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Effect of plant growth regulators on growth, flowering and yield of chrysanthemum (*Dendranthema grandiflorum*)

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Abstract
An experiment entitled "Effect of plant growth regulators on growth, flowering and yield of chrysanthemum (*Dendranthema grandiflorum*)" was carried out at Pt. Kishori Lal Shukla College of Horticulture and Research Station, Pendri Rajnandgaon (C.G.) during the year 2022-23. The experiment was laid out in Randomized Block Design with ten treatments and three replications. The purpose of research was to observe the effect of different concentrations of Gibberellic acid (100, 200, 300 ppm), Salicylic acid (50, 100, 150 ppm) and Cycocel (1000, 1500, 2000 ppm) in chrysanthemum plants vegetative growth, flowering parameters and yield attributes. The result revealed that GA_3 300 ppm recorded maximum plant height (85.41 cm), days to first flower bud initiation (67.23 days), minimum days to flower opening from bud emergence (8.34 days), days to 50 percent flowering (99.03 days), maximum flower yield per plant (115.67 g), maximum flower yield per hectare (128.52 q), CCC 2000 ppm recorded maximum number of branches per plant (18.40), maximum number of leaves per plant (190.36), maximum stem diameter (2.78 mm), higher plant spread (24.80 cm) in (N-S) and (24.90 cm) in (E-W) direction, maximum number of flower per plant (45.42). In research, control was reported minimum for every trait except CCC 2000 ppm which showed minimum result for plant height from different concentrated PGR taken in the investigation.

Keywords: Chrysanthemum, Gibberellic acid, Cycocel, Salicylic acid, Growth, flowering and yield

Introduction
Chrysanthemum belongs to the family Asteraceae. It is also recognized as "Queen of the east", "glory of east", "autumn queen" and "guldaudi". Chrysanthemum is native to East Asia, North Eastern Europe and the centre of diversity is China.

Chrysanthemum is coined from a posh of species that were all hexaploid (2n = 6x= 54). It's a short day photo sensitive plant that required ten hours of daily sunlight. Most flowers of the genus are perennial herbs or subshrubs. Several have easy aromatic leaves that are alternate and should be pinnate, lobed and serrate (dentate), however seldom entire alternate on the stem. Some have each disk and ray floret within the heads but others lack ray or disk flowers. The single row of ray florets is white, yellow and red the disc florets are yellow in colour. Cultivated species and hybrids sometimes have giant flower heads, those of wild species are much smaller. Botanically inflorescence of chrysanthemum is known as capitulum.

Chrysanthemum is widely grown for beautification, fragrance, clean air and serenity inside and outdoors. It‟s used as a cut flower, loose flower and conjointly as a potted plant. In several parts of India and abroad it is popularly used as, wreath, venies, bouquet and garlands that are utilized in marriages, festivals, non-secular offerings and death rituals. Peoples are also used for to create medicine. The dwarf and compact plants are used in flower beds, mixed borders, edging, hanging basket, window boxes and ahead row plantings.

Plant growth regulators have quicker impact on vegetative further more as flower yield of flowering crops because it has various benefits like less time consuming to treat the plant and setting friendly (Pal 2019) [16].

Gibberellic acid (GA_3) increases flower size and stem length in flower crops. It influences a wide range of development process in plant life like germination, breaking dormancy, stem elongation, flowering, sex expression, enzyme induction and flower senesces (Mujadidi *et al.* 2019) [13]. SA has direct involvement in plant growth, thermogenesis, flower induction and uptake of ions. It affects ethylene biosynthesis, stomatal movement and also reverses the effects of ABA on leaf abscission (Hayat and Ahmad 2007) [6]. Cycocel (CCC) or chlormequat chloride is a synthetic growth retardant which shows a positive influence on reducing plant height and increasing shoot number, flowering period and number of flower per plant. Moreover, chlorophyll and carotenoids contents were enhanced in plants. (Elateeq *et al.* 2021) [5].

Materials and Methods

The experiment was laid out in Randomized Block Design with ten treatments with three replications. The treatments *viz.* Control (T_1), GA_3 100 ppm (T_2), GA_3 200 ppm (T_3), GA_3 300 ppm (T_4), SA 50 ppm (T_5), SA 100 ppm (T_6), SA 150 ppm (T_7), CCC 1000 ppm (T_8),CCC 1500 ppm (T_9), CCC 2000 ppm (T_{10}).

The plant growth regulator solution is evenly sprayed on the vegetative parts of the plant using a hand-held sprayer with a fine nozzle. Spraying was carried out early in the morning. The growth regulator with the corresponding concentration was sprayed at 20 days after transplanting. The control plant was sprayed with distilled water.

Result and Discussion

The data pertaining to the vegetative growth are presented in table-1

Growth parameters

Plant height

The experimental data revealed that the maximum plant height (85.41 cm) was recorded in GA_3 300 ppm followed by GA_3 200 ppm (78.31 cm) while the minimum height of plant (69.13 cm) was obtained under CCC 2000 ppm.

The significant results was found under different treatments might be applications of gibberellic acid. It might be due to the fact that GA_3 increased the growth of plant by increasing internodal length and due to cell division, cell enlargement and enhanced apical dominance indirectly by increasing the auxin content in plant system. It elongate plants cell and tissues, thereby increasing height of plant. Similar type of results has been also reported by Alhajhol (2017) [2] and Sahu *et al.* (2021) [17] in chrysanthemum.

Number of branches per plant

Analyzed data revealed that CCC 2000 ppm had given significantly the maximum number of branches per plant (18.40) followed by CCC 1500 ppm (16.73), while the minimum number of branches (10.28) was obtained under treatment control.

Number of branches per plant was observed highest under application of cycocel it is mainly due to inhibitory effect of CCC on cell division in the apical bud which subsequently might have stopped the growth of main axis. It is also useful for the energy required for plant growth which energy are useful for growth of lateral shoots and also useful for increase the number of branches. These have supportive evidence from the finding of Munikrishnappa *et al.* (2014) [14] in China aster, Kumar *et al.* (2019) [11] in nerium, Elateeq *et al.* (2021) [5] in chrysanthemum.

Number of leaves per plant

It is apparent from the data CCC 2000 ppm had given significantly the maximum number of leaves per plant (190.36) which was at par with CCC 1500 ppm (186.39) and CCC 1000 ppm (179.94), whereas the minimum number of leaves (154.19) was obtained under control.

Maximum number of leaves per plant was observed under application of cycocel it is mainly due to the influence of growth retardants on arresting the shoot growth and lateral buds developed into shoot by destruction of apical dominance, which ultimately increased the number of branches and whereas number of leaves. This is in line with the findings of Tripathi *et al.* (2003) [25] in marigold and Elateeq *et al*. (2021) [5] in chrysanthemum.

Stem diameter (mm)

Analyzed data revealed that among all the treatments of plant growth regulators gave significant effect on stem diameter over control. The maximum stem diameter (2.78 mm) was recorded under CCC 2000 ppm followed by CCC 1500 ppm (2.59 mm). However, the minimum stem diameter (1.04 mm) was found under control.

The diameter of main stem is increased due to reaction of cycocel with gibberellic acid to lower down the level of diffusible auxin thereby suppressing vegetative growth and ultimately utilized for increasing the diameter of main stem. These finding is in line with Singh and Tomar (2015) [23], Singh *et al.* (2018) [24] and Kedar *et al.* (2022) [9] in chrysanthemum.

Plant spread (cm)

CCC 2000 ppm had given significantly higher plant spread (24.80 cm) in North –South direction followed by CCC 1500 ppm (22.70 cm), whereas the minimum plant spread (16.87 cm) were recorded under treatment control. For East-West direction, higher plant spread (24.90 cm) was recorded under CCC 2000 ppm followed by CCC 1500 ppm (22.70 cm), whereas the minimum plant spread (16.57 cm) were recorded under treatment control.

Maximum plant spread for were recorded under application of cycocel it may due to cycocel retard the shoot length of plant without inducing phytotoxic effect. Cycocel play an important role in suppression of apical dominance by reduces plant height and induces the lateral vegetative growth which might have resulted in increased plant spread. The present investigation are in agreement with the results of Porwal *et al.* (2002) in rose, Sasikumar *et al.* (2015) [19] in marigold, Kedar *et al.* (2022) [9] and Nariya & Kumari (2022) [15] in chrysanthemum.

Table 1: Effect of foliar application of PGR on Growth parameters of Chrysanthemum

Notation	Treatment	Plant height	Number of branches per plant	Number of leaves per plant	Stem diameter (mm)	Plant spread	
						(N-S)	(E-W)
T_1	Control	75.80	10.28	154.19	1.04	16.87	16.57
T_2	GA_3 100 ppm	77.81	13.04	163.86	1.92	18.21	18.59
T_3	GA_3 200 ppm	78.31	12.26	160.43	1.78	17.81	17.95
T_4	GA_3 300 ppm	85.41	10.87	157.97	1.65	17.10	17.70
T_5	SA 50 ppm	74.91	13.17	167.43	2.26	18.80	18.84
T_6	SA 100 ppm	74.59	14.24	170.50	2.31	19.70	20.53
T_7	SA 150 ppm	73.79	15.85	174.74	2.43	21.01	20.89
T_8	CCC 1000 ppm	72.71	16.15	179.94	2.50	22.03	21.80
T_9	CCC 1500 ppm	70.52	16.73	186.39	2.59	22.70	22.70
T_{10}	CCC 2000 ppm	69.13	18.40	190.36	2.78	24.80	24.90
S.Em±		2.36	0.55	4.99	0.07	0.70	0.73
C.D. at 5%		7.08	1.65	14.84	0.20	2.08	2.18
C.V. (%)		5.43	6.78	5.07	5.54	6.06	6.29

Flowering parameters

The data related to flowering parameter in table- 2

Days to first flower bud initiation

It is apparent from the data that minimum days was required for first flower bud initiation (67.23 days) in GA_3 300 ppm which was found *at par* with GA_3 200 ppm (71.51 days) and GA_3 100 ppm (74.94 days). Maximum days required for initiation of first flower bud (86.10 days) was recorded in treatment control.

Earliest bud initiation was observed with the application of GA_3 might have stimulated and enhanced the vegetative growth by increasing photosynthesis and respiration with enhanced carbon dioxide fixation in treated plant which would have associated with an early flowering. These finding is in line with the report of Khangjarakpam *et al.* (2019) [10] in marigold, Kadam *et al.* (2020) [7] in Gaillardia and Singh *et al.* (2022) [22] in China aster.

Days to opening of flower from bud emergence

The minimum days to flower opening from bud emergence (8.34 days) was recorded in GA_3 300 ppm which was at par with GA_3 200 ppm (9.40 days) and GA_3 100 ppm (10.46 days). It was noted that, control take maximum days to opening of flower from bud emergence (17.50 days) among the all treatment.

Minimum days required for opening of flower from bud emergence in GA_3 might be due to more rapid cell development and elongation. Whereas growth retardants required more number of days for flower bud opening and the present findings are supported by Kaur *et al.* (2021) [8] in chrysanthemum, Singh *et al.* (2022) [22] in china aster.

Days to 50% flowering

The minimum days to 50 percent flowering (99.03 days) was recorded in GA_3 300 ppm which was *at par* with GA_3 200 ppm (104.02 days) and GA_3 100 ppm (106.54 days). The maximum days to 50 percent flowering was recorded in control (116.70 days) which was statistically highest to other plant growth regulator concentration during the observation.

Early 50% flowering was found in the plants treated with GA_3 as compared to control and other treatments it may be due to early production of florigin in GA_3 which is required for the formation of flowers in the plant system. These findings are in consonance with the report of Choudhari *et al.* (2018) [4] in chrysanthemum, Kadam *et al.* (2020) [7] in gaillardia, Kaur *et al.* (2021) [8] in chrysanthemum.

Yield parameter

Number of flowers per plant: The maximum number of flower per plant (45.42) was obtained in CCC 2000 ppm which followed by CCC 1500 ppm (41.53). In research, control was reported minimum number of flower per plant (27.93) among the all treatment of plant growth regulators.

The maximum number of flower per plant was recorded under application of cycocel it might be due to reduction in plant height with increasing plant spread and number of branches further resulted higher production of photosynthates. The quick mobilization of these photosynthates from leaves (source) to flower (sink) might have increased number of flower per plant. These results are in accordance with the findings of Moon *et al.* (2017) [12] in gaillardia, Sindhuja and Prasad (2018) [21] in China aster and Nariya & Kumari (2022) [15] in chrysanthemum.

Flower yield per plant (g)

The maximum flower yield per plant (115.67 g) was recorded under GA_3 300 ppm followed by GA_3 200 ppm (102.15 g). In research, control was reported minimum flower yield per plant (85.04 g) in all treatment of plant growth regulators.

The maximum flower yield per plant was recorded under application of GA_3 it may due to increase number of branches which led to increase in the number of flower. After successful vegetative phase only, the plant could step into reproductive phase with better yield. These results are in confirmly with findings of Sajid *et al.* (2016) [18], Sharma *et al.* (2016) [20] in chrysanthemum, Beese and Sarvanan (2020) [3] in crossandra.

Flower yield per hectare (q)

The maximum flower yield per hectare (128.52 q) was recorded under GA_3 300 ppm followed by GA_3 200 ppm (113.48 q). In research, control was reported minimum flower yield per plant (97.49 q) in all treatment of plant growth regulators.

Maximum flower yield per hectare were observed under application of GA_3 it may due to greater dry matter accumulation is certainly suggestive of better photosynthetic activities and uptake of nutrients from soil also close parallelism between vegetative growth and flowering that promontory effect of GA_3 on vegetative growth associated with efficient mobilization capacity. Therefore, the growth promoting substances might have positive influence on the yield of flower. The findings are in line with the results obtained by Aklade *et al.* (2009), Singh *et al.* (2018) [24] in chrysanthemum and Singh *et al.* (2022) [22] in china aster.

Table 2: Effect of foliar application of PGR on flowering and yield parameters of chrysanthemum

Notation	Treatment	Days to first flower bud initiation	Days to opening of flower from bud emergence	Days to 50% flowering	Number of flowers per plant	Flower yield per plant (g)	Flower yield per hectare (q)
T_1	Control	86.10	17.50	116.70	27.93	85.04	97.49
T_2	GA_3 100 ppm	74.94	10.46	106.54	33.03	98.27	109.86
T_3	GA_3 200 ppm	71.51	9.40	104.02	31.98	102.15	113.48
T_4	GA_3 300 ppm	67.23	8.34	99.03	30.85	115.67	128.52
T_5	SA 50 ppm	85.74	16.25	115.76	35.74	88.55	100.30
T_6	SA 100 ppm	84.50	15.66	115.10	37.19	90.35	102.61
T_7	SA 150 ppm	83.74	13.85	114.82	38.87	93.26	104.40
T_8	CCC 1000 ppm	81.30	13.36	113.64	40.02	95.46	105.96
T_9	CCC 1500 ppm	79.56	12.81	112.58	41.53	96.39	107.43
T_{10}	CCC 2000 ppm	77.61	12.59	111.10	45.42	100.41	111.54
S.Em±		3.09	0.84	2.92	1.24	4.51	5.01
C.D. at 5%		9.25	2.51	8.75	3.72	13.51	15.01
C.V. (%)		6.76	11.13	4.56	5.93	8.10	8.03

Conclusion

According to the experimental result, it could be concluded that the treatment GA_3 300 ppm was suitable for increasing plant height. CCC 2000 ppm was suitable for other all vegetative parameters. The flowering parameters are performed best for the application of treatment GA_3 300 ppm. The yield parameters were performed better with the application of CCC 2000 ppm and GA_3 300 ppm. Finally it may be concluded that application of GA_3 300 ppm is beneficial for cultivation of chrysanthemum.

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