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" carried out during the 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 consists of 4 levels of spacing (S₁ – (60×45 cm), S₂ – (45×45 cm), S₃ – (45×30 cm), S₄ (30×30 cm)) and factor B consists of 3 levels of pinching (P₁ – No pinching, P₂ – Pinching at 30 days after transplanting, P₃ – Pinching at 40 days after transplanting with twelve treatments replicated thrice. Minimum plant height was recorded in S₁ (30×30 cm) and P₁ (pinching at 40 days after transplanting) whereas stem girth, number of branches plant⁻¹ and plant spread were recorded maximum with a spacing S₁ (60×45 cm), and P₃ (pinching at 40 days after transplanting), P₁ (No pinching) and P₂ (pinching at 30 days after transplanting) respectively. Significantly maximum plant height was recorded maximum in S₁ (60×45 cm) and P₁ (No pinching) and stem girth, number of branches plant⁻¹ and plant spread were recorded minimum with a spacing S₄ (30×30 cm), and P₃ (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 observed in the treatment combination of S₁ (45×30 cm), and P₃ (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 worshipping 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 m\(\times\)2.7 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\(_2\) (30×30 cm) obtained significantly minimum plant height (78.92 cm) which was at par with S\(_1\) (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\(^{-1}\) (1.93 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 Dhaduk (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\(_1\) (54.77 cm) and followed by S\(_2\) (50.02 cm) i.e. (45×45 cm). 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 Chandra and Roychoudhury (1991), Ravindran et al. (1986) \[14\], Janakiram and Rao (1995) \[8\].

Effect of pinching on growth parameter

At 90 days after transplanting, treatment P\(_1\) (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 Chezhiyan 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\(_1\) (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\(^{-1}\) (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) P1 (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)       |                 |                    |              |
| S1– 60× 45 cm       | 85.00             | 1.95            | 31.41              | 57.90        |
| S2– 45× 45 cm       | 83.35             | 1.93            | 30.50              | 50.02        |
| S3– 45 × 30 cm      | 80.61             | 1.89            | 29.14              | 54.77        |
| S4– 30 × 30 cm      | 78.92             | 1.85            | 25.86              | 47.04        |
| F Test              | Sig.              | Sig.            | Sig.               |              |
| S.E. (m) ±          | 0.82              | 0.02            | 0.58               |              |
| C D at 5%           | 2.42              | 0.06            | 1.71               | 3.99         |
| Pinching (P)        |                   |                 |                    |              |
| P1– No pinching     | 84.88             | 1.83            | 27.06              | 48.52        |
| P2– pinching at 30 DAT | 81.32         | 2.04            | 31.87              | 56.84        |
| P3– pinching at 40 DAT | 79.70         | 2.06            | 28.76              | 52.29        |
| F Test              | 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         |

**Effect of plant spacing on flower yield parameter**

Significantly, maximum number of flowers plant⁻¹ (67.14) was recorded with spacing S1 (45×30 cm) which was found to be followed by S2 (60×45 cm) (65.22) S1 (45×45 cm) (62.45) whereas, number of flowers plant⁻¹ was found minimum (46.38) with S1 (30×30 cm) treatment. The increase in the number of flowers 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) in chrysanthemum cv. “Co-1”, Khanna et al. (1986) in carnation cv. “Marguerite Scarlet”, Belorkar et al. (1992) 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 S1 (45×30 cm) which was followed by S4 (45×30 cm) (183.29 g). However, significantly minimum number of flowers yield plant⁻¹ (112.36 g) was recorded in S1 (60×45 cm) treatment. From above finding, it was noticed that, spacing of S1 (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 (S1) to medium (S3) but decrease in closer spacing (S4) treatment. Similar findings

### 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)               |                          |                         |                       |
| S1– 60× 45 cm       | 65.22                     | 112.36                   | 4.75                    | 176.21                |
| S2– 45× 45 cm       | 62.45                     | 108.57                   | 5.33                    | 220.13                |
| S3– 45 × 30 cm      | 67.14                     | 234.99                   | 7.99                    | 178.41                |
| S4– 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)        |                           |                          |                         |                       |
| P1– No pinching     | 49.18                     | 151.61                   | 4.67                    | 131.54                |
| P2– pinching at 30 DAT | 69.92             | 211.17                   | 6.95                    | 198.66                |
| P3– 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                 |
were observed by Balgaonkar et al. (1997) in annual chrysanthemum, Karavadia and Dhaduk (2002) [9] in annual chrysanthemum cv. “Local White”. The spacing of S1 (45x30 cm) had recorded significantly maximum flower yield plot1 (7.99 kg) which was followed by S2 (30x30 cm) (6.87 kg). However, significantly minimum flower yield plot1 (4.75 kg) was recorded in S3 (60x45 cm) treatment. From above finding, it was noticed that, the spacing S3 (45x30 cm) of maximum flower yield plot1. 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 S1 (45x45 cm) had recorded significantly maximum flower yield ha-1 (220.13 q) which was followed by S2 (45x30 cm) (178.41 q). However, significantly minimum flower yield ha-1 (136.40 q) was recorded in S3 (30x30 cm) treatment. From above finding, it was noticed that the spacing of S3 (45x45 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 P2 (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 numbers 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 plot1 was maximum (7.09 kg) in pinching at 40 days after transplanting which was at par with P2 (pinching at 30 days after transplanting) (6.95 kg). Whereas, minimum flower yield plot1 (4.67 kg) was recorded in no pinching treatment. From above finding, it was shown that maximum flower yield plot1 was recorded under the treatment pinching at 40 days after transplanting increase the flower yield plot1. The increase in yield of flowers (per plot and per hectare) in P1 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 S1 (30x30 cm) and P1 (pinching at 40 days after transplanting) and stem girth, number of branches plant-1 and plant spread were recorded maximum with a spacing S1 (60x45 cm), and P1 (pinching at 40 days after transplanting), P1 (No pinching) and P2 (pinching at 30 days after transplanting) respectively. Significantly plant height is recorded maximum in S1 (60x45 cm) and P1 (No pinching) and stem girth, number of branches plant-1 and plant spread were recorded minimum with a spacing S1 (30x30 cm), and P1 (No pinching).

In respect of yield contributing characters viz., number of flowers plant-1, flower yield plant-1, flower yield plot1 and flower yield ha-1 were recorded maximum with the S1 (45x30 cm), and P2 (pinching at 30 days after transplanting). Significantly maximum number of flowers plant-1, flower yield plant-1, flower yield plot1 and flower yield ha-1 were observed in the treatment combination of S1P1; S1 (45x30 cm), and P2 (pinching at 30 days after transplanting).

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