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Research Article

BRANCHING PATTERN AS INFLUENCED BY PINCHING TIME IN GARLAND CHRYSANTHEMUM (*CHRYSANTHEMUM CORONARIUM* L.)

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ABSTRACT
Plants were consistently taller in non-pinched plots. Pinching at 20 DAS recorded maximum plant height at final stage followed by pinching at 10 DAT. Pinching in nursery at 20 DAS and 10 DAT recorded the highest number of leaves and leaf area per plant due to the higher number of branches being produced by them. Number of branches, plant spread and stem girth were at maximum levels in those plants pinched in the nursery at 20 DAS. Pinching at 20 DAT appeared too had stressed the plants greatly, so that they remained significantly less spreading with lesser stem girth. Early pinched plants showed significantly more plant spread and stem girth.

Key Words: *Branching, Garland Chrysanthemum and Pinching Time*

INTRODUCTION
Garland chrysanthemum has indeterminate growth habit. It is an annual and short durated species unlike florist chrysanthemum. Pinching is the act of cutting or nipping off the new growth on a plant in order to force branching so that the eventual number of flowers is increased. A plant generally grows straight up due to apical dominance. If the growing tips are pinched out, assimilates are diverted into lateral buds and branching occurs. Modification of plant architecture by means of pinching has been done in several commercial flower crops. In the present investigation, pinching time has been evaluated on the growth, yield and quality of the crop.

MATERIALS AND METHODS
The experiment comprised six treatments as listed below:
- Pinching at 20 DAS (pinching in nursery)
- Pinching at 10 DAT
- Pinching at 20 DAT
- Pinching at 30 DAT
- Pinching at 40 DAT
- No pinching (control)

The experiment was laid out in randomized block design with three replications. The layout plan is given in figure no. 5. The gross plot size was 3.0 m x 2.1 m and the net plot size was 2.7 m x 1.8 m. The spacing adopted was 30 cm both between rows and plants within a row. A few seedlings from a part of nursery were pinched off the apical buds at 20 days after sowing. Pinching after planting was done at different stages as per the treatments by removing the apical bud along with the crown of juvenile leaves manually.

RESULTS AND DISCUSSION
Plant Height
Significant differences existed in the plant height due to time of pinching at all growth stages during both the seasons (Table 1). At 65 DAT during *kharif*, maximum plant height (122.48 cm) was recorded by non-pinched plants. It was on par with the plants pinched at 20 DAS and at 10 DAT (117.58 cm and 112.33 cm) whereas the plant height was minimum (101.40 cm) in the plants pinched at 40 DAT. At 85 DAT during *rabi*, maximum plant height (129.95 cm) was recorded by was recorded by no pinching treatment. It was

significantly superior to pinching at 20 DAT having plant height of 113.50 cm but at par with the plants pinched earlier. The plant height was minimum (106.78 cm) in the plants pinched at 40 DAT.

Number of Leaves per Plant

There were significant differences with respect to number of leaves per plant due to variation in time of pinching at all growth stages during both the seasons (Table 1). At 65 DAT during *kharif*, maximum number of leaves (147.66) was recorded by pinching at 10 DAT which was at par with pinching at 20 DAS and no pinching. It was significantly superior to the pinching at 20 DAT (130.33). At 85 DAT during *rabi*, maximum number of leaves (150.09) was recorded by pinching at 10 DAT. It was at par with pinching at 20 DAS (151.16) and but significantly superior to pinching at 20 DAT (134.24) whereas the number of leaves was minimum (127.32) with pinching at 40 DAT.

Leaf Area per Plant

Leaf area per plant varied significantly due to time of pinching at all growth stages during both the seasons (Table 1). At 65 DAT during *kharif*, maximum leaf area (1315.0 cm^2) was recorded by pinching at 20 DAS. It was at par with the leaf area (1211.6 cm^2) with the pinching at 10 DAT whereas the leaf area was minimum (885.5 cm^2) with pinching at 40 DAT. At 85 DAT during *rabi*, maximum leaf area (1298.5 cm^2) was recorded by pinching at 20 DAS. It was at par with the leaf area (1196.5 cm^2) with the pinching at 10 DAT whereas the leaf area was minimum (874.4 cm^2) with late pinching at 40 DAT.

Number of Branches per Plant

Pinching time influenced number of branches per plant significantly at all growth stages during both the seasons (Table 2). At 65 DAT during *kharif*, maximum number of branches (37.70) was recorded by pinching at 20 DAS. It was at par with the number of branches (37.20) with the pinching at 10 DAT but significantly superior to later pinching at 20 DAT (29.33) whereas the number of branches was minimum (24.86) with pinching at 40 DAT. At 85 DAT during *rabi*, maximum number of branches (39.58) was recorded by pinching at 20 DAS. It was at par with the pinching at 10 DAT (39.31) but significantly superior to pinching at 20 DAT (30.98) whereas the number of branches was minimum (26.27) with the pinching at 40 DAT.

Plant Spread

The effect of pinching time on plant spread was significant at all growth stages during both the seasons (Table 2). At 65 DAT during *kharif*, maximum mean plant spread (29.14 cm) was recorded by the pinching at 20 DAS. It was at par with pinching at 10 DAT (26.85 cm) and no pinching (23.14 cm) whereas the plant spread was minimum (15.58 cm) with pinching at 40 DAT. At 85 DAT during *rabi*, maximum plant spread (29.22 cm) was recorded by pinching at 20 DAS. It was at par with pinching at 10 DAT (26.93 cm) and no pinching (23.20 cm) but significantly superior to pinching at 40 DAT (26.93 cm) whereas the plant spread was minimum (15.62) by pinching at 40 DAT.

Stem Girth

The mean stem girth varied significantly due to time of pinching at all growth stages during both the seasons (Table 2). At 65 DAT during *kharif*, maximum stem girth (13.66 mm) was recorded by pinching at 20 DAS. It was at par with the no pinching (11.07 mm) and late pinching until 20 DAT (11.12 mm) whereas the stem girth was minimum (7.71 mm) with pinching at 40 DAT. At 85 DAT during *rabi*, maximum stem girth (13.69 mm) was recorded by pinching at 20 DAS. It was at par with the no pinching (11.04 mm) and late pinching treatments until 20 DAT (11.15 mm) but significantly superior to the pinching at 30 DAT (7.90 mm) whereas the number of branches was minimum (7.73) with pinching at 40 DAT.

Days Taken for First Flower Bud Appearance

The number of days taken for first flower bud appearance varied significantly among the different treatments during both the seasons (Table 3). The greatest delay in flower bud appearance was noticed in the treatment pinching at 20 DAT during *kharif* and *rabi* (29.50 days and 33.04 days) which

was significantly late compared to the rest of the treatments. The number of days taken for first flower bud appearance by other times of pinching was on par with non-pinched control plots.

Number of Flowers per Plant

The number of flowers per plant exhibited significant differences among the different pinching times during both the seasons (Table 3). In *kharif*, pinching at 20 DAS recorded the highest number of flowers per plant (32.04) which was significantly superior to no pinching treatment (24.65) but on par with pinching at 10 DAT (30.71). A minimum of 20.24 flowers per plant was recorded by pinching at 40 DAT. In *rabi*, pinching at 20 DAS resulted in the maximum number of flowers per plant (42.80) significantly superior to non-pinched plants (34.48 flowers per plant) but on par with the plants pinched at 10 DAT (41.29 flowers per plant). Minimum number of flowers per plant was recorded by late pinching at 40 DAT (29.52).

Table1: Plant height, number of leaves and leaf area per plant as influenced by pinching time in garland chrysanthemum during *kharif* and *rabi*

Treatment	Plant Height (Cm)		Number of Leaves Per Plant		Leaf Area Per Plant (Cm^2)	
	Kharif 65 DAT	*Rabi* 85 DAT	*Kharif* 65 DAT	*Rabi* 85 DAT	*Kharif* 65 DAT	*Rabi* 85 DAT
Pinching at 20 DAS	117.58	124.76	147.22	151.16	1315.0	1298.5
Pinching at 10 DAT	112.33	119.19	147.66	152.09	1211.6	1196.5
Pinching at 20 DAT	106.97	115.50	130.33	134.24	1067.1	1053.7
Pinching at 30 DAT	106.93	111.38	126.81	130.61	898.6	887.3
Pinching at 40 DAT	101.40	106.78	123.61	127.32	885.5	874.4
No pinching	122.48	129.95	132.38	136.36	1004.0	991.4
Mean	**111.98**	**117.93**	**134.67**	**138.63**	**1063.6**	**1050.3**
S Em	3.88	4.35	5.17	5.27	50.54	56.56
CD at 5%	11.64	13.05	15.49	15.79	151.51	169.56

Table 2: Number of branches per plant, plant spread and stems girth as influenced by pinching time in garland chrysanthemum during *kharif* and *rabi*

Treatment	Number of Branches Per Plant		Plant Spread (Cm)		Stem Girth (Mm)	
	Kharif 65 DAT	*Rabi* 85 DAT	*Kharif* 65 DAT	*Rabi* 85 DAT	*Kharif* 65 DAT	*Rabi* 85 DAT
Pinching at 20 DAS	37.70	39.58	29.14	29.22	13.66	13.69
Pinching at 10 DAT	37.20	39.31	26.85	26.93	13.62	13.66
Pinching at 20 DAT	29.33	30.98	20.41	20.47	11.12	11.15
Pinching at 30 DAT	26.14	27.62	16.73	16.77	7.88	7.90
Pinching at 40 DAT	24.86	26.27	15.58	15.62	7.71	7.73
No pinching	27.67	29.23	23.14	23.20	11.01	11.04

Mean	**30.01**	**31.67**	**21.97**	**22.03**	**10.83**	**10.86**
S Em	2.80	2.93	2.71	2.72	1.31	1.31
CD at 5%	8.40	8.78	8.14	8.16	3.93	3.94

Flower Diameter

The flower diameter did not exhibit significant differences among the various pinching treatments during both the seasons (Table 3). During *kharif*, pinching at 20 DAS recorded the highest size of flowers having a diameter of 4.91 cm whereas; a minimum flower diameter of 3.45 cm was recorded by late pinching at 40 DAT. During *rabi*, pinching at 20 DAS produced the largest flowers with 5.16 cm diameter while minimum diameter of flowers (3.83 cm) was recorded by pinching at 40 DAT.

Table 3: Days taken to first flower bud appearance, number flowers per plant and flower yield per hectare as influenced by growth regulators/chemicals in garland chrysanthemum during *kharif* and *rabi*

Treatment	**Days Taken to First Flower Bud Appearance**		**Number of Flowers Per Plant**		**Flower Diameter (Cm)**		**Hundred Flower Weight (G)**	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
Pinching at 20 DAS	23.58	26.41	32.0	42.8	4.91	5.16	205.69	227.47
Pinching at 10 DAT	24.56	27.51	30.7	41.3	4.57	4.81	202.23	225.33
Pinching at 20 DAT	29.50	33.04	22.8	32.4	3.98	4.18	173.48	201.22
Pinching at 30 DAT	23.50	26.32	20.6	29.9	3.75	3.94	165.69	193.33
Pinching at 40 DAT	22.50	25.20	20.2	29.5	3.45	3.83	143.76	171.28
No pinching	22.05	24.70	24.7	34.5	4.42	4.65	168.21	183.79
Mean	**24.28**	**27.20**	**25.2**	**35.1**	**4.18**	**4.24**	**176.51**	**200.40**
S Em	1.08	1.01	1.45	1.63	0.49	0.45	12.42	11.10
CD at 5%	3.24	3.03	4.24	4.77	NS	NS	36.26	32.38

Hundred Flower Weight

Significant differences were recorded in hundred flower weights among the different pinching treatments during both the seasons (Table 3). During *kharif*, the heavier flowers were obtained by the nursery pinched (10 DAS) flowers with a hundred flower weight of 205.69 g, which was significantly superior to pinching at 30 DAT (165.69 g) whereas minimum value of hundred flower weight (143.76 g) was recorded by pinching at 40 DAT. During *rabi* the highest value of hundred flower weight (227.47 g) was recorded by the plants pinched at 20 DAS, significantly superior to pinching at 30 DAT (193.33 g) whereas minimum value of hundred flower weight (171.28 g) was recorded by pinching at 40 DAT.

Number of flowers per plant was recorded maximum by pinching at 20 days after sowing (nursery) which was on par with those plants pinched at 10 days after transplanting. Pinching at 20 DAT registered a performance at par with non-pinched plants. Delay in pinching beyond 20 DAT, decreased the number of flowers per plant compared to non-pinched plants. Similar trend was also recorded in the weight of flowers per unit area, since the plant population is kept constant in all the treatments. Pinching in nursery increased the number of flowers per plant in China aster (Malleshappa, 1984) and in marigold (Basavaraj, 1984). Significant differences in number of flowers per plant due to time of pinching in chrysanthemum

were also observed by Singh and Baboo (2003) and (Beniwal *et al.,* 2005). The enhanced yield due to pinching was attributed to increased number of branches per plant that could increase flowering points in China aster (Malleshappa, 1984). Arora and Khanna (1986) and (Sehrawat *et al.,* 2003) also observed more number of branches associated with more number of flowers per plant in marigold. Similar to the number of flowers per plant, the highest seed yield per plant was recorded by pinching in nursery at 20 DAS, which was at par with pinching at 10 DAT, indicating the dependence of seed yield on flower yield (Table). Pinching at 20 DAT was on par with non-pinched plants with regard to seed yield per plant, other treatments being significantly inferior in seed yield. Bhat and Shepherd (2007) and (Sunitha *et al.,* 2007) observed significant differences in seed yield due to pinching in marigold, which were attributed to growth and flowering characters. The superiority of early pinching treatments in garland chrysanthemum can be attributed to the efficient photosynthetic area, better assimilation into reproductive parts and putting up optimum vegetative growth without interrupting floral bud initiation. This will be clearer upon examining the data on various growth and quality parameters.

Plants were consistently taller in non-pinched plots. Every delay in pinching caused reduction in plant height at final stage during both *kharif* and *rabi* seasons (Table). Among the plots that were pinched, the treatment of pinching at 20 DAS recorded maximum plant height at final stage followed by pinching at 10 DAT. Other treatments recorded significantly shorter plant height compared to non-pinched plants. Pinching at 20 DAT had dwarfed plants from first stage of observation itself; however, they were able to recover later to some extent showing taller plants at par with those pinched at 10 DAT. When pinching was done at 30 and 40 DAT, such plants were not able to recover and catch up the growth, thus remaining significantly dwarf compared to non-pinched plants and plants pinched earlier. Plant height was significantly reduced by the pinching treatment in chrysanthemum cv. MDU-1 (Yassin and Pappiah, 1990).

Number of leaves (Table) and leaf area per plant (Table) were influenced alike due to various pinching treatments. Pinching in nursery at 20 DAS and 10 DAT recorded the highest values on par between themselves and significantly superior to non-pinched plants as well as other treatments. Pinching at 20 DAT recorded these values at par with non-pinched plants. But by pinching beyond this stage, the plants were losing both the number of leaves and leaf area per plant either from first or second stage, so significantly that these treatments finally registered lesser leaf cover compared to the early pinched plants. The highest number of leaves and leaf area per plant in such plants can be attributed to the higher number of branches being produced by them.

As a consequence of higher leaf area per plant, pinching in nursery at 20 DAS and at 10 DAT recorded higher values of leaf area index and leaf area duration (Table) significantly superior to other plants pinched at later times as well as non-pinched plants. Other pinching treatments resulted in suppression of leaf area index and leaf area duration values which were closely related to the trends in leaf area and number of branches per plant.

Number of branches (Table), plant spread and stem girth (Table) were at maximum levels in those plants pinched in the nursery at 20 DAS. This treatment was on par with the plants pinched at 10 DAT with respect to these vegetative parameters. Pinching at 20 DAT recorded significantly lower number of branches at the first growth stage compared to early pinched plants. However, it improved branching in the later stages, so that at final stage, the number of branches reached at par with that recorded by the plants pinched at 10 DAT. Similar results were obtained by (Sharma *et al.,* 2006) who stated that by removal of the apical portion, more energy might have been diverted for the development of a higher number of side branches per plant in African marigold.

Pinching at 20 DAT appeared too had stressed the plants greatly, so that they remained significantly less spreading with lesser stem girth till the final growth stages in both the seasons when compared to the plants pinched in nursery and at 10 DAT. Early pinched plants showed significantly more plant spread and stem girth. (Sharma *et al.,* 2006) also found that early pinching in marigold resulted in more plant

spread compared to late pinching. Delay in taking up pinching up to 30 and 40 DAT reduced the number of branches per plant; plant spread and stems girth even lower than non-pinched plants. Thus it is inferred that pinching the apical bud at or after 30 DAT in garland chrysanthemum suppressed the vertical growth as well as horizontal spread so significantly that the plants could not recover till the final stages. From this examination it becomes clear that garland chrysanthemum plants put up maximum vegetative growth before 30 DAT, by which time even flower bud appearance also might had completed. Any attempt to suppress the apical dominance after this point of time by pinching might had altered the plant metabolism in such a way that instead of initiating floral buds it had to continue shoot growth from lateral buds. However, senescence had set in before the plant could put up sufficient shoot growth to make the branches sufficiently longer and thicker. Architecture of the plant varied significantly depending on the time of pinching. Plants left to nature produced sturdier and blooming branches between 25 and 30 DAT, from points above and below the middle of a mature plant that appeared at the final stage. Had it been pinched at 20 DAS or 10 DAT there were productive branches even below the middle of the plant. However, plants pinched at 20 DAT could also make lower branches productive with significant delay in flowering compared to non-pinched plants. Later pinching treatments being done at active branching stage neither allowed the existing branches to mature nor could produce additional productive branches before the plants entered senile phase.

Pinching at 20 DAT significantly delayed flowering. This treatment increased the number of days taken for the appearance of first flower bud by 7 days compared to non-pinched plants and by 5 to 6 days compared to early pinched plants *i.e.* at 20 DAS and at 10 DAT (Table). This indicated that the effort to suppress the apical dominance by means of pinching had a delaying effect on flower initiation. When non-pinched plants were able to initiate flower buds as early as 22 days after transplanting, early pinched plants up to 10 DAT showed a meager delay of only 2 to 3 days on account of a quick restructuring of their architecture. Whereas, pinching at 20 DAT suppressed the plant height, number of branches, leaf area as well as dry matter assimilation to a substantial extent so that such plants needed a longer time in restructuring themselves and to maintain a reasonable growth rate at least on par with non-pinched plants. Finally such plants bearded a significantly lesser number of flowers compared to early pinched plants. However, pinching at 20 DAT is found to be useful in delaying the initiation of flowering by seven days without significant difference in the number of flowers per plant compared to non-pinched plants. Later pinching performed after the initiation of flowering resulted in significant reduction in the number of flowers per plant on account of diverting the assimilates into vegetative parts, which would have otherwise sinked into reproductive parts. (Srivastava *et al.,* 2005) and (Sehrawat *et al.,* 2003) also observed significant differences in the time taken for flower initiation due to pinching in marigold.

Flower quality in terms of mean flower weight and flower diameter is at maximum in the treatments of pinching at 20 DAS and pinching at 10 DAT, which are at par. Pinching at 20 DAT resulted in the production of flowers having a quality on par with non-pinched plants. Since the number of flowers has been increased by this treatment without significant increase in dry matter accumulation into flower, significant increase in size or weight of individual flowers or seeds might be unlikely. However, the differences are not statistically significant among the plants pinched later.

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