Effect of supplemental light, pinching, and number of plants per pot on the growth and flowering of chrysanthemum plant (*Dendranthema grandiflora* Tzvelev)

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Abstract

This study was conducted in the plastic house - Nursery of the Duhok University - Duhok governorate-Kurdistan region-Iraq from the period 10th Apr. 2021 to 10th Jan. 2022. This study aimed to investigate the effect of supplemental light (light and without light), pinching (pinching and without pinching) and number of plants per pot (2, 3, and 4) plants/pot on the growth and flowering of chrysanthemum (*Dendranthema grandiflora* Tzvelev) plant. The results showed that supplemental light for one month delayed the flower bud emergence (223.08) days, and flower anthesis (241.58) days compared with the control (without supplemental light) that gave (198.83, 218.44) days for the two characteristics respectively. Further, supplemental light gave the best results for flower length, flower diameter, flower number, and vase life compared to (without supplemental light). Pinching delayed the flower bud emergence and decreased the plant high, growth index, flower diameter, and vase life of cut flower significantly while it significantly increased the flower diameter and vasa life. Increasing the number of plants per pot to 4 plants caused a significant increment in flower number (8.25) compared with 2 plants which gave 5.64 plants/pot. The triple interaction showed significant differences in all characteristics and number of days to flower bud emergence and flower anthesis were the highest mean for the supplemental light with or without the pinch and 2 plants/pot. Also, the best plant height (72.33) cm and growth index (26761) cm^3 were recorded without supplemental light, without pinch with 2 plants/pot. However, the maximum vase life of 26.33 days was found from the interaction of supplemental light, pinch, and 2 plants/pot.

Keywords: chrysanthemum, long day, pinching, number of plant/pot

Introduction

Chrysanthemum (*Dendranthema Grandiflora* Tzvelev) also commonly known as Glory of East' or 'Queen of East' or 'Mum' in the U.S.A., is a worldwide essential traditional crop, after Rose, It is the second most important floricultural crop (6) which belongs to the family Asteraceae. China and Southeast Asia are their original native and it is widely distributed in Europe, America, and North Africa (7) with various types, sizes, and colors. It is used as cut flowers, flower potted plants, and a source of beautification, and has more medicinal characteristics. Moreover, it is one of the most pervasive and controlled crop production systems in horticulture (8). Saicharan *et al*. (13) mentioned that the chrysanthemum is familiar as Queen of the East and is also known as an autumn flower, so to add a dense look and a higher atheistic value, potted chrysanthemums are favored to have a more compact, controlled plant height, and full of inflorescences. Some new varieties can meet these consumer expectations, however, for the other varieties to be compacted, different methods are continuously practiced such as the number of plants per pot. It is shown that by increasing the plant number per pot more spreading, the bushy and many-branch plants can be obtained. Also, Sultanpuri *et al.* (15) studied the effect of the number of chrysanthemum plants per pot (1,2,3) and showed that three plants per pot provided a maximum spread of the plant, plant height, days taken for visible flower bud formation, and the number of flowers per pot.

Pinching is one of the most suitable operations for the cultivation of cut flowers to regulate the architecture of plants and flower quality. Ciaffi, *et al*. (1) found that the number of flowers increased after cutting or stopping the apical dominance. Jindal, *et al*. (5) reported that the flower diameter, length of the flower stalk, and vase life increased significantly in non-pinched plants, compared to pinched plants. Also, the pinching in the different stages realized 25, 35, and 45 days after chrysanthemum planting affected bud initiation and flowering. In contrast, the maximum number of buds and flower/plant were obtained from pinching after 25 days of the control treatment and revealed the best size of flower (12).

As well, the chrysanthemum is considered a short-day plant, which means that its growth is significantly affected by the length of the day and night. The plant can form flower buds in 13.5 h or less during the daytime. The stem and internodes can elongate when the daytime is longer than 14 h under supplemental light replacing daylight (16). It can be changed day length (dark length) and controlling the flowering time precisely by using simple lighting or a black-out system. It is possible to produce chrysanthemum during the year by controlling the duration of light (11). Thakur and Grewal (19) conducted a study on the effect of duration of night interruption on the growth and flowering of chrysanthemum, the night interruption was given control, 5 sec (flash of light), 30 min, 60 min, 90 min, and 120 min. the results showed that the treatments which took light significantly increased plant height, days to flower bud appearance, days to color break stage, days to full bloom, and flower diameter compared with the control. Hammo, (4)

showed that subjecting chrysanthemum plants to the long day for 2 months starting from 1st Oct. till 30th Nov. delayed the flowering about 64 days than the short day and start flowering in 2nd Jan. and continued till 3rd Mar. Also, Sunil and Singh, (17) revealed that supplemental high-pressure sodium lighting significantly improved plant height, internode length as well as leaf number with the increase in day length (photoperiod). On the other hand, the flower opening was delayed with the increase in day length. Because of the limited duration of flower production for most chrysanthemum cultivars, this experiment aimed to increase the duration of flower production and flowering potted plants for the longest time year-round.

Materials and Methods

This study was conducted in the plastic house - Nursery of the Duhok University - Duhok governorate-Kurdistan region from the period 10th Jun. 2021 to 10th Jan. 2022. The aim was to investigate the effects of supplemental light 6 hours daily (from 5 pm to 11 pm) for one month starting from 15th Sep. to 15th Oct. (supplemental light, without supplemental light), pinching (pinching, without pinching) and number of plants per pot (2, 3, and 4) plants/pot on the growth and flowering of chrysanthemum (*Dendranthema grandiflora* Tzvelev) plants. One month rooted cuttings were planted in plastic pot size (17) cm using mixed media (3 garden soil and 1 local compost) by volume. All plant management such as irrigation, fertilization, and weed control was done accordingly. The experiment was performed using a Randomized Complete Block Design (RCBD) with three factors 2*2*3= 12 treatments and three replications using three plants for each replicate. Data recorded for flower bud emergence (days), flower anthesis (days), plant height (cm), growth index (cm^3), length of flower (cm), flower diameter (cm), flower number, and vase life of cut flowers (days). The data were analyzed statistically by SAS program and means comparison was done using Duncan's Multiple Range Test at 0.05 (SAS, 2013)

Results and Discussion

1- Effect of supplemental light, pinching, and number of plants per pot on the growth and flowering characteristics of chrysanthemum plants.

The data in table (1) showed that the effect of the light factor was significant on most of the studied characteristics and led to an increase in the number of days required for flower bud emergence to 223.08 days, flower anthesis to 241.58 days, and provided longer flower length 47.44 cm, better flower diameter 6.49 cm, more flower number 7.61 and longer vase life of cut flowers 22.89 days when supplied with the light. While the treatments which remained without supplement of light recorded less number of days 198.83 for flower bud emergence, 218.44 days for flower anthesis, shorter flower length 42.97 cm, less flower diameter 5.46 cm, lower flower number 6.33, and lower vase life 12.33 days of cut flowers. Both plant height and growth index recorded non-significant results. As for the pinching factor, it is shown that when plants were pinched provided significant results in an increasing number of days required for flower bud emergence recorded 215.8 days, maximum flower

diameter 6.62 cm, and longer vase life of cut flowers 20.28 days. In contrast, plants that remained without pinch gave lower results 206.08 days for flower bud emergence, 5.33 cm flower diameter, and 14.94 days for vase life of cut flowers, while plant high, growth index and flower length provided superior results when plants remained without pinching and recorded maximum values 63.83 cm, 20390 cm^3, and 55.31 cm, respectively, compared to lower results of pinched plant. Further, both flower anthesis and flower number recorded non-significant results. Regarding the effect of the last factor plant number per pot, it showed a significant increase in number of days for flower bud emergence 212.25 recorded for 4 plants/pot, in comparison with 3 plants/pot recorded 209.25 days. However, significant results of growth index 20821 cm^3, flower length 47.83 cm, and flower diameter 6.40 cm were recorded when using 2 plants/pot compared to 4 plants/pot giving lesser values 15950 cm^3, 41.17 cm, and 5.60 cm, respectively. In addition, a maximum flower number 8.25 was found in 4 plants/pot compared to 2 plants/pot recorded 5.64 flowers. Also, the longer vase life of cut flowers 18.08 days was recorded in 3 plants/pot in comparison to 4 plants/pot gave 16.92 days of vase life. Lastly, a non-significant difference was recorded in flower anthesis and plant high.

Table 1. Effect of supplemental light, pinching, and number of plants per pot on the growth and flowering characteristics of the chrysanthemum plant

Characteristic	Light		Pinching		plant/ pot		
	Supplemental	without supplemental	pinch	without pinch	2	3	4
flower bud emergence	223.08^{a}	198.83^{b}	215.8^{a}	206.08^{b}	211.3^{ab}	209.25^{b}	212.25^{a}
flower anthesis	241.58^{a}	218.44^{b}	231.4^{a}	228.56^{a}	230.71^{a}	228.71^{a}	230.63^{a}
plant high	56.11^{a}	50.89^{a}	44.17^{b}	63.83^{a}	56.75^{a}	53.75^{a}	50.00^{a}
growth index	18074^{a}	17224^{a}	1490^{b}	20390^{a}	20821^{a}	16175^{b}	15950^{b}
flower length	47.44^{a}	42.97^{b}	35.11^{b}	55.31^{a}	47.83^{a}	46.63^{a}	41.17^{b}
flower diameter	6.49^{a}	5.46^{b}	6.62^{a}	5.33^{b}	6.40^{a}	5.92^{ab}	5.60^{b}
flower number	7.61^{a}	6.33^{b}	7.23^{a}	6.71^{a}	5.64^{c}	7.03^{b}	8.25^{a}
vase life	22.89^{a}	12.33^{b}	20.28^{a}	14.94^{b}	17.83^{ab}	18.08^{a}	16.92^{b}

2-Effect of the interaction among the supplemental light, pinching, and number of plants per pot on the flower bud emergence, flower anthesis, plant high, and growth index of chrysanthemum plant.

The data in table (2) showed that the effect of triple interactions on studied characteristics was significant, the maximum number of days required for flower bud emergence 227.50 days were recorded when plants were

supplied with light both pinched and non-pinched with 2 plants/pot in comparison with plants which remained without supplement of light and non-pinched with 2 plants/pot which recorded 181.00 days for flower bud emergence. Also, a significant increment in number of days required for flower anthesis 244.50 days was recorded from both interaction of plants supplied with light and pinched with 4 plants/pot, and the interaction of plants supplied with light and non-pinched with 2 plants/pot. In contrast, lower days 212.00 was recorded from the triple interaction of plants that remained without supplement of light and non-pinched with 2 plants/pot. Moreover, a significant increase in plant height 72.33 cm was found from the interaction of plants that remained without supplement of light and non-pinched with 2 plants/pot compared with the plants that remained without supplement of light and pinched with 4 plants/pot recorded shorter plant height 33.67 cm. Lastly, a significant improvement in growth index 26761 cm^3 was recorded from the triple interaction of plants that remained without supplement of light and non-pinched with 2 plants/pot in comparison to the plants that remained without supplement of light and pinched with 3 plants/pot recorded lesser growth index 11004 cm^3.

Table 2. Effect of the interaction among the supplemental light, pinching, and number of plants per pot on the flower dud emergence, flower anthesis, plant high, and growth index of chrysanthemum plant

Light	Pinching	plant/pot	flower bud emergence	flower anthesis	plant high	growth index
supplemental light	Pinch	2	227.50^{a}	243.00^{a}	48.67^{b-d}	20165^{b-c}
		3	215.00^{b}	237.00^{ab}	55.00^{bc}	14709 ^{cd}
		4	223.50^{a}	244.50^{a}	44.00^{c-e}	14040 ^{cd}
	without pinch	2	227.50^{a}	244.50^{a}	61.33^{ab}	18260^{b-d}
		3	222.50^{a}	239.50^{a}	58.00^{a-c}	17863^{b-d}
		4	222.50^{a}	241.00^{a}	69.67^{a}	23406 ^{ab}
without supplemental light	Pinch	2	209.50^{bc}	223.33^{bc}	44.67^{c-e}	18099^{b-d}
		3	210.50^{bc}	224.33^{bc}	39.00^{de}	11004^{d}
		4	209.00^{c}	216.67^{c}	33.67^{e}	11429^{d}
	without pinch	2	181.00^{e}	212.00^{c}	72.33^{a}	26761^{a}
		3	189.00^{d}	214.00^{c}	63.00^{ab}	21124^{a-c}
		4	194.00^{d}	220.33^{c}	52.67^{b-d}	14925^{cd}

3- Effect of the interaction among the supplemental light, pinching, and number of plants per pot on the flower's length, diameter, number per pot and vase life of chrysanthemum plant

The data in table (3) showed a significant difference from the triple interaction effect of factors on the studied characteristics. The longest flower length 64.67 cm was recorded from the interaction of supplement light and pinched with 2 plants/pot compared to the lower length 31.67 cm recorded from the interaction of supplement light without pinch with 4 plants/pot. Furthermore, the highest flower diameter 7.77 cm was recorded from the interaction of supplement light, with pinch and 4 plants/pot compared with the plants grown without supplement light and non-pinched with 4 plants/pot recorded lesser diameter 4.33 cm. Also, the maximum flower number 9.53 was found from the interaction of supplemental light with no pinch and 4 plants/pot compared to the lower 5.40 flower number resulting from the interaction of both supplement light without pinch and 2 plants/pot and the interaction of plant remained without supplement light with no pinch and 2 plants/pot. Finally, the longest vase life 26.33 days was recorded from the interaction among supplement light, pinch, and 2 plants/pot in comparison with the interaction among plants remained without supplement of light with no pinch and 3 plants/pot gave the shortest vase life 8.67 days.

Table 3. Effect of the interaction among the light, pinching, and number of plants per pot on the flower length, diameter, flower number, and vase life of chrysanthemum plant

Light	pinching	plant/pot	flower length	flower diameter	flower number	vase life
supplemental light	pinch	2	39.50^{de}	7.33^{ab}	6.00^{cd}	26.33^{a}
		3	35.83^{e}	6.50^{a-c}	8.40^{ab}	25.33^{a}
		4	31.67^{e}	7.77^{a}	9.10^{a}	25.67^{a}
	without pinch	2	64.67^{a}	6.00^{b-d}	5.40^{d}	20.00^{b}
		3	61.67^{ab}	5.50^{c-f}	7.20^{bc}	20.33^{b}
		4	51.33^{bc}	5.83^{c-e}	9.53^{a}	19.67^{b}
without supplemental light	pinch	2	33.67^{e}	6.77^{a-c}	5.75^{cd}	13.33^{c}
		3	36.00^{e}	6.83^{a-c}	6.90^{b-d}	18.00^{b}
		4	34.00^{e}	4.50^{ef}	7.20^{bc}	13.00^{c}
	without pinch	2	53.50^{bc}	5.50^{c-e}	5.40^{d}	11.67^{c}
		3	53.00^{bc}	4.83^{d-f}	5.60^{d}	8.67^{d}
		4	47.67^{cd}	4.33^{f}	7.15^{bc}	9.33^{d}

Delay flower bud emergence and flowering anthesis as a result of supplemental light exposure might refer to the supplemental light role in the interference of the movement

of carbohydrate and florigen to the reception site, production of transmissible inhibitor, and production of a substance that antagonistically acting to the flowering hormone at the apex of the plants under long-day condition Vince-Prue, (20). Besides supplemental light might have probably caused a shift in the balance of hormones leading to increasing in substances like gibberellins that would have resulted in significant vegetative growth Thakur and Grewal, (19). Moreover, photosynthetic activity is enhanced under supplemental light conditions accompanied by accumulation of carbohydrate and nitrogen Datta and Ramadas, (2) which ultimately result in increasing growth and flowering characteristics. Also when plants were pinched provided the best results of flower bud emergence which may be due to shifting plant to the vegetative phase when removing apical dominance and new shoots forming which take longer time to mature physiologically which in turn bear flowers and cause the delay in the initiation of buds and formation of flowers Ranveet, (12). Further, the best flower diameter results were in agreement with Moon, et al. (9) referred to pinching at an earlier stage could induce vigorous branching which might have favored to development of larger flowers of Gaillardia plants, or due to the physiological influence of pinching practice which can be helpful to gain extra energy Patade, et al. (10). Longer vase life of flower might be due to pinching helped in improving the luster and keeping quality of flower, pinching accelerates most of the physiological attributes, which results in increased cell division and cell elongation. The cell enlargement occurs as a result of the plasticity of the cell wall. This reduces the wall pressure around the cell wall and turgor pressure caused by osmotic forces in the vascular sap which led to the entry of water into the cell resulting in cell enlargement and thereby enhancing the vase life of flowers Patade, et al. (10). While the minimum plant height, growth index and flower length result from the effect of pinching mainly due to elimination of apical dominance of plants and repetitive removal of the apical portion of the main branch; axillary buds become free from correlative inhibition of apical dominance and started growing. This resulted in more branching and spread of plants. Thus, plant height was reduced in pinched plants Ehsanullah, et al. (3). Similar results were also observed by Susila et al. (18) for chrysanthemum flower plants. Lastly, the significant maximum results of flower bud emergence and flower numbers result from the effect of 4 plants/pot might be due to the spread of nutrients and water content in the media of pots to more plants, and this caused the availability of lesser nutrient and water to each plant which caused plants to require more days for the flower emergence. Also, more flower numbers might be due to the presence of more branches from more plants in a pot providing higher flower numbers, and these findings were also found by Sultanpuri, et.al. (15) for chrysanthemum plants. As for the best growth index, flower length and flower diameter result from the effect of two plants/pot were due to less competence between plants in a pot on contents of media which cause a positive effect on the aforementioned parameters.

Conclusion

It's concluded from the conducted study that using supplemental light was profitable in delaying the flower bud emergence, flower anthesis, and increasing length of flower, flower diameter, number of flowers, and vase life of cut flowers. Likewise, pinching also caused a delay in flower bud emergence, increasing flower diameter and vase life of cut flowers. In contrast, plant height, growth index, and flower length were found better when plants remained without pinching. Lastly, using two plants/pot provided the best growth index, flower length, and diameter of flower, while the longer period of flower bud emergence and flower number were realized using four plants/pot, and the maximum vase life of cut flower was found when three plants/pot were used.

Conflict of interest

The authors have no conflict of interest.

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