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Effect of plant spacing and pinching on growth and flower yield of annual chrysanthemum

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Abstract
This research was conducted to investigate the "Effect of plant spacing and pinching on growth and flower yield of annual chrysanthemum" was carried out during *rabi* season of the year 2018-2019 at the farm of Horticulture Section, College of Agriculture, Nagpur The treatments comprised of two factors i.e. factor A and factor B. Factor A consist of 4 levels of spacing (S_1 – (60×45 cm), S_2 – (45×45 cm), S_3 – (45×30 cm), S_4 (30×30 cm) and factor B consist of 3 levels of pinching (P_1 – No pinching, P_2 – Pinching at 30 days after transplanting, P_3 – Pinching at 40 days after transplanting with twelve treatment combinations replicated thrice. Minimum plant height was recorded in S_4 (30×30 cm) and P_3 (pinching at 40 days after transplanting) whereas stem girth, number of branches plant^{-1} and plant spread were recorded maximum with a spacing S_1 (60×45 cm), and P_3 (pinching at 40 days after transplanting), P_1 (No pinching) and P_2 (pinching at 30 days after transplanting) respectively. Significantly maximum plant height was recorded maximum in S_1 (60×45 cm) and P_1 (No pinching) and stem girth, number of branches plant^{-1} and plant spread were recorded minimum with a spacing S_4 (30×30 cm), and P_1 (No pinching). The interaction effect of spacing and pinching on all growth parameters was found non-significant. In respect of yield contributing characters *viz*., number of flowers plant^{-1}, flower yield plant^{-1}, flower yield plot^{-1} and flower yield ha^{-1} were recorded maximum with the S_3 (45×30 cm), and P_2 (pinching at 30 days after transplanting). Significantly maximum number of flowers plant^{-1}, flower yield plant^{-1}, flower yield plot^{-1} and flower yield ha^{-1} were observed in the treatment combination of S_3 (45×30 cm), and P_2 (pinching at 30 days after transplanting).

Keywords: Annual chrysanthemum, spacing, pinching, growth, yield

Introduction
Annual chrysanthemum (*Chrysanthemum coronarium* L.) is one of the most important flower crops grown in India, though it is originated in South Europe. It is a winter annual crop and belongs to the family *Asteraceae*. It is also known as 'Crown Daisy' or 'Garland chrysanthemum'. The variation in size, shape and colour of flowers, the annual chrysanthemum is popular among the people. These flowers have a constant demand during the days of festivals, functions, in the place of worshiping and decoration throughout the year. Annual chrysanthemum comprise of three species *viz*., *Chrysanthemum segtum* (corn marigold), *Chrysanthemum carinatum* (tricoloured chrysanthemum) and *Chrysanthemum coronarium* (crown daisy or garland chrysanthemum). The crown daisy or Garland chrysanthemum (*C. coronarium*) is a native to Southern Europe. It is branching annual with finely cut foliage reaching a height up to a metre, size of flowers varies from 2.5 to 4 cm and colour is usually in shades of yellow and white with cream zone at the center. It is a fast growing winter blooming annual. Annual chrysanthemum comprise of three species *viz*., *Chrysanthemum segtum* (corn marigold), *Chrysanthemum carinatum* (tricoloured chrysanthemum) and *Chrysanthemum coronarium* (crown daisy or garland chrysanthemum). The crown daisy or Garland chrysanthemum (*C. coronarium*) is a native to Southern Europe. It is branching annual with finely cut foliage reaching a height up to a metre, size of flowers varies from 2.5 to 4 cm and colour is usually in shades of yellow and white with cream zone at the center. It is a fast growing winter blooming annual. The flowers are pulverized and an active component called pyrethrin is extracted and used in insecticidal preparation and it is a good companion plant, protecting neighboring plants from caterpillars. In recent years, it has been introduced as a valuable source of feed for animals.

Material and Methods

"The field experiment entitled, "Effect of plant spacing and pinching on growth and flower yield of annual chrysanthemum" was carried out at Maharaj Bag, Horticulture Section, College of Agriculture, Nagpur during *rabi* season of the Year 2018-2019. An experiment was conducted in Factorial Randomized Block Design with 12 treatment combinations which were replicated for three times. The experimental land was ploughed once, cross-wise harrowing was done for clod crushing and soil was brought into the fine tilth. At the time of land preparation, well rotten FYM @ 25 tonnes ha^{-1} was mixed uniformly in the soil before last harrowing. The field was laid out with raised beds of the dimensions of 2.4 mx2.7 m. The recommended dose of fertilizer 100 Kg N, 50 Kg P, 50 kg K ha^{-1} was applied to all the plots in the form of urea, single super phosphate and murate of potash respectively. Out of this, full dose of P and K and half dose of nitrogen was applied at the time of transplanting. The remaining dose of nitrogen was applied in 30 days after transplanting.

Results and Discussion

Effect of plant spacing on growth parameter

At 90 days after transplanting, a spacing of S_4 (30×30 cm) obtained significantly minimum plant height (78.92 cm) which was at par with S_3 (80.61 cm) *i.e.* (45×45 cm). However, maximum plant height (85.00 cm) was recorded in S_1 (60×45 cm) From the above results, it is shown that spacing of (30×30 cm) recorded minimum plant height in all growth stages of annual chrysanthemum. This might be due to the fact that there would be competition among the plants for sunlight, air and nutrients. Thus plants tend to grow vertically for more light and air and consequently they became taller. A similar response of spacing with respect to plant height have been reported by Chezhiyan *et al*. (1986) [6] in chrysanthemum cv- "CO-1", Khanna *et al*. (1986) [10] in carnation cv. "Marguerite Scarlet" and Belorkar *et al*. (1992) [2] in African marigold.

At 90 days after transplanting, treatment of S_1 (60×45 cm) obtained significantly maximum stem girth $plant^{-1}$ (1.95 cm) which was at par with S_2 (1.93 cm) *i.e.* (45×45 cm) and S_3 (1.89 cm) i.e. (45×30 cm). However, minimum stem girth $plant^{-1}$ (1.85 cm) was recorded in S_4 (30×30 cm). The decrease in plant height is always associated with increase in stem diameter, because shorter the height thicker was the stem and vice versa. These findings lend support by Belorkar *et al*. (1992) [2] in African marigold and Karavadia and Dahduk (2002) [9] in annual chrysanthemum cv. "Local White".

At 90 days after transplanting, treatment S_1 (60×45 cm) obtained significantly maximum number of branches (31.41) which was followed by S_2 (30.50) i.e. (45×45 cm) and S_3 (29.14) i.e. (45×30 cm). However, minimum number of branches (25.86) was recorded in S_4 (30×30 cm). From the above data it was found that maximum number of branches were found in the treatment S_1 *i.e*. (60×45 cm). It might be due to the reason that the total plant population per unit area was less in wider spacing and therefore, there was more space available for each of the plants to grow vigorously as they received sufficient light, air and nutrients. The above results are in close conformity with the findings of Ravindran *et al*. (1986) [14] in African marigold, Belorkar *et al*. (1992) [2] in African marigold, Belgaonker *et al*. (1996) in annual chrysanthemum and Karavadia and Dhaduk (2002) [9] in annual chrysanthemum cv. "Local White".

Plant spread at 50 per cent flowering stage was significantly influenced by different plant spacing. Significantly maximum plant spread (57.90 cm) was recorded in S_1 (60×45 cm) which was at par with S_3 (54.77cm) and followed by S_2 (50.02 cm) i.e. (45x45cm). Whereas, minimum plant spread (47.04 cm) was recorded in S_4 (30×30 cm) i.e. (45×45 cm). From the above findings, it is shown that the plant spread was found maximum with spacing S_1 (60×45 cm). The present study revealed that the plant spread was more under wider spacing that may be due to the favourable growing conditions like more space available for growth of roots and shoots, which ultimately helps in higher uptake of nutrients and water from the soil. Similarly, more amount of sunshine was also available in wider spacing that might have increased rate of photosynthesis and thereby growth of plants. Similar views have also been expressed by Chanda and Roychaudhury (1991), Ravindran *et al*. (1986) [14], Janakiram and Rao (1995) [8].

Effect of pinching on growth parameter

At 90 days after transplanting, treatment P_3 (pinching at 30 DAT) obtained significantly minimum plant height (79.70 cm) which was at par with P_2 (81.32 cm) i.e. pinching at 30 days after transplanting. However, maximum plant height (84.88 cm) was recorded in P_1 (No pinching). The lower plant height due to pinching treatment may be due to the top most shoots of one third of an inch being removed from the plant at each pinching treatment and therefore, the axillary buds below the pinched stem of plant forced to grow luxuriantly as the apical dominance of plant was arrested. Similar effect of pinching on plant height was recorded by Chezhigan *et al*. (1986) in chrysanthemum cv "CO-1", Khanna *et al*. (1986) [10] in carnation cv. "Marguerite Scarlet", Pappiah (1987) [11] in chrysanthemum cv. "MDU-1" and Yassin and Pappiah (1990) [15] in chrysanthemum cv. "MDU-1".

At 90 days after transplanting, the treatment P_3 (pinching at 40 DAT) obtained significantly maximum stem girth of plant (2.06 cm) which was at par with P_2 (2.04 cm) i.e. pinching at 30 days after transplanting. However, minimum stem girth of plant (1.83 cm) was recorded in P_1 (No pinching). The above results might be due to the fact that decrease in plant height is always associated with increase in stem girth. The result obtained in the present findings are in close conformity with the findings of Ramesh Kumar *et al*. (2002) [13] in carnation.

At 90 days after transplanting, treatment P_2 (pinching at 30 DAT) obtained significantly maximum branches plant (31.87) which was at par with P_3 (28.76) *i.e*. pinching at 40 days after transplanting. However, minimum branches $plant^{-1}$ (27.06) was recorded in P_1 (no pinching). From the above results it was found that, the increase in number of primary branches by pinching treatments might be due to the fact that the axillary buds below the pinched stem of plant forced to grow luxuriantly as the apical dominance of plant was arrested. Consequently, more number of primary branches per plant was noticed. The above findings are in close agreement with the findings of Patel and Arora (1983) in Carnation cv. "Marguerite White", Chezhiyan *et al*. (1986) [6] in chrysanthemum cv "CO-1" Yassin and Pappiah (1990) [15] in chrysanthemum cv. "MDU-1", Ramesh Kumar *et al*. (2002) [13] in carnation and Beniwal *et al*. (2003) [3] in chrysanthemum cv "Flirt".

Plant spread at 50 per cent flowering stage was significantly influenced by different levels of pinching. Significantly maximum plant spread (56.84 cm) was recorded in P_2 (pinching at 30 DAT) which was followed by P_3 (52.29 cm)

i.e. pinching at 40 days after transplanting. Whereas, minimum plant spread (48.52 cm) P_1 (no pinching). Significant increase in plant spread was recorded with pinching at 30 DAT. The possible reason for more plant spread under different pinching treatments may be due to cell elongation and pinching reduced the apical growth of stem, which finally results in more number of secondary branches plant^{-1}.

Table 1: Effect of plant spacing and pinching on growth parameters of annual chrysanthemum

Treatments	Plant height (cm)	Stem girth (cm)	Number of branches	Plant Spread
Spacing (S)				
S_1– 60× 45 cm	85.00	1.95	31.41	57.90
S_2 –45× 45 cm	83.35	1.93	30.50	50.02
S_3 –45 × 30 cm	80.61	1.89	29.14	54.77
S_4 –30 × 30 cm	78.92	1.85	25.86	47.04
F Test	Sig.	Sig.	Sig.	Sig.
S.E. (m) ±	0.82	0.02	0.58	1.36
C D at 5%	2.42	0.06	1.71	3.99
Pinching (P)				
P_1– No pinching	84.88	1.83	27.06	48.52
P_2–pinching at 30 DAT	81.32	2.04	31.87	56.84
P_3–pinching at 40 DAT	79.70	2.06	28.76	52.29
F Test	Sig.	Sig.	Sig.	Sig.
S.E. (m) ±	0.71	0.01	0.50	1.18
C D at 5%	2.10	0.05	1.48	3.46
Interaction (S x P)				
F Test	N.S.	N.S.	N.S.	Sig.
S.E. (m) ±	1.75	0.04	1.23	2.89
C D at 5%	-	-	-	8.47

Table 2: Effect of plant spacing and pinching on flower yield parameters of annual chrysanthemum

Treatments	Number of flowers plant^{-1}	Flower yield plant^{-1} (g)	Flower yield plot^{-1} (kg)	Flower yield ha^{-1} (q)
Spacing (S)				
S_1– 60× 45 cm	65.22	112.36	4.75	176.21
S_2–45× 45 cm	62.45	168.57	5.33	220.13
S_3–45 × 30 cm	67.14	243.99	7.99	178.41
S_4–30 × 30 cm	46.38	183.29	6.87	136.4
F Test	Sig.	Sig.	Sig.	Sig.
S.E. (m) ±	1.69	12.65	0.23	8.68
C D at 5%	4.96	37.11	0.68	25.23
Pinching (P)				
P_1– No pinching	49.18	151.61	4.67	131.54
P_2 pinching at 30 DAT	69.92	211.17	6.95	198.66
P_3 pinching at 40 DAT	61.79	168.39	7.09	203.15
F Test	Sig.	Sig.	Sig.	Sig.
S.E. (m) ±	1.46	10.95	0.20	7.45
C D at 5%	4.30	32.13	0.59	21.85
Interaction (S x P)				
F Test	Sig.	Sig.	Sig.	Sig.
S.E. (m) ±	3.59	26.84	0.49	18.25
C D at 5%	10.54	78.72	1.44	53.53

Effect of plant spacing on flower yield parameter

Significantly, maximum number of flowers plant^{-1} (67.14) was recorded with spacing S_3 (45×30 cm) which was found to be followed by S_1 (60×45 cm) (65.22) S_2 (45×45 cm) (62.45) whereas, number of flowers plant^{-1} was found minimum (46.38) with S_4 (30×30 cm) treatment. The increase in the number of flower because of spacing treatment may be correlated with the vegetative growth characters like number of branches and stem diameter where the treatments produced significant effect. As a result of this the plant had comparatively higher levels of organic reserves, conductive for better floral development and there by increased the number of flowers. In other words the increase in number of flowers may be due to termination of vertical growth. More lateral branches might have produced more axis from where flowers originate thereby producing more number of flowers per plant. Increase in number of flowers by increasing spacing have also been reported by Chezhiyan *et al.* (1986) [6] in chrysanthemum cv. "Co-1", Khanna *et al.* (1986) [10] in carnation cv. "Marguarite Scarlet", Belorkar *et al.* (1992) [2] in African marigold and Rao *et al.* (1992) in chrysanthemum cv. "Kasturi".

Significantly, maximum flower yield plant^{-1} (243.99 g) was recorded with spacing of S_3 (45×30 cm) which was followed by S_4 (45×30 cm) (183.29 g). However, significantly minimum number of flowers yield plant^{-1} (112.36 g) was recorded in S_1 (60×45 cm) treatment. From above finding, it was noticed that, spacing of S_3 (45×30 cm) recorded maximum flower yield plant^{-1}. In wider spacing plant produced more number of flowers with low weight, whereas in closer spacing plant produced lesser number of flowers with higher weight. So the yield of flower per plant increased with increased in the spacing from wider (S_1) to medium (S_3) but decrease in closer spacing (S_4) treatment. Similar findings

were observed by Balgaonkar *et al.* (1997) in annual chrysanthemum, Karavadia and Dhaduk (2002) [9] in annual chrysanthemum cv. "Local White".

The spacing of S_3 (45×30 cm) had recorded significantly maximum flower yield plot^{-1} (7.99 kg) which was followed by S_4 (30×30 cm) (6.87 kg). However, significantly minimum flower yield plot^{-1} (4.75 kg) was recorded in S_1 (60×45 cm) treatment. From above finding, it was noticed that, the spacing S_3 (45×30 cm) of maximum flower yield plot^{-1}. This might be due to the decrease in flower yield (per plot and per hectare) with increasing the spacing was due to the decrease in plant population per unit area. These results are in close conformity with findings of Chezhiyan *et al.* (1986) [6] in chrysanthemum cv. "Co-1", Gowda and Jayanthi (1988) [7] in chrysanthemum, Karavadia and Dhaduk (2002) [9] in annual chrysanthemum cv. "Local White" and Baniwal *et al.* (2005) in chrysanthemum cv. "Flirt".

The spacing of S_2 (45×45 cm) had recorded significantly maximum flower yield ha^{-1} (220.13 q) which was followed by S_3 (45×30 cm) (178.41 q). However, significantly minimum flower yield ha^{-1} (136.40 q) was recorded in S_4 (30×30 cm) treatment. From above finding, it was noticed that the spacing of S_2 (45×45 cm) recorded maximum flower yield ha^{-1}.

Effect of pinching on flower yield parameter

Significantly, maximum number of flowers plant^{-1} (69.92) was recorded with pinching at 30 days after transplanting which was followed by swith pinching at 40 days after transplanting (61.79). Whereas, total number of flowers plant^{-1} was found minimum (49.18) with no pinching treatment. From above results, it is shown that, the maximum number of flowers plant^{-1} was recorded with the pinching at 30 days after transplanting. The increase in number of flowers due to the pinching treatment may be correlated with vegetative growth characters like number of branches. Due to the pinching treatment more side branches were formed below the pinched portion of the main stem of plant. These more vegetative growth obtained in pinched plants resulted in production of maximum number of flower plant^{-1}. The present result are in agreement with the finding of Ramesh Kumar *et al.* (2002) [13] in carnation.

Effect of pinching on flower yield plant^{-1} was significantly influenced with different levels of pinching. Significantly maximum flower yield plant^{-1} (211.17 g) was recorded with the treatment of pinching at 30 days after transplanting which was followed by P_3 (168.39 g). Whereas, minimum flower yield plant^{-1} (151.61 g) was recorded in no pinching treatment. From above finding, it was shown that maximum flower yield plant^{-1} was recorded under the treatment pinching at 30 days after transplanting. The increase in flower yield due to pinching treatment might be due to the reason that the pinched plants obtained superior vegetative growth and it was responsible for the production of more number of flowers per plant and consequently, yield of flower per plant was increased in pinched plant as compared to unpinched plant. The findings are in accordance with Chezhiyan *et al.* (1986) [6] in chrysanthemum cv. "Co-1", Yassin and Pappiah (1990) [15] in chrysanthemum cv. "MDU-1", Ramesh Kumar *et al.* (2002) [13] in carnation and Rakesh *et al.* (2005) [4] in chrysanthemum.

The flower yield plot^{-1} was maximum (7.09 kg) in pinching at 40 days after transplanting which was at par with P_2 (pinching at 30 days after transplanting) (6.95 kg). Whereas, minimum flower yield plot^{-1} (4.67 kg) was recorded in no pinching treatment. From above finding, it was shown that maximum flower yield plot^{-1} was recorded under the treatment pinching at 40 days after transplanting increase the flower yield plot^{-1}. The increase in yield of flowers (per plot and per hectare) in P_3 treatment in comparison of other pinching treatments was due to the lower weight of individual flower than other treatments. The present results are supported by Chezhiyan *et al.* (1986) [6] in chrysanthemum cv. "Co-1".

Significantly maximum flower yield ha^{-1} was recorded in pinching at 40 days after transplanting (203.15 q) which was at par with pinching at 30 days after transplanting (198.66 q). Whereas, the minimum flower yield ha^{-1} (131.54 q) was recorded in no pinching treatment. From above finding, it was shown that, maximum flower yield ha^{-1} was recorded under the treatment pinching at 40 days after transplanting.

Conclusion

Minimum plant height is recorded in S_4 (30×30 cm) and P_3 (pinching at 40 days after transplanting) and stem girth, number of branches plant^{-1} and plant spread were recorded maximum with a spacing S_1 (60×45 cm), and P_3 (pinching at 40 days after transplanting), P_1 (No pinching) and P_2 (pinching at 30 days after transplanting) respectively. Significantly plant height is recorded maximum in S_1 (60×45 cm) and P_1 (No pinching) and stem girth, number of branches plant^{-1} and plant spread were recorded minimum with a spacing S_4 (30×30 cm), and P_1 (No pinching).

In respect of yield contributing characters *viz*., number of flowers plant^{-1}, flower yield plant^{-1}, flower yield plot^{-1} and flower yield ha^{-1} were recorded maximum with the S_3 (45×30 cm), and P_2 (pinching at 30 days after transplanting). Significantly maximum number of flowers plant^{-1}, flower yield plant^{-1}, flower yield plot^{-1} and flower yield ha^{-1} were observed in the treatment combination of S_3P_2 S_3 (45×30 cm), and P_2 (pinching at 30 days after transplanting).

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