Effect of nitrogen and potassium on growth and flowering of *Calendula officinalis.*

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ABSTRACT

The investigation entitled "Effect of nitrogen and potassium on growth and flowering of *Calendula officinalis"* was carried out in the Agri-farm of the Department of Horticulture, School of Agriculture, Lovely Professional University, Punjab, India, during 2022 - 2023. The experiment consists of 16 different treatments with three replications and was laid out in a randomized block design. The treatments included T1: (Control), T2 (10gN + 10gK/m^2), T3 (15gN + 10gK/m^2), T4 (20gN + 10gK/m^2), T5 (25gN + 10gK/m^2), T6 (30gN + 10gK/m^2), T7 (10gN + 20gK/m^2), T8 (15gN + 20gK/m^2), T9 (20gN + 20gK/m^2), T10 (25gN + 20gK/m^2), T11 (30gN + 20gK/m^2), T12 (10gN + 30gK/m^2), T13 (15gN + 30gK/m^2), T14 (20gN + 30gK/m^2), T15 (25gN + 30gK/m^2), T16 (30gN + 30gK/m^2). Significant differences were observed among different treatments for various vegetative and flowering parameters. Among various parameters, maximum plant height (84.16 cm), stem diameter (8.59 mm), flowering duration (38.66 days) and minimum days for flower bud initiation (46 days) and minimum days for 50% of flowering (91 days) were recorded in treatment T15 (25gN + 30gK/m^2). Whereas maximum numbers of branches per plant (12.55), leaves per plant (50.33), flowers per plant (128.33), flowers per meter square(1540), maximum individual flower weight (1.91g) and flower yield (2941.4 g/m^2) were reported in treatment T4 (20gN + 10gK/m^2). It was concluded that flowering and yield calendula plants be fertilized with N and K @ 20 and 10g/m^2 for better growth, respectively.

Keywords: Pot marigold, plant height, flower yield, flowering duration, vase life.

1. INTRODUCTION

Calendula officinalis L. (pot marigold) is an important ornamental and therapeutic crop and is growth as winter season annual flower cropping part of the world. This crop bears yellow to orange color head inflorescence. It is native to the Mediterranean climate areas [1]. Calendula flowers have antioxidant activities, and it is utilized as an efficient drug in the treatment of lung adenocarcinoma in humans [2]. These flowers are rich in lutein pigment and have become an important cultivated plant for local use and export [3]. For good growth and development of flower crops proper fertilizer application especially phosphorus, nitrogen and potassium are very important. However, using intense chemical fertilization causes serious health problems [4] so using recommended dose is important. Potassium fertilizer plays an important role in movement of carbohydrate, water and nutrition in plant tissue, production of ATP, photosynthesis regulation and opening and closing of stomata. Deficiency of this nutrient in plants leads to stunting and less yield. Nitrogen is an important constituent of protein and chlorophyll and therefore optimum dose of nitrogen in plants leads to good vegetative growth and flowering. Less fertilizer in soil or in plant systems leads to deficiency symptoms and lower yield,

whereas excess NPK leads to toxicity in soil and plants and can have a detrimental effect on plant growth. Therefore, it is very important to use the optimum dose of NPK fertilizer for plant growth and development. Limited studies on nutrient uptake on calendula, in the present experiment, the combined effect of different doses of N and K on calendula growth, predominantly focuses on macro-level assessments, such as growth and flowering parameters.

MATERIAL AND METHOD.

The present research work entitled "Effect of nitrogen and potassium on growth and flowering of *Calendula officinalis*" was carried out in the Agri-farm of the Department of Horticulture, School of Agriculture, Lovely Professional University, Punjab, India. The soil of the experimental plot was well prepared by repeated ploughing followed by planking to obtain fine tilth. The experiment consists of 16 different treatments with three replications and was laid out in a randomized block design. The treatments included T1: (Control), T2 (10gN + 10gK/m^2), T3 (15gN + 10gK/m^2), T4 (20gN + 10gK/m^2), T5 (25gN + 10gK/m^2), T6 (30gN + 10gK/m^2), T7 (10gN + 20gK/m^2), T8 (15gN + 20gK/m^2), T9 (20gN + 20gK/m^2), T10 (25gN + 20gK/m^2), T11 (30gN + 20gK/m^2), T12 (10gN + 30gK/m^2), T13 (15gN + 30gK/m^2), T14 (20gN + 30gK/m^2), T15 (25gN + 30gK/m^2), T16 (30gN + 30gK/m^2). Phosphorus @10g/m^2 was applied uniformly for all the treatments [5]. Fertilizer was given in a two-split dose. The first dose was applied on the day of planting and the second dose was given 45 days after transplanting. Data was analyzed in ICAR, GOA WASP web-based agricultural statistics software package. The critical difference values were calculated at 5 percent level of significance.

RESULTS AND DISCUSSION

Vegetative parameters

Plant height

The maximum plant height after 60 days of transplantation (16.55 cm) was recorded in T14 (20gN +30gK/m^2), this treatment was found to be statistically at par with treatment T4 (20gN +10gK/m^2) and T15 (25gN + 30gK/m^2) with a plant height of 15.66cm and 15.55cm respectively. This treatment was followed by T3(15gN + 10gK/m^2) with a plant height of 14.29 cm. The minimum plant height (11.66 cm) was recorded in the T1 (control). Maximum plant height after 90 days of transplanting was noted (46.44cm) in T14 (20gN +30gK/m^2) and T9 (20gN + 20gK/m^2), which was found to be statistically at par with treatment T8 (15gN +20K/m^2), T10 (25gN +20gK/m^2), T15 (25gN + 30gK/m^2) and T13 (15gN + 30gK/m^2) with a plant height of 45.11cm, 44.77cm, 44.44cm and 43.44cm respectively, while minimum plant height (31.16 cm) was recorded in the T1 (control). Maximum plant height after 120 days of transplanting (84.16 cm) was recorded in T15 (25gN + 30gK/m^2) which was found to be statistically at par (78.33 cm) with T5 treatment (25gN + 10gK/m^2). While a minimum plant height of (53.83 cm) is recorded in T1 i.e., control (table 1).

Number of branches per plant

The maximum number of branches per plant (12.55) was recorded in treatment T4 (20g N + 10g K/m^2), this treatment was found to be statistically at par with treatment T9 (20gN+ 20gK/m^2), T14 (20gN + 30gK/m^2) and T15 (25gN + 30gK/m^2). The number of branches per plant in these treatments was recorded as 11.51, 11.37 and

11.12 respectively. The minimum number of branches per plant (8.77) was recorded in treatment T6 (30gN + 10gK/m^2) and, this treatment was found to be statistically at par (8.88) with Treatment T1 i.e., control (Table 2).

Stem diameter

The maximum stem diameter (8.59mm) was recorded in treatment T15 (25g N + 30g K/m^2), this treatment was found to be statistically at par with treatment T14 (20gN+ 30gK/m^2), T5 (25gN + 10gK/m^2), T13 (15gN + 30gK/m^2), T4(20gN + 10gK/m^2), T10 (25gN +20gK/m^2), T9(20gN +20K/m^2), T8(15gN +20gK/m^2) and T16(30gN + 30gK/m^2). The stem diameter in these treatments was recorded as 8.52mm, 8.46mm, 8.43mm, 8.39mm, 8.15mm, 8.13mm, 8.08mm, and 7.92mm respectively. Minimum stem diameter (6.37mm) was recorded in treatment T1 i.e., control (Table 2).

Number of leaves per plant

The maximum number of leaves per plant (50.33) was recorded in treatment T4 (20g N + 10g K/m^2), this treatment was found to be statistically superior to all other treatments. The minimum number of leaves per plant (22.33) was recorded in treatment T1 i.e., control (Table 2).

Leaf area

The maximum leaf area (34.92 cm^2) was recorded in treatment T10 (25gN + 20gK/m^2), this treatment was found to be statistically superior to all other treatments. The minimum leaf area (15.83cm2) was recorded in treatment T1 i.e., control (Table 2).

A perusal of data presented in Table 1 and Table 2 shows that different combined doses of nitrogen and potassium have notably influenced the various growth parameters. Vegetative growth increased gradually with a corresponding increase in N and K doses, and it decreases in the highest concentration of combined N and K. The results, in general, agree with the findings, increasing trend in plant growth parameters with increasing levels of nitrogen at 60 DAT, they recorded significantly highest plant height, number of primary branches, number of secondary branches per plant and plant spread when nitrogen applied at 200 kg N/ha [6]. Nitrogen is needed for vegetative growth and low nitrogen and high potassium level promotes flowering resulting in maximum flower yield [7]. Levels of NPK caused significant effects on plant height, number of leaves and flowers. The best result of plant height was obtained from 0.75 g. kg^{-1} NPK. However, the highest number of leaves and flowers was observed from 0.50 g. kg^{-1} NPK [8].

Flowering Parameters

Number of days to flower bud initiation

The minimum number of days for flower bud initiation was observed (46 days) in the treatment T15 (25gN + 30gK/m^2), which was found to be statistically superior to all other treatments. While the maximum days to initiation of flower bud was recorded (56 days) in the treatment T1 i.e., control (Table 3).

Number of days for first flowering

The minimum number of days to first flowering (64 days) was recorded in the treatment T15 (25gN + 30gK/m^2) which was found to be statistically superior to all other treatments. While late flowering (74.33) was observed in T1 i.e., control (Table 3)

Number of days for 50% flowering

The minimum number of days to 50% flowering (91 days) was observed in the treatment T15 (25gN + 30gK/m^2), which was found to be statistically superior to all other treatments. While maximum days for 50% of flowering (104.66) were observed in the treatment T1 i.e., control (Table 3).

Flower diameter

The maximum flower diameter (15.25cm) was noted in treatment T10 (25gN +20gK/m^2), which was found to be statistically at par with (14.41cm) treatment T4 (20gN +10Kg/m2). While the minimum flower diameter was noted as 7.60cm in T1 i.e., control (Table 3).

Flower weight

The maximum flower weight (1.91g) was recorded in treatment T4 (20g N + 10g K/m^2), which was found to be statistically superior to all other parameters. The minimum flower weight (0.98g) was recorded in treatment T1 i.e., control (Table 3).

Number of flowers per plant

Among different treatments T4 (20g N + 10g K/m^2) recorded the maximum number of flowers per plant (128.33), this treatment was found to be statistically superior to all other treatments. While treatment T1 i.e., control recorded the lowest number of flowers (55.66) (Table 4).

Number of flowers per meter square

Among different treatments T4 (20g N + 10g K/m^2) recorded the maximum number of flowers per meter square (1540), which was found to be statistically superior to all other treatments. While treatment T1 i.e., control recorded the lowest number of flowers (668) (Table 4).

Flower yield per meter square

Among different treatments T4 (20g N + 10g K/m^2) reported maximum flowers yield per meter square (2941.40 g/m2) which was found to be statistically superior to all other treatments. While treatment T1 i.e., control recorded minimum yield per meter square (654.64 g/m2) (Table 4).

Vase life

The maximum vase life is noted in treatment T9 (20gN +20gK/m^2) with a vase life of 6.32 days, which was found to be statistically at par with treatment T10 (25gN +20gK/m^2), T4 (20gN +10gK/m^2), T14 (20gN + 30gK/m^2), T11 (30gN +20gK/m^2). The vase life of flowers in these treatments was recorded as 6.45 days 6.32

days, 6.40 days, and 5.80 days respectively. While minimum vase life was noted in T1 i.e., control as (4.16 days) (Table 4).

Flowering duration

The maximum flowering duration was observed (68.66 days) in T15 (25gN + 30gK/m^2) which is statistically par with T5 (25gN + 10gK/m^2) with a duration of 66.33 days. While the minimum flowering duration (52.66 days) was observed in the treatment T1 i.e., control (Table 4).

A perusal of the data presented in Table 3 shows that different combined doses of N and K have remarkably influenced the various flowering parameters. The flowering parameter increased gradually with nitrogen and potassium doses, and it decreased in the highest concentration of combined N and K whereas good result was found in the medium fertilizer doses. The results in general agree with the finding's, good flowering parameter was observed when calendula crops were with a fertilizer dose of 120:45:45 N:P: K Kg/ha [9]. Application of 90-40-90 kg NPK/ha along with a blanket dose of 2 kg B and 4 kg Zn ha^1 showed the best performance for marigold production [10]. Minimum days required for first flowering is with nitrogen at 150 kg N/ha that is 64.55 days [11].

A perusal of the data presented in Table 4 shows that different combined doses of N and K have notably influenced the various flowering. Flowering parameters increase gradually in N and K combined doses, and it decreases in the highest concentration of combined N and K. The results in number generally agree with the findings, maximum number of buds per plant, of flowers per plant and duration of flowering was recorded with 30g N/m^2 [12]. Minimum days to flowering with the application of nitrogen (120 kg N/ha) and potassium (30 kg K/ha) [13]. Nitrogen had a significant effect on floral parameters with nitrogen at 150 kg/ha recording significantly maximum flower weight, number of flowers per plant and flower yield [14]. Application of 90-40-90 kg NPK/ha along with blanket dose of 2 kg B and 4 kg Zn/ha showed the best performance for marigold production [15].

Table 1. Effect of combined application of nitrogen and potassium on plant height of *Calendula officinalis* at 60, 90 and 120 days after transplanting.

Treatments	Plant height at 60 days after transplanting	Plant height at 90 days after transplanting	Plant height at 120 days after transplanting
T1	11.66^{fg}	31.81^{g}	53.83^{g}
T2	14.10^{cd}	38.25^{bc}	61.83^{f}
T3	14.29^{bc}	41.33^{cde}	70.16^{cde}
T4	15.66^{a}	42.77^{bcd}	71.83^{bcd}
T5	13.22^{cde}	37.33^{f}	78.33^{ab}
T6	12.10^{efg}	36.44^{f}	75.00^{bc}
T7	11.55^{g}	42.66^{bcd}	68.16^{cdef}
T8	12.88^{def}	45.11^{ab}	68.50^{cdef}
T9	14.22^{c}	46.44^{a}	70.66^{cde}
T10	13.87^{cd}	44.77^{abc}	72.66^{bcd}
T11	12.33^{efg}	39.44^{def}	72.33^{bcd}
T12	11.44^{g}	42.11^{bcd}	64.00^{ef}
T13	11.77^{fg}	43.44^{abc}	66.00^{def}
T14	16.55^{a}	46.44^{a}	70.50^{cde}
T15	15.55^{ab}	44.44^{abc}	84.16^{a}
T16	12.33^{efg}	42.77^{bcd}	72.33^{bcd}
CD at 5% (0.05)	1.27	3.52	7.01

Table 2. Effect of combined application of nitrogen and potassium on the number of branches per plant, stem diameter, number of leaves per plant and leaf area of *Calendula officinalis*.

Treatments	Number of branches per plant	Stem diameter (mm)	Number of leaves per plant	Leaf area (cm^2)
T1	8.88^{de}	6.37^{f}	22.33^{j}	15.83^{k}
T2	10.77^{bc}	7.17^{def}	27.66^{h}	22.08^{j}
T3	11.00^{bc}	7.53^{bcde}	31.33^{g}	24.68^{i}
T4	12.55^{a}	8.39^{ab}	50.33^{a}	26.58^{fgh}
T5	9.88^{cde}	8.46^{ab}	41.00^{b}	27.84^{ef}
T6	8.778^{e}	7.32^{cdef}	38.00^{cd}	24.66^{i}
T7	10.33^{bcd}	7.17^{def}	25.66^{hi}	29.50^{de}
T8	10.88^{bc}	8.08^{abcd}	34.66^{ef}	30.99^{cd}
T9	11.51^{ab}	8.13^{abcd}	35.66^{de}	32.87^{b}
T10	10.84^{bc}	8.15^{abc}	41.33^{b}	34.92^{a}
T11	10.74^{bc}	7.88^{abcde}	39.33^{bc}	31.95^{bc}
T12	10.07^{bc}	7.11^{ef}	28.00^{h}	21.53^{j}

T13	10.33^{bcd}	8.43^{ab}	31.66^{g}	24.86^{hi}
T14	11.37^{ab}	8.52^{a}	32.33^{fg}	26.03^{ghi}
T15	11.12^{abc}	8.59^{a}	25.66^{hi}	30.96^{cd}
T16	10.22^{bcde}	7.92^{abcde}	24.66^{ij}	26.70^{fg}
CD at 5% (0.05)	1.45	0.96	2.92	1.74

Table 3. Effect of combined application of nitrogen and potassium on number of days for flower bud initiation, number of days for first flowering, number of days for 50% flowering, flower diameter and flower weight of *Calendula officinalis.*

Treatments	**Number of days to flower bud initiation**	**Number of days for first flowering**	**Number of days for 50% of flowering**	**Flower diameter (cm)**	**Flower weight (g)**
T1	56.00^{a}	74.33^{a}	104.66^{a}	7.60^{i}	0.98^{g}
T2	54.00^{cd}	72.33^{abc}	99.00^{bc}	8.60^{gh}	1.02^{fg}
T3	49.66^{fgh}	69.33^{bcd}	96.33^{d}	10.12^{e}	1.31^{bc}
T4	49.00^{ghi}	68.00^{cde}	95.00^{de}	14.41^{ab}	1.91^{a}
T5	48.33i	66.66^{de}	93.66^{e}	13.26^{c}	1.46^{b}
T6	56.33^{a}	74.00^{a}	101.00^{b}	8.53^{gh}	1.23^{cd}
T7	54.66^{bc}	72.00^{abc}	99.00^{bc}	9.69^{ef}	1.04^{efg}
T8	53.00^{de}	70.00^{abcd}	97.00^{cd}	11.87^{d}	1.22^{cde}
T9	50.66^{f}	69.33^{bcd}	96.33^{d}	13.77^{bc}	1.31^{bc}
T10	48.66^{hi}	67.33^{de}	95.00^{de}	15.25^{a}	1.17^{cdef}
T11	55.33^{ab}	73.33^{ab}	97.33^{cd}	11.28^{d}	1.09^{defg}
T12	52.66^{e}	70.33^{abcd}	96.33^{d}	7.57^{i}	1.04^{efg}
T13	50.33^{f}	69.00^{bcd}	96.00^{de}	7.89^{hi}	1.10^{defg}
T14	49.00^{ghi}	66.00^{de}	93.66^{e}	8.44^{ghi}	1.44^{b}
T15	46.00^{j}	64.00^{e}	91.00^{f}	9.23^{efg}	1.29^{bc}
T16	50.00^{fg}	70.33^{abcd}	101.00^{b}	9.06^{fg}	1.25^{cd}
CD at 5% (0.05)	1.17	4.46	2.59	0.89	0.18

Table 4. Effect of combined application of nitrogen and potassium on the number of flowers per plant, number of flowers per meter square, flower yield per meter square, vase life, and flowering duration of *Calendula officinalis.*

Treatments	**Number of flowers per plant**	**Number of flowers per meter square**	**Flower yield per meter square (g)**	**Vase life (days)**	**Flowering duration (days)**
T1	55.66^{f}	668.00^{f}	654.64^{l}	4.16^{i}	52.66^{i}
T2	70.66^{e}	848.00^{e}	864.96^{k}	4.29^{hi}	56.33^{h}
T3	96.00^{bc}	1152.00^{bc}	1509.12^{cde}	5.43^{def}	61.66^{def}
T4	128.33^{a}	1540.00^{a}	2941.40^{a}	6.32^{abc}	64.00^{bcd}
T5	97.66^{bc}	1172.00^{bc}	1711.12^{b}	5.70^{bcd}	66.33^{ab}
T6	96.33^{bc}	1156.00^{bc}	1429.72^{defg}	5.36^{defg}	58.00^{gh}
T7	91.00^{cd}	1092.00^{cd}	1135.68^{ij}	4.57^{fghi}	58.00^{gh}
T8	92.66^{cd}	1112.00^{cd}	1356.64^{fgh}	5.12^{defgh}	61.00^{ef}
T9	104.66^{b}	1256.00^{b}	1645.36^{bc}	6.65^{a}	62.66^{de}
T10	97.00^{bc}	1164.00^{bc}	1361.88^{efgh}	6.45^{ab}	63.00^{cde}
T11	95.00^{bc}	1140.00^{bc}	1242.60^{hi}	5.80^{abcd}	57.66^{gh}
T12	83.66^{d}	1004.00^{d}	1044.16j	4.48^{hi}	59.66^{fg}
T13	97.33^{bc}	1168.00^{bc}	1284.80^{ghi}	5.45^{cdef}	62.00^{def}
T14	103.66^{b}	1244.00^{b}	1791.36^{b}	6.40^{abc}	65.33^{bc}
T15	100.66^{bc}	1208.00^{bc}	1558.32^{cd}	5.47^{cde}	68.66^{a}
T16	97.66^{bc}	1172.00^{bc}	1465.00^{def}	4.72^{efghi}	57.00^{h}
CD at 5% (0.05)	10.20	122.51	150.11	0.88	2.39

4. CONCLUSION

The response of different combined doses of nitrogen and potassium on the growth and flowering of Calendula officinalis reveals that a combined application of 25g N/m2 and 30 g K/m2 exhibited maximum values for stem diameter and flowering duration. This treatment also recorded minimum days for flower bud initiation, first flowering, and 50% of flowering. While maximum branches per plant, number of leaves per plant, number of flowers per plant, number of flowers per meter square, flower weight, and flower yield per meter square were found with the combined application of 20g N/m2 and 10g K/m2. Leaf area was found to be maximum in the combined application of 25g N/m2 and 20g K/m2 and the vase life of flowers was found maximum in the combined application of 20g N/m2 and 20g K/m2. Hence, it was concluded that for better growth, flowering and yield of Calendula officinalis, plants be fertilized with N and K @ 20g + 10g/m2 under Punjab conditions.

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