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Optimising pinching levels and plant density on flower yield and pot present ability of potted annual: *Zinnia elegans*

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Abstract
The current investigation **"**Optimising pinching levels and plant density on flower yield and pot present ability of potted annual – *Zinnia elegans"* was carried out at College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, Hyderabad during December 2021 to February 2022. The experiment was laid out in Factorial Completely Randomized Design with nine treatments and three replications. The main objective of the experiment was to identify the effect of pinching and plant density on flower yield and pot present ability of *Zinnia elegans*. The treatments consisted of three levels of pinching *viz*., P1: Single pinching, P_2: double pinching and P_3: no pinching with three plant density *viz*., R_1: one plant per pot, R_2: two plants per pot, and R_3: three plants per pot.
Among different levels of pinching and plant density, no pinch with one plant per pot (P_3R_1) recorded maximum flower diameter (5.41 cm), Flower longevity (20.25 days), fresh weight of flower per plant (62.92 g) and dry weight of flower per plant (26.12 g) at 30, 60 and 90 DAS respectively. Double pinch with three plants per pot (P_2R_3) recorded greater value for number of flowers per plant (28.6) and pot present ability (90.07). Interaction effect for some parameters like days to flower bud initiation, days to 50 percent flowering and number of days taken to full bloom were found non-significant.

Keywords: Zinnia, pinching, plant density, pot, number of plants

Introduction
Flowers have been a part of Indian culture since the early days. They serve diverse uses, including ornamental uses in religious offerings, hair braiding, etc., aesthetic uses in bouquets, interior decorations and more. The symbol of beauty, tranquilly, purity, and love is a bouquet of flowers. Floriculture is one of the most promising elements in horticulture sector. Cut or loose flowers, decorative plants, potted plants, dried flowers, essential oils, and landscape gardening are all included in floriculture.
Zinnia is a genus of annual and perennial flowering plant belonging to Asteraceae (Compositae) family with about 20 species. *Zinnia elegans* (syn. *Zinnia violacea*) is the utmost popular and well known annual among the genus. Zinnia flowers have bright, uniform color and sturdy stems with biotic and abiotic resistant and long vase life. The chromosome number of *Zinnia elegans* is 2n =24. Zinnias are little, short garden plants that grow to be between 31.0 and 46.0vcm tall (Metcalf and Sharma, 1971) [9]. They have a vast selection of flower forms are available in single, semi double, and double forms.
Zinnias are little, short garden plants that grow to be between 31.0 and 46.0 cm tall (Metcalf and Sharma, 1971) [9]. It is a high-quality short-day plant that blooms nicely after 5 days of at least 12 hours of light (Kim *et al*., 2009) [6]. Zinnias have diverse uses like cut flower, potted plant, dried flower, in butterfly gardens to attract butterflies, as a companion plant with vegetables to prevent cucumber beetles, tomato worms, and whiteflies, and as a nematicidal plant to prepare dyes and paints. Antifungal, antioxidant, hepatoprotective, antibacterial, antiviral, antimalarial, cytotoxic (demonstrated on cancer cell lines), and insecticidal properties of some Zinnia species have been investigated (Burlec *et al.*, 2019) [3]. With regular water changes, cut flowers will stay fresh for 5–7 days, and even up to 20 days.
The prime objective of pinching is to promote branching, bushy growth, and emergence of greater number of flowers, which results in a higher flower yield. Rapid urbanization and changing lifestyle have increased the demand for potted plants in India. It is important to understand the performance of existing varieties available in market and also to identify the best number of plants per pot looks attractive. The dimension of the containers has the ability

to regulate different physiological and morphological traits in plants (Taherpazir and Hashemabadi, 2016) [14].

Materials and Methods

The present investigation was carried out during *rabi* season in the year 2021-2022 at P.G research farm, College of Horticulture, Rajendranagar, Hyderabad. Sri Konda Laxman Telangana State Horticultural University. The experimental site is situated at a latitude of 17º.32' North, longitude of 78º.40' East and altitude of 542.3 m above mean sea level. The plots were demarcated into three (3) replications, each replication consisted of five pots and each pot was filled with one, two and three zinnia plant. A gap of 60 cm space was left between the treatments. 9 treatments and experimental design followed is Completely Randomized Block Design (CRBD).

The experimental plot was made free from weeds, stones and then leveled by using spade. The pots were arranged according to the treatments designed. Potting media was prepared with red earth, vermicompost, FYM and cocopeat. They were thoroughly combined in the ratio of 1:1:1:1 and filled in the pots. Healthy seedlings were selected and carefully transplanted into the pots with one plant per pot, two plants per pot, three plants per pot. Plantlets were transplanted after 21st days after sowing. Plants with single and double pinch treatments were pinched at 3-4th pair of leaf stage and the plants with no pinch treatments were left un-pinched. Plants with double pinch were pinched second time when the branches of single pinch have 3-4 pairs of leaves. Hand weeding is done time to time to avoid any unnecessary weed growth.

Plants were fertilized occasionally with 19:19:19 at 2g/l, 3g/1, 4g/1 which was water-soluble fertilizer and approximately, 500 ml of fertilizer solution was applied for one plant per pot, two plants per pot, three plants per pot respectively. All other cultural and plant protection measures were done as per the recommended package of practices for the healthy crop.

The observations were recorded on flowering and yield parameters like number of days to flower bud initiation, numbers days to 50% flowering, number of days taken to full bloom, number of flowers per plant, flower diameter, fresh weight of flower per plant, dry weight of flower per plant, flower longevity and pot presentability. The data collected were analyzed statistically by following the analysis of variance (ANOVA) technique. Statistical significance was tested with 'F' value at 5 per cent level of significance and whenever the F value was found significant, critical difference was worked out at five per cent level of significance.

Results and Discussion

Number of days taken to flower bud initiation

The mean data regarding number of days taken for flower bud initiation after transplanting as influenced by pinching, plant density and their interaction effects was depicted in Table 1. The significant variation on number of days to flower bud initiation was observed among the different pinching levels. The lowest number of days taken to flower bud initiation (15.02 days) was noted in the plants with no pinch (P3). Parallel outcomes were also reported by Sehrawat *et al.* (2003) [12]. In African marigold and Kumar *et al.* (2002) [8]. in carnation.

Days taken to blossom bud initiation was significantly influenced by different plant density. Less number of days to flower bud initiation (31.85 days) was recorded in three plants per pot (R3). In general, lower planting density had delayed bud formation while, earliest bud formation was observed with the highest planting density. Due to there was a reduction in development of plants (vegetative) at the higher planting density. These results were reported by Bhargav *et al.* (2016) [2]. in China aster. The interaction effects of pinching levels and plant density on days taken to flower bud initiation was shown non-significant.

Days to 50% flowering

The mean data regarding number of days to 50 percent flowering as influenced by pinching, density of plant and their interaction effects was depicted in Table 2. The significant variation on number of days to 50 percent flowering was observed among the various pinching levels.

The lowest number of days to 50 percent flowering (29.49 days) was stated in the plants with no pinch (P_3) Similar outcomes were also observed by Khan *et al.* (2018) [5] in Marigold. Lowest number of days taken to 50 percent flowering (45.19 days) was recorded in three plants per pot (R_3). The plants grown at the higher density produced 34 lesser growth and tried to complete its reproductive stage earlier because of availability of more nutrients, soil moisture and sunlight etc. Similar results were in accordance with the findings of Bhargav *et al.* (2016) [2] in China aster. The interaction effects of pinching levels and plant density on days taken to 50 percent blooming was shown non-significant.

Number of days taken to full bloom

The mean data regarding number of days taken to full flowering as influenced by pinching, plant density and their interaction effects was depicted in Table 3. The significant variation on number of days taken to full bloom was observed among the different pinching levels. The least number of days taken to full bloom (52.70 days) was observed in the plants with no pinch (P_3) Comparable outcomes were also reported by Khan *et al.* (2018) [5] in marigold.

Number of days to full bloom was significantly affected by various plant density. Lowest number of days to full bloom (61.60 days) was noticed in three plants per pot (R_3). similar results were reported by Bhargav *et al.* (2016) [2] in China aster. The interaction effect of pinching levels and plant density on number of days taken to full bloom was shown non-significant.

Number of flowers per plant

The mean data regarding number of flowers per plant as affected by pinching, plant density and their interaction effects was depicted in the Table 4. The significant variation on number of flowers per plant was observed among the different pinching levels. The greater number of flowers (23.95) was observed in double pinching (P_2). Rise in number of flowers per plant might be that the pinched plant induced the production of large number of axillary shoots (branches) resulting in well-shaped bushy plants bearing a greater number of uniform flowers. Similar outcomes were also observed by Tomar *et al.* (2004) [15] and Khan *et al.* (2018) [5] in marigold and Ona *et al.* (2015) [10] in chrysanthemum. Number of flowers per plant was significantly affected by various plant density. One plant per pot (R_1) recorded greater number of flowers (18.06).

At lowest plant density there was a decrease in competition between plant and increasing of light and material absorption by each plant resulting in a greater number of flowers per plant. Comparable outcomes obtained by Abdulrahman (2011) [1] in stock plant. The interaction effects of pinching levels and plant density on number of flowers per plant was shown significant. The highest number of flowers (28.6) was recorded in P_2R_1 (double pinching with one plant per pot).

Flower diameter (cm)

Effect of pinching levels and plant density were shown significant on flower diameter. Maximum flower diameter (4.97 cm) was recorded in no pinch (P_3). In un-pinched plants the energy sharing was limited to the flower developing on main branch only. Comparable outcomes were also reported by Sailaja and panchbhai (2014) [11] in china aster.

Flower diameter was significantly influenced by different plant density. One plant per pot (R_1) observed maximum flower diameter (4.57cm). At lowest plant density there was comparatively lesser competition for space, nutrients, soil moisture and light etc., thereby up taken more nutrients which ultimately leads to better growth and quality of plants. Hence, producing better quality flowers. These results were in close agreement with the earlier work of Malam *et al*. (2010) and Khalaj *et al.* [4]. (2012) in tuberose; Kullur *et al.* [7] (2018) in spider lily; Singh *et al.* (2018) [13] in marigold as well as Yadav and Bhatia (2018) [17] in gladiolus. The interaction effect of pinching and plant density on flower diameter was found to be significant. The maximum flower diameter (5.41 cm) was observed in P_3R_1 which is no pinch with one plant per pot.

Fresh weight of flowers per plant (g)

The average mean data affecting to dry weight of flowers per plant as influence by pinching and plant density is depicted in Table 6. Among different levels of pinching, maximum fresh weight of flowers per plant (54.7 g) was observed in P_2-double pinching. Similar results were observed by Ullah *et al*. (2019) [16] in zinnia. Fresh weight of flower per plant was affected by different plant density. One plant per pot (R_1) recorded maximum fresh weight of flower per plant (45.17g). The interaction effect of pinching and plant density on fresh weight of flower per plant was found to be significant. The treatment combination P_2R_1 (double pinch with one plant per pot) recorded maximum fresh weight of flower per plant (62.92 g).

Dry weight of flowers per plant (g)

The mean data pertaining on dry weight of flowers per plant as influenced by pinching and plant density at 30, 60 and 90 DAS is presented in Table 7. Significant difference was recoded among different pinching levels in zinnia. Maximum dry weight of flowers per plant (24.54 g) was observed in P_2-(double pinching). As fresh weight was more in this treatment, corresponding results were obtained. Parallel outcomes were also reported by Atrachi *et al*. (2010) [2] in zinnia.

Dry weight of flower per plant was significantly influenced by different plant density. One plant per pot (R_1) recoded maximum fresh weight of flower per plant (20.05 g). The effect of interaction of pinching and plant density on dry weight of flower per plant was statistically significant. Among combination of different treatment P_2R_1 (double pinch with one plant per pot) recorded maximum dry weight of flower per plant (26.25 g).

Flower longevity (days)

The mean data pertaining to flower longevity as affected by pinching and plant density is presented in Table 8. Significant difference was observed among different pinching levels in zinnia. Maximum flower longevity (19.58 days) was stated in P_3-(no pinching) and among different plant density maximum flower longevity was recorded in one plant per pot (R_1) (15.18 days). The accumulation of more assimilates in non-pinching treatment with a smaller number of flowers. Comparable outcomes were also reported by Sailaja and Panchbhai (2014) [11] in chinaster.

The effect of interaction of pinching and plant density on flower longevity was statistically significant. Maximum flower longevity recorded in no pinch with one plant per pot (P_3R_1) (20.28)

Pot present ability (score)

The mean data pertaining on pot present ability as affected by pinching and plant density is presented in Table 8. Significant difference was observed among different pinching levels in zinnia. Among different levels of pinching, maximum pot present ability (86.02) was recorded in P_2- (double pinching). Among plant density maximum pot present ability was recorded in three plants per pot (R_3) (77.06).

The effect of interaction of pinching and plant density on pot present ability was statistically significant. Maximum pot present ability recorded in double pinch with three plants per pot (P_2R_3) (90.07). Plants with double pinching with three plants per pot showed best pot present ability score, because it had maximum number of flowers per plot, optimum flower size and good color with self-supporting strong stems and foliage without any infestation.

Table 1: Effect of pinching practices and plant density on days to flower bud initiation (days) in potted annual -*Zinnia elegans*

Pinching Levels (P)	Plant Density (R)			
	One plant per pot (R1)	Two plant per pot (R2)	Three plant per pot (R3)	Mean P
Single pinch (P1)	32.50	31.75	30.45	31.57
Double pinch (P2)	53.25	52.50	50.45	52.07*
No pinch (P3)	15.50	14.90	14.65	15.02
Mean R	33.75*	33.05	31.85	
	SE±		CD at 5%	
Pinching (P)	0.22		0.66	
Plant Density (R)	0.22		0.66	
P*R	0.38		NS	

T1: P1R1, T2: P1R2, T3: P1R3, T4: P2R1, T5: P2R2, T6: P2R3, T7: P3R1, T8: P3R2, T9: P3R3
P1: Single pinching R1: One plant per pot
P2: Double pinching R2: Two plants per pot
P3: No Pinching R3: Three plants per pot

Table 2: Effect of pinching practices and plant density on days to 50% flowering in potted annual -*Zinnia elegans*

Pinching Levels (P)	Plant Density (R)			
	One plant per pot (R1)	Two plant per pot (R2)	Three plant per pot (R3)	Mean P
Single pinch (P1)	45.75	44.25	43.85	44.62
Double pinch (P2)	65.55	64.78	63.15	64.49*
No pinch (P3)	30.26	29.63	28.58	29.49
Mean R	47.19*	46.22	45.19	
	SE±		CD at 5%	
Pinching (P)	0.41		1.22	
Plant Density (R)	0.41		1.22	
P*R	0.71		NS	

T1: P1R1, T2: P1R2, T3: P1R3, T4: P2R1, T5: P2R2, T6: P2R3, T7: P3R1, T8: P3R2, T9: P3R3
P1: Single pinching R1: One plant per pot
P2: Double pinching R2: Two plants per pot
P3: No Pinching R3: Three plants per pot

Table 3: Effect of pinching practices and plant density on days taken to full bloom (days) in potted annual -*Zinnia elegans*

Pinching levels(p)	Plant density(r)			
	One plant per pot (R1)	Two plant per pot (R2)	Three plant per pot (R3)	Mean P
Single pinch(P1)	60.25	57.65	54.86	57.59
Double pinch(P2)	82.55	80.25	79.18	80.66*
No pinch (P3)	55.35	52.00	50.75	52.70
Mean R	66.05*	63.30	61.60	
	SE±		CD at 5%	
Pinching (p)	0.64		1.91	
Plant density(r)	0.64		1.91	
P*R	1.11		NS	

T1: P1R1, T2: P1R2, T3: P1R3, T4: P2R1, T5: P2R2, T6: P2R3, T7: P3R1, T8: P3R2, T9: P3R3
P1: Single pinching R1: One plant per pot
P2: Double pinching R2: Two plants per pot
P3: No Pinching R3: Three plants per pot

Table 4: Effect of pinching practices and plant density on number of flowers per plant in potted annual -*Zinnia elegans*

Pinching Levels (P)	Plant Density(R)			
	One plant per pot (R1)	Two plant per pot (R2)	Three plant per pot (R3)	Mean P
Single pinch(P1)	12.25	15.5	15.73	14.5
Double pinch(P2)	20.75	22.5	28.6	23.6
No pinch (P3)	5.28	8.9	9.85	8.01
MEAN R	12.76	15.6	18.06	
	SE±		CD at 5%	
PINCHING (P)	0.11		0.33	
PLANT DENSITY (R)	0.11		0.33	
P*R	0.19		0.58	

T1: P1R1, T2: P1R2, T3: P1R3, T4: P2R1, T5: P2R2, T6: P2R3, T7: P3R1, T8: P3R2, T9: P3R3
P1: Single pinching R1: One plant per pot
P2: Double pinching R2: Two plants per pot
P3: No Pinching R3: Three plants per pot

Table 5: Effect of pinching practices and plant density on flower diameter (cm) in potted annual -*Zinnia elegans*

Pinching Levels (P)	Plant Density (R)			
	One plant per pot (R1)	Two plant per pot (R2)	Three plant per pot (R3)	Mean P
Single pinch(P1)	4.42	4.17	4.00	4.19
Double pinch(P2)	3.88	3.48	3.37	3.57
No pinch (P3)	5.41	4.96	4.54	4.97*
MEAN R	4.57*	4.20	3.97	
	SE±		CD at 5%	
PINCHING (P)	0.03		0.10	
PLANT DENSITY(R)	0.03		0.10	
P*R	0.06		0.18	

T1: P1R1, T2: P1R2, T3: P1R3, T4: P2R1, T5: P2R2, T6: P2R3, T7: P3R1, T8: P3R2, T9: P3R3
P1: Single pinching R1: One plant per pot
P2: Double pinching R2: Two plants per pot
P3: No Pinching R3: Three plants per pot

Table 6: Effect of pinching practices and plant density on fresh weight of flowers (g) per plant in potted annual -*Zinnia elegans*

Pinching Levels (P)	Plant Density(R)			
	One plant per pot (R1)	Two plant per pot (R2)	Three plant per pot (R3)	Mean P
Single pinch(P1)	45.65	38.75	34.47	39.62
Double pinch(P2)	62.92	54	47.19	54.70*
No pinch (P3)	26.95	24.92	18.48	23.45
MEAN R	45.17*	39.22	33.38	
	SE±		CD at 5%	
PINCHING (P)	0.30		0.88	
PLANT DENSITY(R)	0.30		0.88	
P*R	0.52		1.53	

T1: P1R1, T2: P1R2, T3: P1R3, T4: P2R1, T5: P2R2, T6: P2R3, T7: P3R1, T8: P3R2, T9: P3R3
P1: Single pinching R1: One plant per pot
P2: Double pinching R2: Two plants per pot
P3: No Pinching R3: Three plants per po

Table 7: Effect of pinching practices and plant density on dry weight of flowers per plant in potted annual -*Zinnia elegans*

Pinching Levels(P)	Plant Density (R)			
	One plant per pot (R1)	Two plant per pot (R2)	Three plant per pot (R3)	Mean P
Single pinch(P1)	20.45	19.37	15.25	18.36
Double pinch(P2)	26.25	24.25	23.13	24.54*
No pinch (P3)	13.45	12.46	9.24	11.72
MEAN R	20.05*	18.69	15.87	
	SE±		CD at 5%	
PINCHING	0.16		0.48	
PLANT DENSITY	0.16		0.48	
P*R	0.28		0.83	

T1: P1R1, T2: P1R2, T3: P1R3, T4: P2R1, T5: P2R2, T6: P2R3, T7: P3R1, T8: P3R2, T9: P3R3
P1: Single pinching R1: One plant per pot
P2: Double pinching R2: Two plants per pot
P3: No Pinching R3: Three plants per pot

Table 8: Effect of pinching practices and plant density on flower longevity (days) potted annual -*Zinnia elegans*

Pinching Levels(P)	Plant Density (R)			
	One plant per pot (R1)	Two plant per pot (R2)	Three plant per pot (R3)	Mean P
Single pinch(P1)	14.55	13.45	12.25	13.42
Double pinch(P2)	10.75	9.85	8.85	9.82
No pinch (P3)	20.25	19.65	18.85	19.58
MEAN R	15.18	14.32	13.32	
	SE±		CD at 5%	
PINCHING	0.06		0.19	
PLANT DENSITY	0.06		0.19	
P*R	0.11		0.33	

T1: P1R1, T2: P1R2, T3: P1R3, T4: P2R1, T5: P2R2, T6: P2R3, T7: P3R1, T8: P3R2, T9: P3R3
P1: Single pinching R1: One plant per pot
P2: Double pinching R2: Two plants per pot
P3: No Pinching R3: Three plants per pot

Table 9: Effect of pinching practices and plant density on pot present ability in potted annual -*Zinnia elegans*

Pinching Levels (P)	Plant Density (R)			
	One plant per pot (R1)	Two plant per pot (R2)	Three plant per pot (R3)	Mean P
Single pinch(P1)	73.47	76.28	80.35	76.7
Double pinch(P2)	82.38	85.62	90.07	86.02
No pinch (P3)	55.35	58.43	60.76	58.18
MEAN R	70.40	73.44	77.06	
	SE±		CD at 5%	
PINCHING	0.50		1.5	
PLANT DENSITY	0.50		1.5	
P*R	0.87		2.60	

T1: P1R1, T2: P1R2, T3: P1R3, T4: P2R1, T5: P2R2, T6: P2R3, T7: P3R1, T8: P3R2, T9: P3R3
P1: Single pinching R1: One plant per pot
P2: Double pinching R2: Two plants per pot
P3: No Pinching R3: Three plants per pot

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