number of flowers/plant (87.48), per plot (1721.97) and per ha (100.54) and weight of flowers/plant (130.47 g), per plot (2713.15 g) and per ha (153.28 q ha^{-1}) were recorded significantly maximum under F_1 (120:45:45 N:P:K Kg/ha), followed by F_2 (96:36:36 N:P:K Kg/ha) treatment. It is evident from the result that delay in flowering under lower fertilization due to less vegetative growth may be the possible reason, which resulted in delayed flowering. Similar results were noticed by Patel *et al* (2017) in bird of paradise; Samoon *et al* (2018); Maheta *et al* (2016) in China aster.

Effect of plant geometry

It was founded that minimal days to 1st flowering (46.04 days) and 50 % flowering (56.21) was resulted in closer spacing of treatment S_1 (30 x 20 cm^2). Nevertheless, maximum flower diameter (7.13 cm), flower longevity (14.05), number of flowers/plant (84.00) and weight of flowers/plant (123.68 g) were noted significant with wider spacing S_3 (40 x 30 cm^2). Non-significant results were noted for stalk length (cm) and time taken to bloom (d). Delay in flowering was recorded under wider spacing of 40 x 30 cm^2; this might be due to increased, vigor and enhanced vegetative growth of calendula plants under this treatment which eventually delayed flowering. The similar results were also recorded by Beniwal *et al* (2005) and Kour (2009) in chrysanthemum. In the same way, utmost number of flowers/plot (1794.51) (Table 2), flowers/ha (102.73) and weight of flowers/plot (3100.28 g), per ha (164.20 q/ha) (Table 2) were found under closer spacing of S_1 (30 x 20 cm^2). This might be recognized as closer spacing resulted in the production of more number and weight of flowers per plot and per ha due to accommodation of maximum number of plants per unit area as compared to wider spacing. Similar findings were evaluated by chaturvedi *et al* (2010) in marigold.

Interaction effect of varying levels of fertilizer and plant geometry

The interaction effect on floral parameters earliest days (40.89) taken to 1st flower were recorded in F_2S_2 (96:36:36 N: P: K Kg/ha + 30 x 30 cm^2). Although, flowering duration of calendula flower on plant was recorded significantly maximum (76.48) with the treatment combination F_1S_2 (120:45:45 N:P:K Kg/ha + 30 x 30 cm^2). The treatment combinations F_1S_1(120:45:45 N:P:K Kg/ha + 30 x 20 cm^2) was noted with least (46.37) number of days to 50% flowering along with maximum days to flower longevity (16.75), number of flowers/plot (2025.42), per ha (127.19) and weight of flowers/ plot (3513.50 g), per ha (194.75 q/ha), This was due to the combined effect of varying levels of fertilizer and different levels of spacing which influenced early vegetative growth along with physiological maturity of plants due to which maximum number of bud formation occurred.

On the other hand, treatment combinations F_1S_3 (120:45:45 N:P:K Kg/ha + 40 x 30 cm^2) was resulted maximum diameter of flower (8.53 cm), number of flowers/plant (94.75) (Table 2) and weight of flowers/plant (148.65 g) (Table 2). The treatment combinations F_4S_3 (64:24:24 N:P:K Kg/ha + 40 x 30 cm^2) was significantly inferior to remaining treatment combinations with respect to days taken to 50 % flowering, flower diameter (cm), duration of flowering, number of flowers and weight of flowers per plot and per ha.

Yield parameters

Effect of varying levels of fertilizer

Yield attributing characters resulted significantly (Table 2) such as seed yield per plant (g), per plot (g) and q/ha. The maximum seed yield/plant (13.60 g), per plot (256.30 g) and per ha (14.27 q/ha) was obtained under F_1 (120:45:45 N:P:K Kg/ha).

Effect of plant geometry

Yield attributing characters (Table 2) the maximum seed yield/plant (12.85 g), was obtained under wider spacing of S_3 (40 x 30 cm^2) treatment. Although, highest seed yield/plot (282.49 g) and per ha (15.40 q/ha) were found with closer spacing S_1 (30 x 20 cm^2) due to accumulation of maximum plants per unit area. This might be due the improvement in morphological characteristics and enhancement in vegetative growth which resulted with increased flowering along with maximum seed production under the application of balanced fertilizers

Interaction effect of varying levels of fertilizer and plant geometry

Combined effect of fertilizers and spacing (Table 2) showed significantly maximum yield of seed per plant (15.50 g) under the treatment combination of F_1S_3 (120:45:45 N:P:K Kg/ha + 40 x 30 cm^2). However, F_1S_1 (120:45:45 N:P:K Kg/ha + 30 x 20 cm^2) treatment combination recorded with maximum seed yield per plot (313.60 g) and per ha (17.77 q/ha). The treatment combination F_4S_3 (64:24:24 N:P:K Kg/ha + 40 x 30 cm^2) was noted significantly inferior to seed yield per plot and q/ha. Combined effect of fertilizers and plant geometry played significant role in overall development of the plant and increased their vegetative growth due to which positive result was obtained from seed yield/plant, per Plot and per ha of overall plant.

CONCLUSION

It may be concluded that that the interactive effect of fertilizers and plant geometry in F_1S_1 (120:45:45 N:P:K Kg/ha + 30 X 20 cm^2) was found satisfactory for highest number and weight of flowers per plot, per ha and seed yield per plot and per ha. In sort of obtaining higher benefit in northern hilly regions of Chhattisgarh for better quality of flowers and maximum flower and seed yield, interaction effect of higher dose of fertilizer application is important factor along with plant geometry for commercial cultivation of calendula.

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