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Effect of spacing and growth retardants on growth, flowering and seed yield of annual *Chrysanthemum* (cv. Bijli super)

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Abstract
An investigation was carried out to study the "Effect of spacing and growth retardants growth, flowering and seed yield 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 (Flatbed), 45 x 30 cm (Flatbed) 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, in terms diameter of main stem and spread of plant at 50% flowering was found highest under the treatment spacing 120 x 45 x 45 cm as well as cycocel 1000 ppm. Whereas, The flowering parameters in terms of days to first flower bud initiation was observed in the treatment spacing 120 x 30 x 30 cm as well as control treatment. Fully opening of flower from bud initiation were found earlier in the treatment spacing 120 x 45 x 45 cm as well as control treatment. The seed yield parameters like number of seeds per plant highest under the treatment spacing 120 x 45 x 45 cm and seed yield per plot was recorded in spacing 45 x 30 cm as well as cycocel 1000 ppm.

Keywords: Spacing, cyococel, MH, growth, flowering, yield

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 coronarium*. 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 considered to be hardier, vigorous and grows taller. Among the annuals, annual *Chrysanthemum* is one of the popular flower which is easy to grow. In Vidarbha 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 $_{K2O}$ 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
Growth parameter

The growth parameters included diameter of main stem and spread of plant at 50% flowering or blooming period. The observation recorded on growth parameters are given in table 1.

During the year 2019-20 and 2020-21 at 90 DAT, of experimentation, significantly maximum diameter of main stem was noticed in spacing 120 x 45 x 45 cm (2.09 and 2.04 cm) However, significantly minimum diameter of main stem observed in spacing 45 x 30 cm (1.64 and 1.58 cm). In pooled data similar trend was exhibited and reported that, at 90 DAT, during both the years of study, significantly maximum main stem diameter observes in spacing 120 x 45 x 45 cm (2.07 cm) and significantly minimum diameter of main stem were found in spacing 45 x 30 cm (1.61 cm). The above results might be due to the fact that decrease in plant height is always associated with increase in stem girth. Reduced the plant height with corresponding increase in branches per plant tending to more plant spread and automatically accumulated the carbohydrates in branches resulted into thicker stem. The result obtained in the present findings are in close conformity with the findings of Ramesh Kumar *et al.* (2002) in carnation.

In both year of experimentation, significantly highest plant spread at 50% flowering was noticed in spacing 120 x 45 x 45 cm (47.45 cm, 44.99 cm). However, significantly lowest plant spread was recorded in the spacing 45 x 30 cm (36.01 cm, 37.13 cm). The pooled data observed that, the significantly highest plant spread was noticed in the spacing 120 x 45 x 45 cm (46.22 cm) Whereas, the significantly lowest plant spread was noted in the spacing 45 x 30 cm (36.57 cm). Study revealed that, the plant spread was more under wider spacing with pair row system on raised bed as well as increase growth as compair to flatbed along with 25-30% irrigation water and he present 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), Janakiram and Rao (1995) [2, 17, 6] in African marigold.

Effect of spacing
Flowering parameter

The flowering parameters included days to first flower bud initiation and fully opening of flower from bud initiation the observation recorded on flowering parameters are given in table 2.

During the first years 2019-2020 and second years 2020-2021 of experimentation, significantly an early flower bud initiation was noticed in spacing 120 x 30 x 30 cm (49.31 days, 49.94 days) However, significantly highest days to first flower bud initiation from transplanting were recorded in the spacing 60 x 45 cm (54.08 days, 54.84 days). Pooled analysis also confirmed the minimum days to first flower bud emergence was observed in the spacing 120 x 30 x 30 cm (49.63 days) However significantly highest days was required for first flower bud initiation from transplanting were recorded in the spacing 60 x 45 cm (54.46 days). Thus, it is noticed that the flower bud appearance delayed successively as the planting distances were increased. This might be due to more competition among plants in closer spacing for space, light, air and nutrition, hence the closer spacing plants tended to grow vertically and led to early physiological maturity as a result of their taller growth. These findings support by Khanna *et al.* (1986) [8] in carnation cv. "Marguerite Scarlet", Mohanty *et al.* (1993) [14] in African marigold and Nagdeve (2019) [16] in annual *Chrysanthemum*.

Days to fully opened flower from bud initiation in both year of experimentation, significantly minimum days to fully opened flower from bud initiation was noted in spacing 120 x 45 x 45 cm (18.70 days, 18.93 days). However, significantly maximum days required to fully opened flower from bud initiation was observed in spacing 45 x 30 cm (21.95 days, 22.38 days). Pooled analysis also confirmed the minimum days to fully opened flower from bud initiation in spacing 120 x 45 x 45 cm (18.82 days). from above results it was noticed that, cycocel delayed the flower opening after bud emergence and was happened due to their growth retarding action that might have inhibited the endogenous synthesis of gibberellins as resulted in delayed opening of flower buds. Similar results were also reported by Shivankar (2010) [21] who observed that, cycocel delayed initiation of first flower bud in annual *Chrysanthemum*, Korde (2012) [13] in annual *Chrysanthemum* and Taksande (2017) [23] in annual *Chrysanthemum*.

Effect of spacing
Yield parameter

The yield parameters included seed yield $plant^{-1}$ and seed yield $plot^{-1}$ the observation recorded on seed yield parameters are given in table 3.

During the year 2019-20 and 2020-21 of experimentation, significantly highest seeds yield plant^{-1} were found in the spacing 120 x 45 x 45 cm (10.56 g, 10.52 g), while significantly lowest seed yield plant^{-1} was observed in the treatment spacing 45 x 30 cm (7.07 g, 6.98 g). The pooled data observed that, significantly highest seeds yield plant^{-1} were found in the spacing 120 x 45 x 45 cm (10.54 g). Whereas, significantly lowest seed yield plant^{-1} was recorded in the treatment spacing 45 x 30 cm (7.02 g). From above finding, it was noticed that, spacing of 120 x 45 x 45 cm with pair row system on the raised bed recorded the highest seed yield plant^{-1}. In wider spacing plant produced more number of flowers indirectly maximum seed yield plant^{-1} where as in closer spacing plant produced lesser number of flowers result minimum seed yield plant^{-1} so, the yield of flower per plant and seed yield plant^{-1} increased in wider spacing 120 x 45 x 45 cm to 60 x 45 cm spacing but decrease in closer spacing 120 x 30 x 30 cm to 45 x 30 cm treatment. Similar findings were observed by Balgaonkar *et al*. (1997) in annual *Chrysanthemum*, Karavadia and Dhaduk (2002) in annual *Chrysanthemum* cv. “Local White” and Nagdeve (2019) [16] in annual *Chrysanthemum*.

Both the year of experimentation, seed yield plot^{-1} significantly superior was recorded in spacing 45 x 30 cm (212.01 g, 209.41 g), whereas, significantly the lowest seed yield plot^{-1} was recorded in the spacing 60 x 45 cm (138.14 g, 137.35 g). The pooled data observed that, significantly the highest seed yield plot^{-1} spacing 45 x 30 cm (210.71 g). However, significantly the lowest seed yield plot^{-1} was recorded in the treatment spacing 60 x 45 cm (137.75 g). From above finding of maximum flower yield plot^{-1}. This might be due to the decrease in flower yield (per plot and per hectare) was noticed that, the spacing (45 × 30 cm) with increasing the spacing was due to the decrease in plant population per unit area.

Effect of growth retardants

Growth parameter

The growth parameters included diameter of main stem and spread of plant at 50% flowering or blooming period. The observation recorded on growth parameters are given in table 1.

During both the years 2019-2020 and 2020-2021 of experimentation, diameter of main stem measured at 90 DAT, significantly maximum diameter of main stem was recorded in treatment growth retardant cycocel 1000 ppm (1.93 and 1.88 cm), whereas significantly minimum diameter of main stem was noticed in treatment control (1.79 and 1.74 cm). The pooled data revealed that, at 90 days after transplanting, during both the years of study, significantly maximum diameter of main stem was exhibited with the treatment cycocel 1000 ppm (1.91 cm) and significantly minimum diameter of main stem observed in control (1.76 cm) Might 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) [22] observed that foliar application of cycocel at 1000 ppm had beneficial for increasing stem diameter Similar results were also reported by in Kadam (2009) [12] in China aster, Khandelwal *et al*. (2003) in African marigold, and Jagdale (2017) [7] 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) and Chikte (2017) and Jagdale (2017) [11, 7, 3] in annual *Chrysanthemum*.

Effect of growth retardants

Flowering parameter

The flowering parameters included days to first flower bud initiation and fully opening of flower from bud initiation spread of plant at 50% flowering or blooming period. The observation recorded on flowering parameters are given in table 2.

During the first years 2019-2020 and second years 2020-2021 of experimentation, significantly lowest days to first flower bud initiation was noticed in treatment control (48.60 days, 49.00 days). However, significantly highest days to first flower bud initiation from transplanting were recorded in the treatment MH 1000 (55.53 days, 56.20 days). The pooled data presented in revealed that, the significantly the lowest days required to first flower bud initiation was noticed in the treatment control (48.80 days). However, significantly the highest days required to first flower bud initiation was observed in MH 1000 ppm (55.87 days). From the above results, it was indicated that, cycocel delayed the flowering. cycocel and MH being a growth retardant inhibited the endogenous synthesis of gibberllins responsible for flower bud initiation and hence delayed flowering. Similar results were also found by Sagar (2005) [19] in Tuberose, Khandelwal *et al*. (2003) in African marigold and similar results have also been reported by Shivankar (2010) [21] in Annual *Chrysanthemum*, Chikte *et al*. (2017) [3] in marigold and Taksande *et al*. (2017) [23].

In both the year of experimentation, significantly minimum days to fully opened flower from bud initiation was noted in treatment control (18.15 days, 18.55 days). Whereas, maximum days to require fully opened flower from bud initiation recorded in treatment MH 1000 ppm (22.93 days, 23.32 days). The pooled data revealed that, the significantly minimum days required to fully opened flower from bud initiation was noticed in the treatment control (18.35 days.) and significantly maximum day to fully opened flower from bud initiation was observed in MH 1000 ppm (23.13 days). From above results it was noticed that, cycocel delayed the flower opening after bud emergence and was happened due to their growth retarding action that might have inhibited the endogenous synthesis of gibberellins as resulted in delayed opening of flower buds. Similar results were also reported by Shivankar (2010) [21] who observed that, cycocel delayed initiation of first flower bud in annual *Chrysanthemum*, Korde (2012) [13] in annual *Chrysanthemum* and Taksande (2017) [23] in annual *Chrysanthemum*.

Effect of growth retardants

Yield parameter

The yield parameters included seed yield per plant and seed yield plot[1] the observation recorded on seed yield parameters are given in table 3.

During the year 2019-20 and 2020-21 of experimentation, significantly highest seeds plant^{-1} was observed in treatment cycocel 1000 ppm (9.27 g, 9.23 g). However, significantly the lowest seed yield plant^{-1} was recorded in the treatment control (7.93 g, 7.92 g). The pooled data revealed that, significantly maximum seeds plant^{-1} was observed in treatment cycocel 1000 ppm (9.25 g). Whereas, significantly the lowest seed yield plant^{-1} was observed in treatment control (7.93 mg). Growth retardants is capable of redistribution of dry matter in plant there by bringing improvement in seed yield. These results are consistent with the earlier findings of Naik *et al.* (2004) in African marigold. Sainath (2009) in Annual *Chrysanthemum*. Shivankar *et al.* (2010) [21] and Dorajeerao *et al.* (2010) in annual *Chrysanthemum*.

In both year of experimentation, seed yield plot^{-1} significantly highest seed yield plot-^{1} was observed in treatment cycocel 1000 ppm (184.73 g, 183.47 g). However, significantly the lowest seed yield plot^{-1} was recorded in the treatment control (160.45 g, 159.90 g). The pooled data) revealed that, cycocel 1000 ppm recorded significantly the maximum seed yield plot^{-1} (184.10 g). Whereas, significantly the lowest seed yield plot^{-1} recorded in the treatment control (160.18 g). Seed yield plot^{-1} increased might be due to foliar application of cycocel resulted into more number of branches, more flower diameter and more seeds flower^{-1}. These results are consistent with the earlier findings of Gyandev (2006) in China aster, Sainath (2009) in annual *Chrysanthemum* and Dorajeerao (2010) in annual *Chrysanthemum*, Chikte (2017) [3] in marigold and Taksande (2017) [23] in annual *Chrysanthemum*.

Table 1: Growth parameters as influenced by spacing and growth retardants

Treatments	Diameter of main stem at 90 DAT			spread of plant at 50% flowering (cm)		
	2019-2020	2020-21	Pooled Mean	2019-2020	2020-21	Pooled Mean
A. Spacing (S)						
S_1 – 120 × 45 × 45 cm	2.09	2.04	2.07	47.45	44.99	46.22
S_2 – 120 × 30 × 30 cm	1.79	1.73	1.76	39.46	39.36	39.41
S_3 – 60 × 45 cm	1.91	1.89	1.90	42.49	42.99	42.74
S_4 – 45 × 30 cm	1.64	1.58	1.61	36.01	37.13	36.57
F test	Sig	sig	Sig	Sig	Sig	Sig
SE (m) ±	0.02	0.02	0.02	0.26	0.13	0.14
CD at 5%	0.07	0.07	0.06	0.74	0.37	0.40
B. Growth retardants (G)						
G_1 Control	1.79	1.74	1.76	39.73	40.21	39.97
G_2 Cycocel - 1000 ppm	1.93	1.88	1.91	42.98	41.91	42.45
G_3 Cycocel - 1500 ppm	1.90	1.86	1.88	42.37	41.59	41.98
G_4 Cycocel - 2000 ppm	1.89	1.83	1.86	42.03	41.43	41.73
G_5 MH - 500 ppm	1.81	1.76	1.79	40.17	40.72	40.44
G_6 MH - 750 ppm	1.83	1.79	1.81	40.78	40.84	40.81
G_7 MH - 1000 ppm	1.86	1.80	1.83	41.41	41.12	41.26
F test	Sig	sig	Sig	Sig	Sig	Sig
SE (m) ±	0.03	0.03	0.03	0.35	0.17	0.19
CD at 5%	0.09	0.09	0.07	0.98	0.49	0.53
C. Interaction (S x G)						
F test	NS	NS	NS	NS	NS	NS
SE (m) ±	0.06	0.06	0.05	0.70	0.35	0.38
CD at 5%	--	--	--	--	--	--

Table 2: Flowering parameters as influenced by spacing and growth retardants

Treatments	Days to first flower bud initiation (days)			Days to fully opened flower (days)		
	2019-2020	2020-21	Pooled Mean	2019-2020	2020-21	Pooled Mean
A. Spacing (S)						
S_1 – 120 × 45 × 45 cm	52.32	52.74	52.53	18.70	18.93	18.82
S_2 – 120 × 30 × 30 cm	49.31	49.94	49.63	20.89	21.15	21.02
S_3 – 60 × 45 cm	54.08	54.84	54.46	19.70	20.14	19.92
S_4 – 45 × 30 cm	50.77	50.95	50.86	21.95	22.38	22.17
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.35	0.37	0.25	0.29	0.27	0.16
CD at 5%	0.99	1.05	0.70	0.82	0.76	0.46
B. Growth retardants (G)						
G_1 Control	48.60	49.00	48.80	18.15	18.55	18.35
G_2 Cycocel - 1000 ppm	48.95	49.22	49.08	18.52	18.78	18.65
G_3 Cycocel - 1500 ppm	49.47	49.82	49.64	18.70	19.00	18.85
G_4 Cycocel - 2000 ppm	49.65	50.22	49.93	19.05	19.38	19.22
G_5 MH - 500 ppm	54.25	54.83	54.54	22.18	22.55	22.37
G_6 MH - 750 ppm	54.90	55.55	55.23	22.65	22.98	22.82
G_7 MH - 1000 ppm	55.53	56.20	55.87	22.93	23.32	23.13
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.46	0.49	0.33	0.38	0.36	0.22

CD at 5%	1.31	1.39	0.92	1.09	1.01	0.61
C. Interaction (S x G)						
F test	NS	NS	NS	NS	NS	NS
SE (m) ±	0.92	0.98	0.65	0.77	0.71	0.43
CD at 5%	--	--	--	--	--	--
	NS	NS	NS	NS	NS	NS

Table 3: Seed yield parameters as influenced by spacing and growth retardants

Treatments	**Seed yield plant^{-1} (g)**			**Seed yield plot^{-1} (g)**		
	2019-2020	**2020-21**	**Pooled Mean**	**2019-2020**	**2020-21**	**Pooled Mean**
A. Spacing (S)						
S_1 – 120 × 45 × 45 cm	10.56	10.52	10.54	165.36	164.79	165.08
S_2 – 120 × 30 × 30 cm	7.89	7.78	7.83	172.60	170.28	171.44
S_3 – 60 × 45 cm	8.74	8.69	8.72	138.14	137.35	137.75
S_4 – 45 × 30 cm	7.07	6.98	7.02	212.01	209.41	210.71
F test	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.14	0.13	0.13	2.61	2.83	2.40
CD at 5%	0.39	0.36	0.36	7.37	8.00	6.79
B. Growth retardants (G)						
G_1 Control	7.93	7.92	7.93	160.45	159.90	160.18
G_2 Cycocel - 1000 ppm	9.27	9.23	9.25	184.73	183.47	184.10
G_3 Cycocel - 1500 ppm	9.03	8.89	8.96	180.73	177.71	179.22
G_4 Cycocel - 2000 ppm	8.71	8.62	8.66	174.90	173.47	174.19
G_5 MH - 500 ppm	8.16	8.07	8.11	164.53	162.65	163.59
G_6 MH - 750 ppm	8.33	8.26	8.30	167.50	166.10	166.80
G_7 MH - 1000 ppm	8.51	8.45	8.48	171.34	169.89	170.61
F test	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.18	0.17	0.17	3.34	3.74	3.18
CD at 5%	0.52	0.48	0.48	9.75	10.58	8.98
C. Interaction (S x G)						
F test	NS	NS	NS	NS	NS	NS
SE (m) ±	0.37	0.34	0.34	6.89	7.48	6.35
CD at 5%	--	--	--	--	--	--

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