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Effect of spacing on growth and flowering of annual chrysanthemum (*Chrysanthemum coronarium* L.)

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Abstract
The Present investigation to study effect of spacing on growth and flowering of Annual Chrysanthemum (*Chrysanthemum coronarium*) was carried out in form of a field trial at the Agricultural Research Station, Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar during 2019-20.Result of the study revealed that among four different spacings *viz*., 30 cmX30 cm(S_1),40 cmX30 cm (S_2), 60 cm X40 cm (S_3) and 60 cm X60 cm (S_4) tried, plants with maximum spread (East-West), number of leaves, number of flowers per plant(215.02), and flower diameter were recorded under te widest spacing of 60 cm x60 cm (S_4). However, maximum delay in appearance of first flower bud was noticed under this spacing treatment which took 26.44 days for the same. On the other hand lowest number (5,160.53 nos) of flowers per plot as well as per hectare(5,972839.51nos)were recorded under this widest spacing(S_4).Plants grown under the closest spacing 30cm X30 cm (S_1) recorded the minimum values with respect to plant spread, number of leaves, number of flowers per plant(200.36) and flower diameter. However, appearance of first flower bud in the plant was the earliest (24.84 days) under the closest spacing. Besides, flower yield in terms of number per plot (19,234.13 nos) and per hectare (22,261728.40 nos) was the highest under the closest spacing of 30 cm x30 cm(S_1). Parameter like plant height was not significantly influenced by various spacing treatments although it was the highest and lowest under the closest(S_1) and widest(S_4) spacings respectively. Hence, it was concluded that adoption of closest spacing of 30cm x 30cm was most suitable practice for maximizing flower yield in annual chrysanthemum cv. Local which may be recommended to the flower growers for its commercial cultivation.

Keywords: plant height, plant spread, number of leaves, appearance of flower bud, flower diameter, number of flowers per plant, number of flowers per plot

Introduction
Annual chrysanthemum, botanically known as *Chrysanthemum coronarium* L., is an annual herbaceous plant with aromatic flavor which is popularly known as garland chrysanthemum or edible chrysanthemum belonging to the daisy family Asteraceae. The new name for this flowering annual is *Glebionis coronaria*. It is native to the Mediterranean region. It is cultivated and naturalized in East Asia, in scattered locations in North America. It is a hardy, vigorous and relatively short duration plant which produces attractive flowers in various shades of yellow and white having single or double forms (Desai, 1962) [2]. It is grown commercially in various parts of India for production of loose flowers which are used alone or in combination with marigold and other flowers for making garlands as well as for religious offerings. Although this flower is extensively used in the state of Odisha as loose flower and its popularity is next to marigold, it is mostly used as a garden plant in beds and borders. Its commercial cultivation has not yet been started because of unavailability of suitable horticultural practices to the flower growers of the state.

Among different crop management practices to increase production and quality of various annual flowers including annual chrysanthemum, cultural manipulation of growth and flowering through proper planting density assume greater significance. Spacing or planting density influences, plant growth and yield of flowers in terms of number and size through modifying the microclimate at the close vicinity of the plants exerting a considerable influence on the performance of the crop. Hence, in the present trial an attempt was made to determine the influence of different planting densities on growth and yield of flowers in annual chrysanthemum and to find out the optimum spacing for maximization of production of quality flowers.

Materials and Methods

The present investigation to study effect of spacing on growth and flowering of Annual Chrysanthemum (*Chrysanthemum coronarium*) was carried out in form of a field trial at the Agricultural Research Station, Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar during 2019-20. The experiment was conducted following Factorial Randomized Block Design consisting of two factors *viz*., spacing and pinching as treatments. In this study four levels of spacing *viz*., S_1 (30cmX30cm), S_2 (40cmX30cm), S_3 (60cmX40cm) & S_4 (60cmX60cm) as main plot treatments and three levels of pinching *viz*., P_0 (No pinching), P_1 (Single pinching i.e 30 days after transplanting) & P_2 (Double pinching i.e 30 and 45 days after transplanting) as sub plot treatments under each main plot treatment were included which were replicated thrice. Observations on various growth and flowering parameters such as plant height, plant spread (East-West),number of leaves per plant, days to appearance of first flower bud, flower diameter, number of flowers per plant as well as per plot were recorded after two and three months of transplanting. Yield of flowers per hectare was computed from the per plot yield data. All the data concerning various growth parameters, flowering components and flower characters were analyzed statistically. The treatment effects were tested by 'F' test at 5 % level of significance. The critical difference at 5 % level was calculated for comparing treatment means.

Results and Discussion

Plant height: The data revealed that after two and three months of planting irrespective of pinching treatment, the plants grown at the closest spacing of 30cm X 30cm (S_1) produced the maximum height (93.19 cm and 96.94 cm respectively) which was reduced with increase in planting distance and the minimum (89.10cm and 94.50 cm respectively) was recorded in plants grown at the widest spacing of 60 cm X 60 cm(S_4) during the same observation period (Table 1). Similar findings have been reported by Mahananda *et al.* (2015) [6] in annual chrysanthemum, Khobragade *et al.* (2012) [4] in China aster who observed maximum height at the closer spacing and decreased gradually as the spacing increased. Increase in plant height at closer spacing might be due to heavy competition between plants for light which resulted in elongation of main stem. On the contrary Lee *et al.* (2008) [5] reported that planting density had no significant effect on plant height in perennial chrysanthemum. In the present study however, various levels of spacing could not influence the plant height significantly at any stage of plant growth.

Table 1: Effect of spacing on Plant height, plant spread (East-West) number of leaves and days to appearance of first flower bud in annual chrysanthemum cv. Local

Treatments	Plant height(cm)		Plant spread(e-w) (cm)		No. of leaves per plant		Days to appearance of first flower bud
Spacing(S)	After 2 months	After 3 months	After 2 months	After 3 months	After 2 months	After 3 months	
S_1(30cm X30 cm)	93.19	96.94	39.34	44.92	749.13	1146.20	24.84
S_2 (40cm X30 cm)	92.36	96.05	49.34	53.16	883.36	1284.83	25.53
S_3 (60cmX 40 cm)	90.99	95.97	61.28	66.65	976.00	1499.56	26.20
S_4 (60cm X60cm)	89.10	94.50	76.01	82.65	1525.22	2019.38	26.44
SE(m) ±	2.11	1.85	1.03	1.07	47.57	43.24	0.11
CD at 5%	NS	NS	5.02	5.21	231.62	210.53	0.55

Plant spread (East-West)

Various levels of spacing influenced the plant spread (East-West) significantly during both the observations recorded after two and three months of transplanting (Table 1) irrespective of pinching treatments. Plants with maximum spread was observed under widest spacing of 60cm X 60cm (S_4) which differed significantly from other spacing treatments. It was followed by the same recorded under 60cm X 40cm (S_3) spacing. On the other hand significantly minimum spread was observed under closest spacing of 30cmX30cm (S_1). The same trend was observed during both the observations. Plant spread of 76.01 cm, 61.28 cm,49.34 cm and 39.34 cm were recorded under S_4, S_3, S_2 and S_1 respectively after two months of planting while the same were 82.65 cm (S_4), 66.55 cm(S_3),53.16 cm(S_2) and 44.92 cm (S_1) after three months of planting. The result of the present study is in close agreement with the same obtained by Mahananda *et al.* (2015) [6] who found that plant spread (N-S) increased with increasing levels of spacing. This might be due to availability of more space between plants in wider spacing.

Number of leaves per plant

The data revealed that maximum number of leaves were recorded in plants grown at the widest spacing of 60cmx60cm (S_4) which differed significantly from other spacing treatments (Table 1). It was followed by the same recorded under S_3 (60cmx40cm), S_2 (40cmx30cm) and significantly minimum number was recorded under the closest spacing of 30cmx30cm. It was noticed that as the planting distance was reduced the leaf number was also reduced during both the observations recorded after two and three months of planting irrespective of pinching treatments. The average leaf number per plant were 1525.22, 976.00, 883.36 and 749.13 under S_4, S_3, S_2 and S_1 spacing levels respectively after two months of planting while the same under S_4, S_3, S_2, and S_1 were 2019.38, 1499.56, 1284.83 and 1146.20 respectively after three months of planting. Increase in number of leaves under widest spacing as compared to closest spacing might be due to the reason that there might be less competition for light and nutrients in wider spacing which might have resulted in well spread of plants with production of more leaves utilizing proper carbohydrate and sun light. The results are supported by Khobragade *et al.* (2012) [4] in China aster.

Days taken for appearance of first flower bud

Data in Table 1 revealed that significant difference among various levels of spacing with respect to days to appearance of first flower bud was observed and the plants grown at the closest spacing of 30 cm X 30 cm (S_1) took significantly less time (24.84 days) for the same. On the other hand delay in appearance of first flower bud was noticed with increase in planting distance and the plants took maximum time (26.44

days) for the same when grown at the widest spacing of 60 cm X 60 cm (S_4). However, it was closely followed by 60 cm X 40 cm spacing (S_3) which took 26.20 days without showing significant variation from each other. The result of the study is well supported by Bhargav *et al.* (2016) [1] who also reported earliest flower bud formation in China aster at the closest spacing which increased with increase in planting distance. This might be ascribed to the fact that the individual plant grown at the closer spacing produced less vegetative growth and entered its reproductive phase earlier due to more competition among the plants for nutrient, moisture, sunlight etc

Flower diameter

Significant influence of various levels of spacing was noticed with respect to flower diameter during both the observations (Table -2) irrespective of pinching treatments. Flowers with maximum diameter were produced in plants grown at the widest spacing of 60cm X60cm which was followed by and at par with the same recorded under S_3(60cm X40 cm) and S_2 (40 cm X30 cm) treatments. On the other hand flowers with minimum diameter were produced under the closest spacing of 30cm X 30cm (S_1). However, diameter of flowers recorded under S_1 did not show any significant variation from the same recorded under S_2 and S_3 after two months of planting while it was significantly shorter under S_1 after three months of planting. The flower diameter under S_4, S_3, S_2 and S_1 were 4.95cm, 4.84 cm, 4.79 cm and 4.63 cm respectively after two months of planting while the values were 4.07 cm,4.00 cm,3.81 cm. and 3.64 cm under S_4,S_3,S_2 and S_1 respectively after three months of planting. In the present investigation it was found that flowers with maximum diameter was observed under widest spacing (60cm x 60cm) which decreased with decrease in planting distance and the minimum was recorded under the closest spacing of 30cm X 30cm. Production of flowers with greater diameter under wider spacing as compared to closer spacing might be due to more favorable conditions like nutrients, sun light and soil moisture available to individual plant. The present results are in close conformity to the findings of Khobragade *et al.* (2012) [4] and Bhargav *et al.* (2016) [1] who found that in china aster as the spacing was decreased, the diameter of flower was also reduced.

Table 2: Effect of spacing on flower diameter, number of flowers per plant, number of flowers per plot and per hectare in annual chrysanthemum cv. Local

Treatments	Flower diameter(cm)		No. of flowers per plant	No. of flowers per plot	No. of flowers per hectare
Spacing(S)	After 2 months	After 3 months			
S_1 (30cm X30 cm)	4.63	3.64	200.36	19234.13	22261728.40
S_2 (40cm X30 cm)	4.79	3.81	201.13	10861.20	12570833.33
S_3 (60cmX 40 cm)	4.84	4.00	203.53	7327.20	8480555.56
S_4 (60cm X60cm)	4.95	4.07	215.02	5160.53	5972839.51
SE(m) ±	0.05	0.02	2.88	150.83	174577.61
CD at 5%	0.26	0.09	14.04	734.40	850002.06

Number of flowers per plant

It was noticed that significant difference existed among various spacing treatments with respect to total number of flowers produced per individual plant irrespective of pinching treatments. Plants grown at the widest spacing of 60cmx60cm (S_4) produced maximum number of flowers (215.02) followed by and at par with S_3 (60cmx40cm) and S_2 (40cmx30cm) which recorded 203.53 and 201.13 flowers per plant respectively (Table-2). The minimum number (200.36) was produced under closest spacing of 30cmx30cm (S_1). However, it was statistically comparable with S_2 and S_3 It was noticed that with each increment of planting distance from closest to widest there was corresponding increase in flower number. Plants with greater spread having more number of branches resulted in production of more number of leaves under wider spacing, which might have produced more photosynthate ultimately improving the flower number per plant as compared to the closer spacings and the lowest was produced under the closest spacing. Similar results have also been recorded by Dorajeerao *et al.* (2012) [3] in annual chrysanthemum from UAS, Dharwad

Number of flowers per plot and per hectare

Significant difference was observed among different levels of spacing with respect to number of flowers per plot irrespective of pinching treatments. Maximum number of flowers (19234.13) per plot (8.64 m^2area)was recorded under closest spacing of 30cm X 30cm(S_1) which decreased with increase in planting distance and 10861.20 &7327.20 number of flowers were recorded under 40cm X 30cm (S_2) and 60cm X 40cm (S_3) treatments respectively (Table 2). On the other hand minimum number (5160.53) of flowers per plot was recorded under the widest spacing of 60cm X 60cm. It was found that all the spacing treatments differed significantly from each other with respect to this parameter. The results of the present study are well supported by Dorajeerao *et al.* (2012) [3] and Khobragade *et al.* (2012) [4] who observed increase in number of flowers per plot with a decrease in planting distance in garland chrysanthemum and china aster respectively. The reason for the same may be ascribed to more plants per unit area under closer spacing. Although number of flowers per plant was higher under wider spacing compared to closer spacing, it could not compensate the yield per plot because of less plant population.

The result also indicated that significant difference was noticed among various levels of spacing with respect to total number of flowers produced per hectare (Table 2) as it was computed from the per plot yield data. It was maximum (2,22,61,728.40) under the closest spacing of 30 cm X30 cm (S_1) which decreased with increase in spacing levels and the number of flowers under 40cm X 30cm(S_2) and 60 cm X 40cm(S_3) were 1,25,70,833.33 and 84,80,555.56 respectively while the minimum (59,72,839.51) was recorded under the widest spacing of 60cm X 60cm(S_4).All the spacing treatments differed significantly from each other in this respect.

Conclusion

Based on the result of the present study it was concluded that among four different spacings tried, plants grown under the widest spacing of 60 cm X60 cm (S_4) exhibited better performance with respect to several growth and flowering

parameters. Plants with maximum spread (East-West), number of leaves, number of flowers per plant and flower diameter were recorded under 60cm x 60cm (S_4) spacing. However, lowest number of flowers per plot as well as per hectare were recorded under this widest spacing of 60cm x 60cm.

On the other hand, although plants grown under the closest spacing (S_1) recorded minimum values with respect to plant spread, number of leaves, number of flowers per plant and flower diameter, the flower yield in terms of number per plot as well as per hectare was the highest under the closest spacing of 30 cm x30 cm.

Since the ultimate aim of any crop production programme is to maximize the yield through an ideal crop management practices, in the present investigation it was found that adoption of closest spacing of 30cm x 30cm planting was the most suitable practice for maximizing flower yield in annual chrysanthemum cv. Local which may be recommended to the flower growers for its commercial cultivation.

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