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Effect of pinching and growth retardants on growth and flowering of pot chrysanthemum

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Abstract
Effect of different treatments of pinching and foliar application of various growth retardants on growth and flowering of chrysanthemum (*Chrysanthemum morifolium* L.), as a flowering pot plant was investigated. The experiment includes eleven treatments consisting of different pinching timing and various concentration of Paclobutrazol, Maleic Hydrazide and Daminozide. Results indicated that there was significantly maximum plant spread (N-S and E-W direction), higher number of branches and suckers per plant, maximum number of flowers per plant and flowering period along with reduced flower diameter and plant height in treatment of pinching at 20 and 40 Days After Transplanting (DAT). However, early bud initiation, flower opening, 50% flowering and maximum flower diameter were observed in the control. Looking to the visual appearance of plants as pot plant based on the hedonic scale, an excellent visual score (8.27) was obtained from plants pinched twice at 20 and 40 DAT.

Keywords: Chrysanthemum, pinching, plant growth retardants, pot plant

Introduction
Floriculture is fast emerging industry in India owing to its varied agro-climatic conditions suitable for cultivation of various floriculture crops including cut flowers, loose flowers, cut foliage and potted plants. Rapidly growing urbanization and population explosion with hasty lifestyles have created a space dearth for living, wherein pot plants offer some relief with great scope for urban green scaping (Singh, 2020) [22-23]. Consequently, potted plants are becoming increasingly popular throughout the world for ensuring the sustainability of the urban environment.

Chrysanthemum (*Chrysanthemum morifolium* L.) is an important flower crop that belongs to the family Asteraceae and is native to China. It is mainly grown ornamentally for pot culture with flowers exhibiting a wide range of colours. The dwarf and compact growing types (spray types) are cultivated as pot plants for beautifying indoors and outdoors. The utility and popularity of the chrysanthemum have increased greatly with its vast range of shapes and sizes of flowers, the brilliance of colour tones, shelf life, diversity of height as well as growth habit of the plant, exceptionally hardy nature, relative ease to grow and versatility of use. For pot culture, chrysanthemum plants should have some characteristics with controlled plant growth such as compactness, bushy growth habit, dark green foliage, a well-developed and actively growing root system along with 20-25 flowers of good size is considered to be a desirable pot mum (Archana *et al*., 2019) [2]. Such plants can be achieved genetically by selecting dwarf varieties, culturally by pinching tactics or chemically by use of plant growth retardants.

Pinching is one of the most suitable tactics for the successful cultivation of cut flowers as well as potted ornamental plants. In flower crops *viz*., chrysanthemum, China aster, carnation, marigold, *etc.*, flowering depends on the number of flowers bearing branches, which can be manipulated by arresting vertical growth and encouraging lateral branches through pinching. Pinching removes the source of apical dominance and assimilates are diverted into lateral buds that encourage branching to produce a bushy growth with a greater number of flowers (Cline, 1991) [6].

Plant growth retardants are chemical substances commonly used in potted plants that modify the physiological processes within plant resulting in controlled vegetative growth, improved plant appearance and quality flowers (Kapadiya *et al.*, 2017) [9]. Plant growth retardants *viz.* Paclobutrazol, Maleic Hydrazide, Daminozide, *etc*. give various responses to different plant species and the application rate may vary with species and growing conditions (Taiz and

Zeiger, 2003) [24]. Paclobutrazol commercially traded as Bonzi, Paczol or Cultar is an important plant growth regulator that reduces plant growth and increases the commercial as well aesthetic value of various floricultural crops (Lever, 1986) [14]. It is further known to check the functioning of gibberellins and restricts cell enlargement resulting in controlled plant growth (Latimer, 1991) [13] and more flowering (Koranski *et al.*, 1979) [12]. Maleic hydrazide (MH) is a plant growth retardant, which retards the plant height by inhibiting cell division in the apical meristem and it reduces internodal length (Komossa and Sandermann, 1995) [11]. Daminozide (Alar or B-9) strongly inhibits or reduces the formation of gibberellins that turns out to be dwarf and bushy plants.

With the aim of developing attractive pot plants by manipulation of growth and enhancing flowering through cultural tactics or chemically, the present investigation was carried out to find the effect of pinching and growth retardants on growth and flowering of pot chrysanthemum.

Materials and Methods

The present investigation was carried out at Greenhouse Complex, Department of Floriculture and Landscape Architecture, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India during the winter season under the open condition, 2021-2022. The experiment was laid out in Completely Randomized Design (CRD), consisting of 11 treatments and three repetitions.:

T_1: Control (no pinching, no spray)
T_2: Pinching at 30 DAT
T_3: Pinching at 45 DAT
T_4: Pinching at 30 and 45 DAT
T_5: Pinching at 20 and 40 DAT
T_6: Paclobutrazol 10 mg/l
T_7: Paclobutrazol 20 mg/l
T_8: Maleic Hydrazide 500 mg/l
T_9: Maleic Hydrazide 1000 mg/l
T_{10}: Daminozide 500 mg/l
T_{11}: Daminozide 1000 mg/l

Plastic pots of uniform size (20 cm top diameter, 15 cm bottom diameter and 18.5 cm height) were selected and filled with prepared growing media made up of three parts of yellow soil, one part of vermicompost and one part leaf mould for planting. Well-developed, uniform and healthy one month old seedlings of chrysanthemum var. Thai Chen Queen were procured from Greenhouse Complex, Department of Floriculture and Landscape Architecture and transplanted in each pot. After one week of transplanting, water-soluble fertilizers were applied as drenching *i.e.* 19:19:19 (N:P:K) 50 mg/l of 100 ml per pot once in a week during the vegetative phase and 13:00:45 (N:P:K) 50 mg/l of 100 ml per pot once in a week during flowering phase were undertaken. Observations of vegetative as well as flowering characters were recorded at the full bloom stage. Pinching operations were followed as per treatments and freshly prepared growth retardant solutions were applied as foliar spray at 30 and 45 days after transplanting according to treatments. The observed data were statistically analysed as per Panse and Sukhatme, 1985 [18].

Results and Discussion

Different Pinching treatments and application of growth retardants significantly influenced vegetative growth and flowering in pot chrysanthemum, according to an analysis of the data in Tables 1-3.

A. Vegetative Parameters

It is evident from the data presented in Table 1 that the pinching operation and application of growth retardants significantly reduced plant height. The minimum plant height (31.33 cm and 34.40 cm at 75 DAT and full bloom stage, respectively) was recorded in plants pinched at 20 and 40 DAT (T_5) which was statistically at par with pinching at 30 and 45 DAT (T_4) *i.e.,* 31.67 cm, pinching 45 DAT (T_3) *i.e.,* 32.80 cm, Daminozide @ 1000 mg/l (T_{11}) and @ 500 mg/l (T_{10}) *i.e.,* 33.40 cm and 33.60 cm, respectively. Whereas, maximum plant height (42.33 cm, 46.20 cm at 75 DAT and full bloom stage, respectively) was noted in plants of control treatment (T_1). This might be attributed to non pinched plants grew to their original height without reduction and while in twice pinched plants vertical growth is arrested by removing apical growth therefore, plant height becomes shortened due to breaking of apical dominance. According to Menhennet (1980) [15], daminozide blocks particularly 3ß-hydroxylation, which inhibit the formation of highly active GA_3 from inactive precursors at later stage of GA metabolism and thereby reduce plant height. Similar findings were reported by Baskaran and Abirami (2017) [4] in African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda and Jureshiya (2020) [8] in chrysanthemum.

The highest plant spread in the North-South direction and East-West direction (28.07 cm and 27.33 cm, respectively at full bloom stage) along with other growth parameters such as highest number of branches (6.80) and number of suckers (3.80) per plant were recorded in plants pinched at 20 and 40 DAT (T_5) compare to control (T_1) which was statistically at par with T_4, T_{11} and T_{10} (Table 1). The increased spread of the plant in double pinching treatment might be due to reduced stem apical growth and diversion of the assimilates downwards resulting in more sprouting of auxiliary buds, ultimately producing a greater number of branches and suckers. These findings are in conformity with the earlier reports of Mohanty *et al.* (2015) [16] in African marigold, Ahmade (2018) [1] in garland chrysanthemum, Mounika *et al.* (2019) [17] in chrysanthemum cv. Pusa Kesari and Thakare *et al.* (2020) [25] in annual chrysanthemum.

B. Flowering Parameters

Data presented in Table 2 showed early bud initiation, flower opening and 50 percent flowering in T_1 - control *i.e.,* 33.20, 47.27, 56.67 days respectively, while maximum delayed bud initiation, flower opening, and 50 percent flowering were observed in T_4 - pinching at 30 and 45 days after transplanting *i.e.,* 55.67, 68.27, 76.00 days respectively. The delay in bud initiation in pinching treatments, especially in late pinched plants might be due to the elimination of vegetative growth by removing the tip portion and thereafter the additional time required to attain the physiological maturity of the plant for induction of flower bud. The delayed flower opening and 50% flowering in the pinching treatments might be correlated with the late initiation of first flower bud. Present findings are in line with reports of Sailaja *et al.* (2014) [20] in China aster and Kholiya *et al.* (2020) [10] in African marigold cv. Pusa Narangi Gainda.

According to data presented in Table 2, Maximum flower diameter (7.25 cm) was noted in plants which were in control (T_1) followed by 1000 mg/l Daminozide (T_{11}) *i.e.,* 6.49 cm. While minimum flower diameter (4.92 cm) was observed in

the flowers of plants pinched at 20 and 40 DAT (T_5). Increased flower diameter in plants that were in control might be due to the more assimilates available to fewer flowers. The decrease in flower diameter due to pinching might be attributed to the fact that in pinched plants, the energy was shared by the developing side branches and more flowers. The present result is in agreement with the finding of Sharma (2007) [21] in chrysanthemum cv. Marry Mix and Jureshiya (2020) [8] in chrysanthemum. According to Singh (2016) [23], the application of daminozide causes metabolic changes in the cells. Metabolites are accumulated or conserved in the flowers as the flowers act as a reservoir for metabolites which resulted in increased flower size. This has supporting evidence from the findings of Asrar *et al.* (2014) [3] in chrysanthemum and Chauhan *et al.* (2021) [5] in chrysanthemum cv. Dolly White and Patel *et al.* (2022) [19] in bougainvillaea.

Maximum number of flowers per plant (30.60) and longest flowering period (54.93 days) were recorded in plants pinched at 20 and 40 DAT (T_5) which was statistically at par with T_4 and T_{11} (Table 2). Whereas, least number of flowers per plant (17.80) and minimum flowering period (46.40 days) was recorded in control (T_1). The increase in number of flowers due to the pinching treatment may be correlated with vegetative growth characteristics like higher number of branches as chrysanthemum bears flowers on the apical portion of branch. Having higher number of flowers ultimately prolonged the flowering period. The present result agrees with the finding of Baskaran and Abirami (2017) [4] in African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda, Goud (2020) [7] in pot chrysanthemum and Jureshiya (2020) [8] in chrysanthemum.

Table 3 displays the visual score of the chrysanthemum as a potted plant, which is based on its overall appearance, including qualities like compactness, dwarfness and bushiness along with the size and quality of its flowering head. The plants were rated on a scale of 0 to 9 for their overall desirability. Chrysanthemum plants which were pinched at 20 and 40 DAT (T_5) exhibited excellent visual score (8.27) followed by pinching at 30 and 45 DAT (T_4) *i.e.*, 8.00 and Daminozide @ 1000 mg/l (T_{11}) *i.e.*, 7.60, it was minimum score (3.87) in control (T_1). A chrysanthemum pot plant that had a shorter height, more branches, bushy growth and an attractive flowering head received a high score for its visual appeal.

On the basis of above investigation, it can be concluded that among different treatments T_5 *i.e.*, pinching at 20 and 40 days after transplanting showed significant superiority for pot plant parameters like dwarfness, spreading, more branching and higher number of flowers per plant as well as greater flowering period along with the highest visual score in chrysanthemum. Further, T_4 (pinching at 30 and 45 DAT) and T_{11} (Daminozide @ 1000 mg/l) also showed notable characteristics as a pot plant.

Table 1: Effect of pinching and growth retardants on vegetative growth characters of pot chrysanthemum

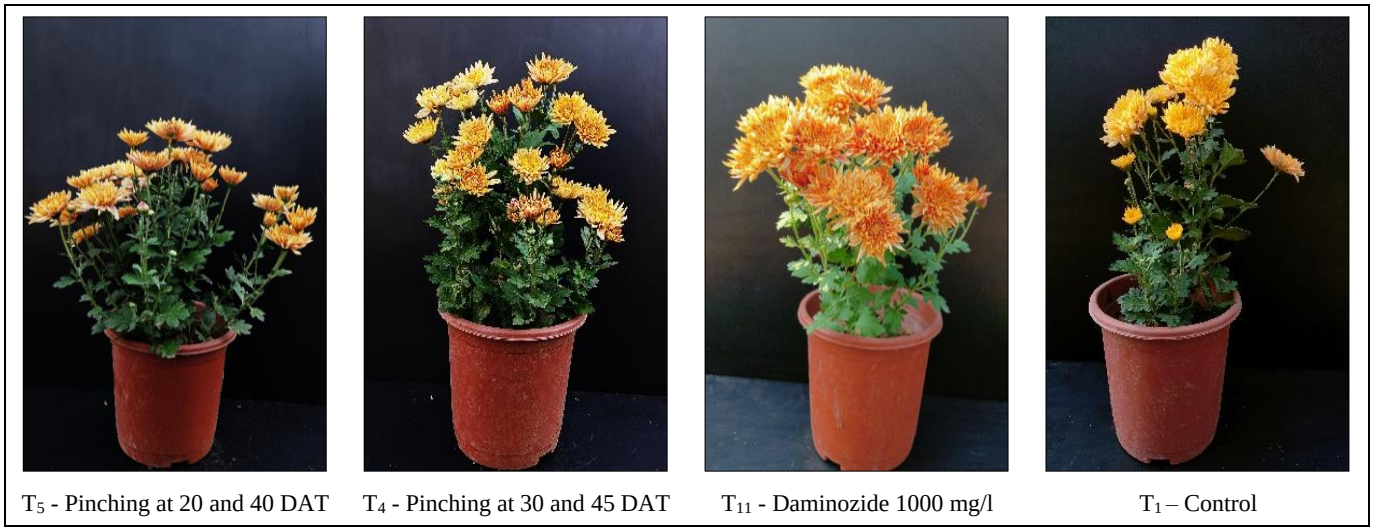
Treatments	Plant Height (cm)		Plant Spread (cm)		Number of Branches per Plant	Number of Suckers per Plant
	75 DAT	Full Bloom Stage	North-South (N-S)	East-West (E-W)		
T_1 : Control	42.33	46.20	22.33	22.60	3.53	1.93
T_2 : Pinching at 30 DAT	35.40	37.87	26.33	25.60	5.13	3.20
T_3 : Pinching at 45 DAT	32.80	35.80	25.87	25.20	4.87	3.07
T_4 : Pinching at 30 and 45 DAT	31.67	34.80	27.47	26.67	6.47	3.53
T_5 : Pinching at 20 and 40 DAT	31.33	34.40	28.07	27.33	6.80	3.80
T_6 : Paclobutrazol 10 mg/l	38.67	42.33	24.60	24.60	4.07	2.53
T_7 : Paclobutrazol 20 mg/l	35.87	40.00	25.27	24.73	4.13	2.67
T_8 : MH 500 mg/l	34.80	39.00	23.33	23.20	4.00	2.00
T_9 : MH 1000 mg/l	34.20	37.00	23.47	23.27	4.47	2.20
T_{10} : Daminozide 500 mg/l	33.60	37.07	27.00	25.20	5.60	2.67
T_{11} : Daminozide 1000 mg/l	33.40	36.47	27.27	26.07	6.20	3.47
S.Em.±	0.81	0.76	0.60	0.62	0.21	0.11
C.D. @ 5%	2.38	2.22	1.77	1.83	0.62	0.33
C.V. %	4.03	3.43	4.08	4.33	7.23	6.86

Table 2: Effect of pinching and growth retar

Treatments	Days taken to bud initiation	Days taken to flower opening	Days to 50% flowering	Flower diameter (cm)	Number of flowers per plant	Total flowering period (days)
T_1 : Control	33.20	47.27	56.67	7.25	17.80	46.40
T_2 : Pinching at 30 DAT	38.60	56.20	66.00	6.02	24.80	51.80
T_3 : Pinching at 45 DAT	52.13	65.67	73.00	5.72	26.33	52.20
T_4 : Pinching at 30 and 45 DAT	55.67	68.27	76.00	5.34	29.20	53.47
T_5 : Pinching at 20 and 40 DAT	48.67	61.93	69.00	4.92	30.60	54.93
T_6 : Paclobutrazol 10 mg/l	34.27	52.60	61.33	5.81	24.00	51.80
T_7 : Paclobutrazol 20 mg/l	35.27	53.27	62.33	5.62	24.87	52.07
T_8 : MH 500 mg/l	34.33	52.20	59.00	5.60	18.67	50.07
T_9 : MH 1000 mg/l	34.93	52.33	61.00	5.66	19.47	49.80
T_{10} : Daminozide 500 mg/l	35.73	51.33	58.33	6.42	27.40	52.53
T_{11} : Daminozide 1000 mg/l	36.60	54.73	63.67	6.49	28.73	54.60
S.Em. ±	0.71	1.23	1.34	0.17	0.73	0.90
C.D. @ 5%	2.08	3.60	3.94	0.50	2.15	2.64
C.V. %	3.08	3.80	3.62	5.05	5.15	3.02

Table 3: Effect of pinching and growth retardants on the visual appearance of chrysanthemum as pot plant (Based on hedonic scale 1-9).

Treatments	Visual appearance
T_1 : Control	3.87
T_2 : Pinching at 30 DAT	6.07
T_3 : Pinching at 45 DAT	7.20
T_4 : Pinching at 30 and 45 DAT	8.00
T_5 : Pinching at 20 and 40 DAT	8.27
T_6 : Paclobutrazol 10 mg/l	5.33
T_7 : Paclobutrazol 20 mg/l	6.00
T_8 : MH 500 mg/l	4.93
T_9 : MH 1000 mg/l	5.27
T_{10} : Daminozide 500 mg/l	7.33
T_{11} : Daminozide 1000 mg/l	7.60



T_5 - Pinching at 20 and 40 DAT T_4 - Pinching at 30 and 45 DAT T_{11} - Daminozide 1000 mg/l T_1 – Control

Photo 1: Effect of pinching and growth retardants on visual appearance of pot chrysanthemum

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