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RESEARCH ARTICLE

Yield and production potential influenced by inter plant spacing's and planting dates in annual chrysanthemum (*Chrysanthemum coronarium* L.)

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Abstract

The present study was carried at the Experimental Farm of the Division of Floriculture and Landscaping, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Union Territory of Jammu and Kashmir, India during the year 2022-2023. The experiment was laid out in factorial Randomized Complete Block Design (RCBD) consisting of 12 treatment combinations viz., four planting dates (10th October, 25th October, 10th November and 25th November) and three inter plant spacings (30 cm × 30 cm, 45 cm × 45cm and 60 cm × 60 cm). Results revealed that maximum plant height (164.37 cm), numbers of side shoots (15.87) and plant spread (9649.45 cm^2) were obtained from 10th October transplanting at 45 cm × 45 cm inter-plant spacing (T_5). Flower quality parameters like maximum flower diameter (6.94 cm), flower weight (5.94 g) and shelf life (6.80 days) were recorded from 25th October transplanting at 60 cm × 60 cm inter-plant spacing (T_{10}). However, maximum flower yield per plant (918.57 g), number of flowers per plant (159.27) and maximum seed yield per plant (41.86 g) were recorded with 25th October transplanting at 45 cm × 45 cm inter-plant spacing (T_6). Maximum flowering duration (39.40 days) and chlorophyll content (27.84 SPAD value) was also recorded with the same treatment (T_6). Since, the main objective of any crop production programme is the yield, so it can be concluded that 25th October transplanting at 45 cm × 45 cm inter-plant spacing is the best treatment combination for annual chrysanthemum under Jammu sub-tropics.

Keywords: chrysanthemum; inter-plant spacing; planting dates; production; yield

Introduction

Annual chrysanthemum (*Chrysanthemum coronarium* L.) belongs to the family Asteraceae and is one of the most widely cultivated garden flowers. Annual chrysanthemum is highly demanded as loose flower in India. The utility of this flower in garland making cannot be underrated. Despite the demand for this flower in domestic market, its production is quite low. The crop differs significantly from other crops in several ways. The plant is regarded as being more robust, hardy and tall. It is mostly used as a garden plant in beds and borders. As a loose flower it is used alone or in combination with marigold and other flowers for garland making.

Cultural practices play a pivotal role in the overall development of plants and adoption of improved cultural practices appreciably leads to increased productivity which further boosts the production. Although flower productivity and quality are mostly influenced by genetics, the environment in which the crop grows during its growth cycle has a significant impact as well (1). Among the various cultural requirements for proper growth and flowering of annual chrysanthemum, planting date is the most important factor which ensures flower yield and its quality. Planting time influences the seed yields of acceptable quality annually to great extent (2). Dates of plantings are also determined by the region's geography and environmental factors. As a result, it cannot be defined on a national level due to variations in planting zones and natural environmental variables that affect plant development and flowering date (3). A lack of comprehensive information on planting times prevents producers from producing high-quality chrysanthemum flowers at the designated period. To prevent glut in the market during peak flowering time and to increase the profit, producers can manipulate the ideal planting time (4).

Besides the planting time, growth and flower production is

also affected by spacing. It is opined by various researchers that closer spacing accommodates more number of plants but deteriorates the quality of flower and reduces yield per plant, whereas wider spacing gives good quality flowers but lower yield as the plant population decreases. Close spacing leads to more competition among the plants for nutrients and light, which can eventually lead to higher disease incidence and impact flower growth, production and quality. Additionally, it could inhibit cultural activities like weeding hoeings and flower harvesting. Wider planting, on the other hand, could lead to inefficient use of natural resources including soil, fertilizers and water (5). So, optimum spacing is required to provide better quality flowers as well as higher yield. Hence, the present experiment was undertaken with the motive to standardize the best time for transplanting and optimum spacing for getting quality flower with maximum yield in annual chrysanthemum in Jammu sub-tropics.

Materials and Methods

Site and location

The present investigation was carried out at the Experimental Farm, Division of Floriculture & Landscaping, Sher-e-Kashmir University of Agricultural Sciences and Technology, Main Campus, Chatha, Jammu (J&K). The place experiences hot dry summer, hot and humid rainy season and cold winter months, the maximum temperature goes up to 45 °C during summers (May to June) and minimum temperature falls to 1 °C during winters.

Notation	Treatment details
T_1	10th October transplanting at 30 cm × 30 cm spacing
T_2	25th October transplanting at 30 cm × 30 cm spacing
T_3	10th November transplanting at 30 cm × 30 cm spacing
T_4	25th November transplanting at 30 cm × 30 cm spacing
T_5	10th October transplanting at 45 cm × 45 cm spacing
T_6	25th October transplanting at 45 cm × 45 cm spacing
T_7	10th November transplanting at 45 cm × 45 cm spacing
T_8	25th November transplanting at 45 cm × 45 cm spacing
T_9	10th October transplanting at 60 cm × 60 cm spacing
T_{10}	25th October transplanting at 60 cm × 60 cm spacing
T_{11}	10th November transplanting at 60 cm × 60 cm spacing
T_{12}	25th November transplanting at 60 cm × 60 cm spacing

Experimental details

The experiment was laid out in factorial Randomized Complete Block Design consisting of 12 treatments replicated thrice.

Treatments

Nursery preparation

Seeds of annual chrysanthemum cv. Local maintained at the Division of Floriculture and Landscaping were used as a source of planting material. A bed size of 1.0 m × 3 m was prepared after proper hoeing and weeding. The bed was kept raised 15 cm above the ground level so as to provide proper drainage of excess water. Well rotten FYM was mixed in the nursery bed and seeds were sown. Line to line sowing of the seed was practiced with lines 5 cm apart and 2-3 cm deep. The opened rows were closed with the mixture of FYM, soil and sand (2:1:1). The surface was covered with the mulching material and then watered with a fine rose-can. After seed germination, the mulch cover was removed. Seed sowing was done on different dates to make available the seedlings on the desired dates for transplanting.

Field preparation

The experimental field was prepared to a fine tilth by 2 to 3 times ploughings with the help of tractor fitted with rotavator and finally the field was levelled by planking after removing the plant residues and weeds. The beds of the required dimensions were then made according to the lay out plan.

Transplanting

After field preparation, layout was done as per the experimental requirements. Healthy seedlings were transplanted on different dates as per the experimental treatments in the experimental plots at spacings of 30 cm x 30, 45cm x45 cm and 60 cm x 60 cm thereby accommodating 30, 16 and 9 seedlings per bed size of 1.8 m × 1.8 m dimensions. Transplanting was done during evening when the temperature was low to avoid the transplanting shock. Light irrigation was given immediately after transplanting. Gap filling was done with fresh seedlings to maintain cent percent plant population in each plot till ten days after transplanting. All other intercultural operations were carried out from time to time. Pinching was done after 30 days after transplanting. The experimental plots were kept clean by regular hand weeding. Irrigations were given as and when required during the crop growth. No disease incidence was recorded during the experiment. Growth, flowering, yield and biomass production in response to different treatments were assessed from five randomly tagged plants from each treatment and each replication. Plant height and plant spread were measured at peak flowering stage. The duration that the flower remains presentable in the field after it fully bloomed was recorded as flower longevity in field. Flower harvesting was done when the flowers were fully opened. After harvesting, the flowers were determined for shelf life at room temperature.

Statistical analysis

The data pertaining to the growth and flowering parameters were analysed using analysis of variance (ANOVA) to test the significance in the data recorded. Duncan's Multiple Range Test was used to determine the statistical significance of the means at $p_{<0.05}$. The analysis was conducted using SPSS analytical package (IBM SPSS Statistics 27.0.1). The results are presented as means ±standard error (SE).

Results and Discussion

Vegetative growth

Highest number of side shoots per plant (15.81) and plant spread (9649.45 cm^2) were recorded with treatment T_5 (10th October transplanting at 45 cm × 45 cm inter-plant spacing) and lowest values for the above parameters was recorded with the treatment T_4 as is evidenced from Table 1. Favourable environmental conditions prevailing during the crop growth period might have resulted in more vegetative growth. On the other hand, increased plant height in closer spacing might be due to intra-plant competition for light, moisture, space and aeration which resulted in elongation of main stem thereby increasing the plant height due to elongation of cells and number of cells due to cell division (6). More plant height might also be due to the fact that the plants tend to grow vertically when they are crowded owing to shadowing effect of the plants on one another (7). Our results are in consonance with the earlier findings of (8) in gladiolus, (9) in marigold and (10) in China aster, (11) in statice, (12) in tuberose.

The wider plant spread might be ascribed to the fact that wider spacing increased plant spread which creates horizontal space for the growth of roots and shoots, which eventually aids in greater uptake of nutrients and water from the soil. Availability of more sunlight available at wider spacings might also have speed up photosynthesis process and contributed to the better growth of plants (13). Similar findings of effect of spacings on plant spread have been reported by previous researchers (14) in statice, (15) in gomphrena, (16) in salvia, (17) in marigold and (18) in China aster.

Flowering characters

Floral traits

Days to bud initiation and 50 % flowering were recorded non-significant (Table 1). However, slight delay in flowering in early planting may be due to long day conditions experienced by early planting producing more photosynthates and other growth promoting substances which resulted in more vegetative growth and hence delayed flowering. However, in later planting, there were short day conditions that resulted in early bud formation. Closer spacing creates microclimate for reproductive phase of plants and resulted in early onset of flower bud emergence (19). These results were in confirmation with the findings of former researchers (20, 21) in marigold. Minimum days to 50 % flowering with November planting in chrysanthemum cv. Ratlam Selection was also reported (22).

Yield attributing traits

Data in Table 1 revealed a non-significant data regarding number of flowers per plant. However, maximum flower yield per plant (918.57g) from 25th October transplanting at 45 cm × 45 cm inter-plant spacing) whereas minimum flower yield per plant (582.93 g) recorded with 10th November planting at 30 cm × 30 cm spacing. The increase in the yield of flowers may be correlated with better vegetative growth characters where the treatments might have produced significant effect. As a result of this the plant had comparatively higher levels of food reserves, conducive for better floral development and thereby increasing the number of flowers (13). Similar findings have been reported by previous researchers (15) in gomphrena, (6) and (23) in marigold and (24) in garland chrysanthemum.

Similarly, the increase in flower yield per plant at wider spacing could also be attributed to availability of greater space and light for photosynthesis with higher availability and uptake of nutrients by plants which could have enhanced cell division, cell elongation as well as protein synthesis and greater accumulation of dry matter in larger sized sink (25). Highest flower production in early planting due to the dominating effect of early planting was reported earlier (26). Also additionally, due to prolonged period of photosynthetic activity, the plants had sufficient food reserves to convert it in to more flowering buds. These results are supported by the earlier findings in chrysanthemum, reported that number of flowers decreased in delayed planting (27).

Data in Table 1 and 2 revealed maximum flower weight (5.94 g) was recorded on 25th October transplanting at 60 cm × 60 cm inter-plant spacing whereas, minimum flower weight (3.73 g) was recorded with 10th November planting at 30 cm × 30 cm spacing. In earlier reports planting produced bigger flower size and weight which might be ascertained due to the increased photosynthetic activity proportionately to better vegetative growth (28). Also, due to favourable conditions, like availability of nutrients, sunlight and soil

Table 1. Effect of planting dates and inter-plant spacings on vegetative and floral parameters of *Chrysanthemum coronarium* L. Different letters indicate significant differences (P≤0.05) between treatments using Duncans Multiple Range Test (DMRT) test

Treatments	Plant Height	Number of side shoots per plant	Plant spread (cm²)	Days to bud initiation	Days to 50 % flowering	Number of flowers per plant	Flower weight (g)
T_1	154.47 ± 15.90 a	12.73 ± 0.72 bcde	4886.29 ± 430.84 de	84.87 ± 6.73 a	122.80 ± 3.08 a	151.93 ± 16.65 a	5.65 ± 0.48 a
T_2	158.37 ± 7.65 a	14.93 ± 1.17 ab	3480.82 ± 362.25 f	88.73 ± 10.76 a	123.40 ± 7.89 a	136.33 ± 10.39 a	4.21 ± 0.38 cde
T_3	143.27 ± 17.02 a	14.00 ± 0.41abc	7196.31 ± 359.72 b	77.27 ± 8.04 a	120.07 ± 11.31 a	151.40 ± 6.95 a	3.73 ± 0.39 e
T_4	132.27 ± 7.70 a	10.20 ± 0.23 e	5565.03 ± 410.42 cde	84.27 ± 2.14 a	117.53 ± 2.21 a	156.13 ± 14.84 a	4.57 ± 0.24 bcde
T_5	164.37 ± 11.04 a	15.87 ± 0.76 a	9649.45 ± 1035.84 a	81.33 ± 7.13 a	124.93 ± 6.25 a	154.67 ± 18.76 a	5.09 ± 0.58 abcd
T_6	154.43 ± 8.61 a	13.93 ± 1.25 abc	6077.34 ± 488.05 bcd	82.93 ± 2.11 a	116.40 ± 6.96 a	159.27 ± 3.52 a	4.03 ± 0.28 de
T_7	133.80 ± 14.58 a	11.60 ± 0.59 cde	5119.52 ± 272.69 cde	87.00 ± 8.98 a	121.07 ± 6.94 a	146.27 ± 7.55 a	4.55 ± 0.53 bcde
T_8	144.97 ± 13.90 a	10.93 ± 0.48 de	4538.81 ± 554.17 ef	80.87 ± 3.25 a	118.27 ± 14.44 a	148.73 ± 5.24 a	4.04 ± 0.12 de
T_9	144.63 ± 17.06 a	14.13 ± 0.86 abc	4547.53 ± 301.84 ef	91.87 ± 9.79 a	123.07 ± 9.99 a	157.13 ± 15.32 a	5.35 ± 0.11 ab
T_{10}	146.83 ± 8.78 a	11.07 ± 1.02 de	6363.62 ± 203.37 bc	79.87 ± 7.26 a	123.60 ± 12.36 a	153.73 ± 2.64 a	5.94 ± 0.29 a
T_{11}	146.83 ± 12.87 a	14.20 ± 1.21 abc	6097.70 ± 514.66 bcd	86.27 ± 3.04 a	117.93 ± 13.82 a	155.40 ± 11.84 a	5.12 ± 0.09 abc
T_{12}	133.63 ± 11.06 a	13.40 ± 0.92 abcd	5531.67 ± 602.87 cde	79.07 ± 5.96 a	116.00 ± 2.76 a	139.93 ± 5.39 a	4.28 ± 0.13 bcde

moisture to individual plant at wider spacing, increase in the weight of flowers was seen (9). Similar findings have been reported in previous studies (6) in marigold. Maximum flower diameter with widest spacing was also reported in chrysanthemum (25), African marigold (23) and gypsophilla (29). In our experiment the flower diameter was found to be non-significant.

Maximum flowering duration (39.40 days) was observed with 25th October transplanting at 45 cm × 45 cm spacing whereas, minimum flowering duration (30.13 days) was observed with 25th November planting at 30 cm × 30 cm (Table 2). Maximum duration of flowering was recorded in wider spacing than closer spacing which might be due to proper availability of light, air and spacing. These results are in conformity with the findings of previous studies in marigold (30).

Seed yield

Maximum seed yield per plant (41.86 g) was recorded with 25th October planting at 45 cm × 45 cm spacing whereas, minimum seed yield per plant (28.47 g) was recorded with 10th November planting at 30 cm × 30 cm spacing (Table 2). Prevalence of congenial growing conditions might have favoured the production of significantly more number and weight of flowers per plant along with higher percentage of seed set in each flower head which in turn might have contributed to more seed yield per plant in early planting (31). More number of flowers and maximum seed yield per plant in wider spaced plants whereas in closer spacing, plant produced lesser number of flowers which result less seed yield per plant was reported previously (32).

Shelf life and chlorophyll content

Maximum shelf life (6.80 days) was recorded with the treatment 25th October transplanting at 60 cm × 60 cm spacing which was statistically at par with the treatment 10th October transplanting at 45 cm × 45 cm recording the shelf life of 6.60 days (Table 2). Early planted crop flowered during the period when climatic conditions were favourable hence less utilization of synthesized photosynthates resulting in longer shelf life (22).

Maximum chlorophyll content (27.84 SPAD value) was recorded with the treatment 25th October transplanting at 45 cm × 45 cm whereas, minimum chlorophyll content (18.00 SPAD value) was recorded with 10th November transplanting at 30 cm × 30 cm spacing (Table 2). This might be because wider spacing might have attributed to increased biomass production because of increased chlorophyll contents and photosynthetic efficiency. Also, it might be attributed to greater availability of plant nutrients, water and better sunlight which plays an important role in metabolic activities of plant resulting in the synthesis of chlorophyll and cytochromes which are essential for photosynthesis process. Previous researchers reported maximum total chlorophyll content in Asiatic Lily with widest spacing (33). Highest chlorophyll content with wider spacings in African marigold was also reported earlier (20).

Conclusion

From the results of present investigation, the following conclusions have been drawn which will be beneficial for cultivation of *Chrysanthemum coronarium* L. under the Jammu agro climatic conditions.

Among the various planting dates tested, 10th October planting date and interplant spacing at 45 cm × 45 cm performed

Table 2. Effect of planting dates and inter-plant spacings on flower quality and seed yield of *Chrysanthemum coronarium* L. Different letters indicate significant differences (P≤0.05) between treatments using Duncans Multiple Range Test (DMRT) test

Treatments	Flower diameter (cm)	Flowering duration (days)	Flower yield per plant (g)	Seed yield per plant (g)	Shelf life (days)	Chlorophyll content (SPAD value)
T_1	6.77 ± 0.26 a	37.07 ± 4.41 ab	854.87 ± 65.36 ab	38.88 ± 0.68 ab	4.40 ± 0.10 d	26.67 ± 3.22 ab
T_2	6.34 ± 0.60 a	33.87 ± 0.64 ab	640.05 ± 38.29 cd	33.55 ± 3.69 bc	4.60 ± 0.15 cd	25.47 ± 1.44 ab
T_3	6.07 ± 0.23 a	35.20 ± 2.33 ab	582.93 ± 45.38 d	28.47 ± 2.89 c	5.67 ± 0.42 abc	18.00 ± 2.09 c
T_4	6.47 ± 0.58 a	30.13 ± 1.04 b	622.63 ± 22.96 cd	34.88 ± 2.63 abc	5.40 ± 0.11 cd	21.98 ± 0.92 abc
T_5	6.37 ± 0.64 a	33.20 ± 1.90 ab	744.00 ± 26.83 bc	34.22 ± 0.59 abc	6.60 ± 0.55 ab	26.26 ± 2.28 ab
T_6	6.25 ± 0.58 a	39.40 ± 3.36 a	918.57 ± 59.47 a	41.86 ± 3.02 a	4.80 ± 0.55 cd	27.84 ± 3.10 a
T_7	6.50 ± 0.75 a	34.33 ± 0.84 ab	676.30 ± 57.08 cd	36.99 ± 3.15 ab	5.33 ± 0.42 cd	23.98 ± 1.91abc
T_8	6.26 ± 0.40 a	35.13 ± 2.82 ab	658.53 ± 65.84 cd	30.83 ± 0.94 bc	5.27 ± 0.50 cd	20.93 ± 1.77 bc
T_9	6.57 ± 0.55 a	35.60 ± 1.40 ab	832.02 ± 70.23 ab	36.97 ± 3.97 ab	5.47 ± 0.14 bcd	25.31 ± 1.85 ab
T_{10}	6.94 ± 0.53 a	32.27 ± 0.66 ab	632.57 ± 18.66 cd	31.65 ± 3.34 bc	6.80 ± 0.54 a	22.86 ± 1.70 abc
T_{11}	6.69 ± 0.81 a	33.07 ± 3.20 ab	715.93 ± 17.01 bcd	38.57 ± 1.77 ab	4.73 ± 0.29 cd	26.95 ± 0.97 ab
T_{12}	6.39 ± 0.54 a	36.87 ± 2.66 ab	643.30 ± 33.74 cd	33.16 ± 2.66 bc	4.40 ± 0.53 d	20.93 ± 1.69 bc

better in terms of better vegetative parameters viz.; plant height, number of side shoots per plant and plant spread whereas in terms of days to bud initiation, number of flowers per plant, flowering duration, flower yield per plant, seed yield per plant and chlorophyll content, the treatment D_2S_2 (25th October + 45 cm × 45 cm) was found to be best.

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Authors' contributions

NL, AS and TS contributed to conceptualization, methodology, investigation and writing (original draft, review and editing). BKS, JSM, SK and AG contributed to study design, data curation and formal analysis. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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