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Dipmala Kedar
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dr. DM Panchbhai
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

DB Chatse
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dr. RP Gajhbhiye
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Corresponding Author:
Dipmala Kedar
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Effect of spacing and growth retardants on flowering quality of annual chrysanthemum (cv. BIJLI SUPER)

Dipmala Kedar, Dr. DM Panchbhai, DB Chatse and Dr. RP Gajhbhiye

Abstract
An investigation was carried out to study the “Effect of spacing and growth retardants on flowering quality of annual chrysanthemum” The experiment was laid out in Factorial Randomized Block Design with four spacing levels 120 x 45 x 45 cm (Raised bed), 120 x 30 x 30 cm (Raised bed), 60 x 45 cm (Flat bed), 45 x 30 cm (Flat bed) and seven levels of growth retardants. Control, CCC 1000 ppm, CCC 1500 ppm, CCC 2000 ppm, MH 500 ppm, MH 750 ppm, MH 1000 ppm) twenty eight treatment combinations replicated thrice. The foliar spray of growth retardant in varying concentrations as per treatments was imposed after 30 DAT. It is evident from the experimental findings that, The flower quality parameters in terms of days to first harvesting from transplanting were found earlier in the treatment spacing 120 x 45 x 45 cm as well as control treatment. Whereas, highest flowering span and diameter of fully opened flower and weight of fully opened flower was found highest in spacing 120 x 45 x 45 cm as well as cycocel @1500 ppm. The maximum number of flower per plant was found in the treatment spacing 120 x 45 x 45 cm as well as cycocel 1000 ppm.

Keywords: spacing, cyococel, MH, quality

Introduction
Annual chrysanthemum (*Chrysanthemum coronarium* L.) is considered to be the most important cultivated commercial flower crop grown all over India. The species is also referred to as *Leucanthemum coronarium* or *Glebionis coronarum*. It is winter season annual propagated through seeds. It produces white and yellow coloured blooms and generally used in garland making as well as bedding material in the landscape gardens. The flowers are generally used for making garlands, veni and also used in the floral decorations during social and religious functions. Annual chrysanthemum is different from the regular chrysanthemum in many aspects. The crop has relatively short duration and photo insensitive. Under moderate climatic conditions flowering is observed almost throughout the year. The plant is hardier, vigorous and grows taller. Among the annuals, annual chrysanthemum is one of the popular flower which is easy to grow. In Vidharbha region of Maharashtra State annual chrysanthemum is cultivated on a large scale but productivity is low and based on latest technology to increase the yield potential. For production of economical yield of annual chrysanthemum flowers, it is necessary to adopt a proper agro-technique by applying new cultural practices like standard cultural practices, growth retardants, growth regulators, nutrition, plant density etc. are most important for production of vegetative growth, flowering, flower yield and seed yield. The growth and flowering of Annual chrysanthemum are greatly influenced by different spacing and application of growth retardant like cycocel and malleic hydrazide.

Material and Methods
The field experiment entitled, "Effect of spacing and growth retardants on growth, flowering and seed yield of Annual Chrysanthemum” cv. PDKV Bijli Super” was carried out at the Experimental field of Horticulture section, college of Agriculture, Nagpur during the kharif season of the year October, 2019-2020 and October, 2020-2021. The allotment of treatment to the flat bed and raised bed for use pair row planting system with different level of spacing was done randomly in each replication. The pair row system on raised bed for easy plant growing, easy cultivation, soil is not compacted, reduce the growth of weed and low cost of management, the same site of experiment and plan of layout as well as randomization were used for both the year of experimentation.

The experimental plot ploughed and subsequent harrowing was done for clod crushing and soil was brought to fine tilth. At the time of land preparation, well rotten FYM @ 20 t ha^{-1} was mixed uniformly in the soil before last harrowing. Layout of flat bed and raised bed 2.4 m x 1.8m size was made in Factorial Randomized Block Design as per treatments and its combinations. A recommended dose of fertilizer 100 Kg N, 50 Kg P_2O_5 and 50 Kg K_2O per ha for annual chrysanthemum was applied (Anon 2018). Full dose of P_2O_5 and K_2O along with half dose of N was applied at the time of transplanting and remaining half dose of nitrogen was given at 30 DAT. The sources of nitrogen, phosphorus and potash were urea (46% N), single super phosphate (16% P_2O_5) and murate of potash (60% K_2O) respectively. The growth retardant like cycocel and maleic hydrazide were used as foliar application as per treatment. The stock solution of growth regulators was prepared for spraying by following ways. One gram of active substance of CCC and MH was dissolved in 10 ml of acetone and final volume was made up 1000 ml by adding distilled water and thus stock solution of 1000 ppm was prepared. Foliar spray was given at 30 days after transplanting. An experiment was conducted in Factorial Randomized Block Design with 28 treatment combinations which were replicated thrice.

Result and Discussion

The result obtained from present investigation are presented below on the basis on the pooled mean of two year of experimentation

Effect of spacing

Flower Quality parameters

The flowering parameters included days to first harvesting (Days), Flowering span (Days) parameters are given in table 1.Diameter of fully opened flower (cm),Weight of flower (g) parameters are given in table 2., Number of flower per plant The observation recorded on flower quality parameters are given in table 3.

During both the years 2019-20 and 2020-21 of experimentation, lowest days to first harvesting of flower for seed was noticed in spacing 120 x 45 x 45 cm (90.86 and 91.43 days) However, significantly highest days to first harvesting was observed in spacing 45 x 30 cm (97.76 and 97.90 days) and Pooled analysis also confirmed lowest days to first harvesting of flower for seed in spacing 120 x 45 x 45 cm (91.14 days) with pair row system on the raised bed. These results are in close conformity with the results in confirmation with Nagdeve (2019) [10] in annual chrysanthemum.

During both the years 2019-20 and 2020-21 of experimentation, significantly highest flowering span was observed in spacing 120 x 45 x 45 cm (55.67 days and 56.29 days) Whereas, significantly the lowest flowering span recorded in spacing 45 x 30 cm (50.67 days and 51.43 days). Pooled analysis also noticed that, the significantly highest flowering span was observed in spacing 120 x 45 x 45 cm (55.98 days). However, significantly minimum flowering span was noticed in the spacing 45 x 30 cm (51.43 days).

From above results, it is shown that, the maximum flowering span was recorded with spacing 120 x 45 x 45 cm with pair row system on the raised bed. Higher availability of space for plant growth result maximum spread of plant with maximum promoting branching and foliage production in plant which resulted elongated duration of flowering. These results are in confirmation with Mali *et al.* (2016) and Nagdeve (2019) [10] in annual chrysanthemum.

During both the years 2019-20 and 2020-21 of experimentation, significantly highest diameter of flower were recorded in the spacing 120 x 45 x 45 cm (5.98 cm and 5.97 cm), which was at par with the treatment 60 x 45 cm (5.78 cm and 5.75 cm). However, significantly lowest diameters of fully opened flower were recorded in spacing 45 x 30 cm (4.96 cm and 4.78 cm). The pooled data observed that, the treatment recorded significantly highest diameter of flower was observed in spacing 120 x 45 x 45 cm (5.98 cm). Whereas the lowest diameter of fully opened flower was observed in spacing 45 x 30 cm (4.87 cm).

It was shown that, the wider spacing 120 x 45 x 45 cm with pair row system on raised bed recorded maximum diameter of flower. This might be due to the higher number of flowers per plant in wider spacing. The developing flowers were supplied with lesser amount of food material as a result flower diameter was reduced in the spacing 45 x 30 cm on the flat bed recorded minimum size of flower, the duration of flowering and size of flower were recorded maximum in widest spacing, because development of more photosynthesis activity in wider spacing might be responsible for longer duration and bigger flower size. Similar results were reported by Belgaonkar *et al.* (1997) [1] in annual chrysanthemum.

During both the years 2019-20 and 2020-21 of experimentation,, significantly highest weight of flower was noted in the spacing 120 x 45 x 45 cm (6.08 g and 6.05 g) However, significantly lowest weight of fully opened flower was recorded in the spacing 45 x 30 cm (4.32 g and 4.28 g). The pooled data indicated that the highest weight of flower was observed in the spacing 120 x 45 x 45 cm (6.07 g). However, significantly minimum weight of fully opened flower was recorded in the treatment spacing 120 x 30 x 30 cm (4.30 g). From the above results, it was shown that, the spacing of 120 x 45 x 45 cm recorded maximum weight of flower.

The reduction in flower weight with decreased spacing might be correlated with the floral characters like number of flowers per plant. It may be pointed out that the wider spacing have increased the number of flowers per plant, hence the developing flower might have been supplied with comparatively more quantities of photosynthates resulting in increase in weight of flower. The present results have supported by Chezhiyan *et al.* (1986) [2] in chrysanthemum, Gowda and Jayanthi (1988) and Beniwal *et al.* (2005) in chrysanthemum and Nagdeve (2019) [10] in annual chrysanthemum.

During both the years 2019-20 and 2020-21 of experimentation, significantly highest number of flowers $plant^{-1}$ were found in the spacing 120 x 45 x 45 cm (94.51 and 94.20). However, significantly minimum number of flower $plant^{-1}$ was recorded in the spacing 45 x 30 cm (78.36 and 78.49). The pooled data observed that, highest numbers of flowers $plant^{-1}$ were found in the spacing 120 x 45 x 45 cm (94.36). However, significantly minimum number of flower $plant^{-1}$ was recorded in the spacing 45 x 30 cm (78.42).

due to reaction of cycocel with gibberellic acid to lower down the level of diffusible auxin there by suppressing vegetative growth and ultimately utilized for lateral branching. However. Shivankar *et al.* (2014) observed that foliar application of cycocel at 1000 ppm had beneficial for increasing stem diameter Similar results were also reported by in Kadam (2009) [7] in China aster, Khandelwal *et al*. (2003) in African marigold, and Jagdale (2017) [4, 5] in annual chrysanthemum.

Both the year of experimentation, significantly highest plant spread at 50% flowering was noticed in the treatment cycocel 1000 ppm (42.98 cm, 41.91 cm). Whereas, the significantly lowest plant spread noted in the treatment control (39.73 cm, 40.21 cm). The pooled data presented revealed that, the significantly highest plant spread was noticed in the treatment cycocel 1000 ppm (42.45 cm). However, significantly lowest plant spread was observed in the treatment control (39.97 cm). From the above results it was indicated that, spread of plant was increased as concentration of cycocel 1000 and cyococel 1500 ppm. The greater plant spread in growth retardant like cycocel and MH, increased plant growth due antiauxine activity, disturb carbohydrate metabolism. Inhibition of cell division and elongation apical meristem reduction in plant height and produced carbohydrates might be utilized to increase the number of branches and plant spread. The results obtained during this investigation are in close agreement with the Kumar *et al.* (2006) [6] and Chikte (2017) [3] and Jagdale (2017) [4, 5] in annual chrysanthemum.

Effect of growth retardants
Flower quality parameters

The flowering parameters included days to first harvesting (Days), Flowering span (Days) parameters are given in table 1.Diameter of fully opened flower (cm),Weight of flower (g) parameters are given in table 2., Number of flower per plant The observation recorded on flower quality parameters are given in table 3.

During the both year 2019-2020 and 2020-2021 of experimentation, significantly lowest days to first harvesting of flower for seed was noticed in control (89.17 and 90.25 days), which was at par with cycocel 1000 ppm (90.00 days), cycocel 1500 ppm (90.92 days). Whereas the treatment MH 1000 ppm recorded highest days to first harvesting of flower (100.17 and 100.00 days). The pooled data revealed that, the significantly lowest days to first harvesting of flower for seed (89.71 days) was noticed in the control, which was at par with cycocel 1000 ppm (90.33 days). However, significantly the highest days to first harvesting of flower was observed in MH 1000 ppm (100.08 days).The lowest days to first harvesting of flower in control treatment. Due to cycocel and MH delayed the flowering in chrysanthemum. These results are in close agreement with findings of Jagdale (2017) [4, 5] in annual chrysanthemum.

During the both year 2019-2020 and 2020-2021 of experimentation, significantly more flowering span was observed in the treatment cycocel 1000 ppm (57.50 days and 58.25 days), which was at par with cycocel 1500 ppm (57.08 days and 57.83 days), cycocel 2000 ppm (56.58 days and 57.25 days). Whereas, significantly the lowest flowering span was recorded in control (49.67 days and 50.33 days). Pooled analysis also confirmed that, significantly highest flowering span was observed in cycocel 1000 ppm (57.88 days), which was at par with cycocel 1500 ppm (57.88 days) and cycocel 2000 ppm (56.92 days). Whereas minimum days to flower span was registered in control (50.00 days).

Maximum flowering span period was observed when cycocel applied at 1000 ppm and it might be happened due to availability of more photosynthesis for the longer period so as to prolong (42.45 cm). However, significantly lowest plant spread was observed in the treatment control (39.97 cm). From the above results it was indicated that, spread of plant was increased as concentration of cycocel 1000 and cyococel 1500 ppm. The greater plant spread in growth retardant like cycocel and MH, increased plant growth due antiauxine activity, disturb carbohydrate metabolism. Inhibition of cell division and elongation apical meristem reduction in plant height and produced carbohydrates might be utilized to increase the number of branches and plant spread. The results obtained during this investigation are in close agreement with the Kumar *et al.* (2006) [6] and Chikte (2017) [3] and Jagdale (2017) [4, 5] in annual chrysanthemum.

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Maximum flowering span period was observed when cycocel applied at 1000 ppm and it might be happened due to availability of more photosynthesis for the longer period so as to prolong plant height by suppressing the apical dominance, increased the main and secondary. branching there by increasing the flower number which ultimately resulted in increased yield of flowers. These results are consistent with the earlier findings of Mittal *et al.* (2015) in chrysanthemum.

Table 1: Days to first harvesting (days) and Duration of flowering (days) as influenced by spacing and growth retardants

Treatments	Days to first harvesting (days)			Duration of flowering (days)		
	2019-2020	2020-21	Pooled Mean	2019-2020	2020-21	Pooled Mean
A. Spacing (S)						
S_1 – 120 × 45 × 45 cm	90.86	91.43	91.14	55.67	56.29	55.98
S_2 – 120 × 30 × 30 cm	95.52	95.43	95.48	52.81	53.48	53.14
S_3 – 60 × 45 cm	92.86	93.71	93.29	54.19	54.81	54.50
S_4 – 45 × 30 cm	97.76	97.90	97.83	50.67	51.43	51.05
F test	Sig	Sig	Sig	Sig.	Sig.	Sig.
SE (m) ±	0.47	0.39	0.28	0.40	0.40	0.31
CD at 5%	1.34	1.09	0.78	1.13	1.13	0.88
B. Growth retardants (G)						
G_1 Control	89.17	90.25	89.71	49.67	50.33	50.00
G_2 Cycocel - 1000 ppm	90.00	90.67	90.33	57.50	58.25	57.88
G_3 Cycocel - 1500 ppm	90.92	91.25	91.08	57.08	57.83	57.46
G_4 Cycocel - 2000 ppm	91.33	91.83	91.58	56.58	57.25	56.92
G_5 MH - 500 ppm	98.58	98.92	98.75	50.33	50.92	50.63
G_6 MH - 750 ppm	99.58	99.42	99.50	50.67	51.33	51.00
G_7 MH - 1000 ppm	100.17	100.00	100.08	51.50	52.08	51.79
F test	Sig	Sig	Sig	Sig.	Sig.	Sig.
SE (m) ±	0.63	0.51	0.36	0.53	0.53	0.41
CD at 5%	1.77	1.44	1.03	1.49	1.49	1.16
C. Interaction (S x G)						
F test	NS	NS	Sig	NS	NS	NS
SE (m) ±	1.25	1.03	0.73	1.05	1.05	0.82
CD at 5%	--	--	--	--	--	--

Table 2: Diameter of fully opened flower (cm) and weight of fully opened flower (g) as influenced by spacing and growth retardants

Treatments	Diameter of fully opened flower (cm)			Weight of fully opened flower (g)		
	2019-2020	2020-21	Pooled Mean	2019-2020	2020-21	Pooled Mean
A. Spacing (S)						
S_1 – 120 × 45 × 45 cm	5.98	5.97	5.98	6.08	6.05	6.07
S_2 – 120 × 30 × 30 cm	5.58	5.37	5.47	4.85	4.82	4.84
S_3 – 60 × 45 cm	5.78	5.75	5.77	5.47	5.44	5.46
S_4 – 45 × 30 cm	4.96	4.78	4.87	4.32	4.28	4.30
F test	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.09	0.07	0.07	0.04	0.04	0.03
CD at 5%	0.26	0.21	0.19	0.11	0.12	0.08
B. Growth retardants (G)						
G_1 Control	5.17	5.13	5.15	4.87	4.84	4.86
G_2 Cycocel - 1000 ppm	5.67	5.63	5.65	5.42	5.40	5.41
G_3 Cycocel - 1500 ppm	5.75	5.65	5.70	5.48	5.44	5.46
G_4 Cycocel - 2000 ppm	5.66	5.61	5.63	5.25	5.25	5.25
G_5 MH - 500 ppm	5.55	5.24	5.40	5.01	4.95	4.98
G_6 MH - 750 ppm	5.61	5.47	5.54	5.06	5.05	5.05
G_7 MH - 1000 ppm	5.62	5.56	5.59	5.18	5.14	5.16
F test	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.12	0.10	0.09	0.05	0.05	0.04
CD at 5%	0.35	0.28	0.25	0.14	0.15	0.11
C. Interaction (S x G)						
F test	NS	NS	NS	NS	NS	NS
SE (m) ±	0.25	0.20	0.18	0.10	0.11	0.08
CD at 5%	--	--	--	--	--	--

Table 3: Number of flower plant^{1}as influenced by spacing and growth retardants

Treatments	Number of flower plant^{1}		
	2019-2020	2019-2020	Pooled
A. Spacing (S)			
S_1 – 120 × 45 × 45 cm	94.51	94.20	94.36
S_2 – 120 × 30 × 30 cm	82.15	81.84	82.00
S_3 – 60 × 45 cm	85.99	85.73	85.86
S_4 – 45 × 30 cm	78.36	78.49	78.42
F test	Sig	Sig	Sig
SE (m) ±	0.82	0.94	0.67

CD at 5%	2.33	2.67	1.90
B. Growth retardants (G)			
G_1 Control	81.75	82.52	82.13
G_2 Cycocel - 1000 ppm	89.03	88.53	88.78
G_3 Cycocel - 1500 ppm	87.62	87.38	87.50
G_4 Cycocel - 2000 ppm	85.97	85.08	85.53
G_5 MH - 500 ppm	83.02	83.62	83.32
G_6 MH - 750 ppm	84.20	83.80	84.00
G_7 MH - 1000 ppm	85.20	84.52	84.86
F test	Sig	Sig	Sig
SE (m) ±	1.09	1.25	0.89
CD at 5%	3.08	3.53	2.52
C. Interaction (S x G)			
F test	F test	F test	F test
SE (m) ±	SE (m) ±	SE (m) ±	SE (m) ±
CD at 5%	CD at 5%	CD at 5%	CD at 5%

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