Enhancing the Aesthetic and Economic Value of Potted Zinnia Through Pinching and Paclobutrazol spray

ABSTRACT

Potted plants constitute a significant portion of the global floriculture trade, highlighting the importance of pot presentation for commercial competitiveness. Despite being a commonly grown annual crop in flower beds during its season, Zinnia's potential as a potted plant has been limited by its natural growth form that looks disproportionate in a pot. This study examines the impact of pinching and paclobutrazol application on enhancing the suitability of Zinnia for pot presentation. Conducted during the rabi season at the College of Horticulture, Hyderabad.The results indicate that both pinching and paclobutrazol treatment significantly reduce plant height while improving plant spread. Among the treatments, the combination of 100 ppm paclobutrazol application and double pinching demonstrated the highest pot presentation score at 87.41, followed by the treatment involving 50 ppm paclobutrazol and double pinching with a score of 85.31. Conversely, the control treatment without pinching or spray exhibited the lowest score of 60.33 points. Furthermore, when assessing the benefit-cost ratio, double pinching with 100 ppm of paclobutrazol proved to have significant commercial advantages with a B:C ratio of 1.4.

Key words: Potted zinnia, aesthetics, B:C ratio, paclobutrazol spray, pinching.

INTRODUCTION

Potted plants emerge as a particularly lucrative aspect of this industry, offering instant solutions for gardening and enhancing both indoor and outdoor spaces. Their portability facilitates easy landscaping, making them a popular choice for immediate beautification. The potted plant sector is experiencing remarkable growth, with considerable commercial importance. This dynamic industry continues to expand as the demand for instant greenery and ornamental additions to various spaces persists.

Among one's option for picking a perfect flowering annual for garden display, Zinnia becomes an obvious choice. Zinnia is a genus of flowering plants that belongs to Asteraceae family and is native to Mexico and Central America. It stands out as a true testament to nature's artistic prowess with its intricate pattern and captivating beauty. It is a kaleidoscope of colours available in almost all warm and cool colours in single and bi-coloured types. It is one of the highly preferable crops for its attractive flower heads and it's availability in different colours and shades. Beyond their fascinating colours, it has a remarkable anatomical structure with intricate petals, leaves and stems that contribute to their resilience and allure. These characteristics make zinnia as a potential ornamental plant.

Apart from its botanical allure, it's usage as a potted plant was restricted due to its disproportionate growth in a pot with large plant height. The term pot presentability refers to certain characteristics that makes it more attractive when potted in a pot of particular size.Growth retardants are recognized for their ability to induce compactness in plants, enhance flower production, and manipulate the timing of flowering (Bayaskar et al., 2018). On the other hand, when the apical portion of a shoot is removed, it eliminates the primary source of apical dominance, leading to a redirection of assimilates into lateral buds, thereby stimulating branching

(Cline, 1991).So, these two practices were found potential to make potted zinnia look attractive in a pot. Hence, this study was taken up to alter the plant architecture by using pinching practices and paclobutrazol to make it suitable for growing as apotted plant.

MATERAL AND METHODS

Planting material and Treatment details

Zinnia elegans, which is a common species used for the ornamental purpose is selected for this experiment. Local open pollinated seeds were selected and sown in portrays till they germinate. Once the seedlings reached transplanting stage, they were transplanted to pots. The study was undertaken with two factors in three replications. First factor is pinching with three levels of Single pinch, Double pinch and No pinch. The second factor is paclobutrazol spray with four concentrations as 0 ppm, 50 ppm, 100 ppm and 150 ppm. Comprehensive information regarding the treatments can be found in Table 1.

Treatment details

Table 1. Tabulated representation of treatment details

S.No	Treatment details
1.	P1R1 – Single pinch+ 50 ppm paclobutrazol spray
2.	P1R2– Single pinch+ 100 ppm paclobutrazol spray
3.	P1R3 – Single pinch+ 150 ppm paclobutrazol spray
4.	P1R4 – Single pinch+ No spray
5.	P2R1 – Double pinch+ 50 ppm paclobutrazol spray
6.	P2R2 – Double pinch+ 100 ppm paclobutrazol spray
7.	P2R3 – Double pinch+ 150 ppm paclobutrazol spray
8.	P2R4 – Double pinch+ No spray
9.	P3R1 – No pinch+ 50 ppm paclobutrazol spray
10.	P3R2 – No pinch+ 100 ppm paclobutrazol spray
11.	P3R3 – No pinch+ 150 ppm paclobutrazol spray
12.	P3R4 – No pinch+ No spray

Cultivation and treatment application details

The cultivation process began with the sowing of seeds in pro-trays, utilizing a growth medium composed of a 1:1 ratio of cocopeat and vermicompost. After a growth period of 21 days, the young plantlets were carefully transplanted into pots characterized by effective drainage. The potting mix employed for this stage comprised a well-balanced combination, featuring a 1:1:1:1 ratio of red earth, vermicompost, farmyard manure and cocopeat.

Pinching: In terms of cultivation practices, pinching was implemented with variations across treatments. Single pinch treatments involved the removal of growing tips at the 3-4th pair of leaf stage, while plants subjected to no pinch treatment were left unaltered. The double pinch

treatment were pinched when 3-4th pair of leaf emerged and also underwent a secondary pinching when the lateral branches of the initially pinched plants developed 3-4 pairs of leaves, enhancing branching and overall plant architecture.

Paclobutrazol spray: To further influence plant growth and development, paclobutrazol spray applications were executed. The paclobutrazol was quantified with the help of micropipette and diluted in distilled water to prepare spray solution. Three distinct concentrations of the paclobutrazol solution *viz.*, 50 ppm, 100 ppm, and 150 ppm were prepared and applied to the respective treatments twice, specifically on the 7th and 21st days following the initial pinching. Notably, a control treatment with 0 ppm was left unsprayed.

Pot presentability

Pot presentability explains the suitability of a potted plant to the specifications of the pot. Such that, the potted plant which secures more score will be the most preferable amongst. The score was given on the basis of the point system modified after Conover (1986). The parameters were studied and points were allotted to each parameter out of a maximum of 100 points. The criteria for allotting the score was given in table -2.

Table 2. Table representing the criteria for pot presentability score

S.No	Parameters	Maximum points	Description	Score
1	Number of flowers per pot	20	>20 flowers per pot	20
			15-20 flowers per pot	18
			10-15 flowers per pot	15
			5-10 flowers per pot	12
			< 5 flowers per pot	10
2	Flower size	10	2.0- 4.0 cm	10
			4.0-6.0 cm	8
			6.0-8.0 cm	6
			8.0-10.0 cm	4
3	Colour	10	Flower with clear colour and no fading, no residue	10
			Slight fading and dull colour	8
			Very dull and faded	6
	B) Shape			
4	Stem and foliages	20	Plant self-supportive with very strongstems having foliage healthy and free ofany infestation of insect- pests,diseases and bruises	20
			Plants less supportive with relativelyless strong stems, foliage somewhathealthy and having little pest anddisease infestation and bruises	15
			Plant not self-supportive, having lessstrong stems with unhealthy foliageand considerable infestation of pestsand	10

			diseases and bruises.	
	C) Form			
5	Plant height	10	Plants in balance with pot neither tootall, nor too small, generally 2.5 timesto the height of the pot.	10
			Plants too large or too small to the height of the pot	6
6	Plant spread	10	Plant spread in balance with pot, neithertoo large nor too small, generally equalto the height of theplant	10
			Plant spread too large or small to theheight of the plan	6
7	Plant Appearance as awhole plant	20	Fresh appearance, no indication ofsenescence, mechanical and insectdamage in flowers/ stems/shoots/foliage	20
			Fresh appearance but slight indication of senescence	15
			Dull appearance and considerableindication of senescence	10
	Total score	**100**		

Benefit- Cost ratio

Crop economics were assessed by computing the cultivation expenses for each treatment. This involved determining the shared costs associated with each treatment and subsequently incorporating the specific fertilizer expenses for each treatment. The Benefit-Cost Ratio (BCR) was then determined using the provided formula. This ratio is obtained by dividing the overall benefits, considering both shared and fertilizer costs, by the total expenses. The Benefit-Cost Ratio provides a valuable metric for evaluating the economic feasibility and effectiveness of each treatment in relation to the overall returns.

$$\textbf{BCratio} = \frac{\textbf{NetMonetaryReturns (Rs.)}}{\textbf{Totalcostofcultivation (Rs.)}}$$

Statistical analysis

The observations documented for different parameters underwent analysis of variance employing FCRD (Factorial Completely Randomized Design). Statistical significance was assessed using the 'F' value at a 5% probability level. Whenever the 'F' value proved to be statistically significant, a critical difference was computed at the five percent probability level.

RESULTS AND DISCUSSION

Pot presentability was systematically categorized into three primary domains: Shape, Form and Flowering. Each of these overarching categories was further subdivided into specific sub-

categories, facilitating a nuanced and detailed assessment to accurately perceive and assign scores based on distinct criteria within each category. This structured approach allowed for a comprehensive evaluation, ensuring a thorough understanding of the various aspects contributing to the overall presentation of the potted plants.

Flowering parameters

Flowering parameters, encompassing factors such as the number of flowers per pot, flower size and flower colour that hold substantial significance in the evaluation of potted plants. These criteria collectively contribute to a maximum score of 40 out of 100 points, underscoring their pivotal role as the primary determinants in selecting a visually appealing and aesthetically pleasing potted arrangement. The allocation of such a significant portion of the total score underscores the emphasis placed on the quality and presentation of the flowers, making them a focal point in the overall assessment of the attractiveness and allure of the potted display.

Number of flowers per pot

Flowers are the foremost and the eye- catching considering aspects of a potted zinnia. The number of flowers per pot was recorded during the peak flowering stage and the maximum score allotted to it was 20. The score was given in such a way that the pot with a greater number of flowers secures more score and vice- versa. The results suggest that, among all the treatments, the treatment P2R2, double pinching with paclobutrazol 100 ppm recorded more score of 19.14. These cumulative results may be due to production of more number of flowers.Pinching reduced the apical dominance and aided in production of more flowering laterals and another factor is that, paclobutrazol at optimum concentrations, can be observed to alter the source- sink relationship. As the vegetative growth was suppressed, it resulted in more laterals and thereby flowers (Asgarian*et. al*, 2013).

Flower size (cm)

In the assessment of potted plants, a unique scoring system was employed, wherein smaller flower diameters were assigned higher scores compared to their larger counterparts. The rationale behind this scoring mechanism lies in the observation that diminutive flower sizes were deemed more favorable. Notably, the treatment involving both double pinch and 150 ppm of paclobutrazol yielded the maximum score of 7.98, underscoring the effectiveness of this specific combination.

The reduction in flower diameter associated with the application of pinching and paclobutrazol can be elucidated by the phenomenon wherein the plant's energy is redirected to a greater number of branches. In this context, the practice of pinching, coupled with the influence of paclobutrazol, promotes increased branching, leading to the distribution of energy and resources among a larger number of flowers. This contrasts with control plants where limited branching occurs, causing a competition for carbohydrates among fewer branches. The findings from Sailaja *et al.* (2014) supported this observation, shedding light on the intricate interplay between cultural practices and the resulting flower characteristics in potted plants.

Flower colour

Within the spectrum of various treatments, the plants subjected to the combination of double pinching along with 50 ppm of paclobutrazol emerged as the most noteworthy, exhibiting vibrant

coloration devoid of any unsightly brown patches. Notably, these plants garnered an impressive score of 9.94, attesting to the exceptional quality of their color display.

The enhanced coloration in this particular treatment can be attributed to the strategic implementation of double pinching during the cultivation process. This technique facilitates an increased availability of photosynthates, compounds essential for the plant's photosynthetic processes, ultimately contributing to a more robust and vivid production of colors in the flowers.

Furthermore, the specific concentration of paclobutrazol employed in this treatment (50 ppm) appears to be optimal for achieving the desired flower coloration. Paclobutrazol, a plant growth regulator, likely played a crucial role in fine-tuning the balance of growth hormones, resulting in an optimal color expression without the development of undesirable brown patches. This synergy between double pinching and the precise concentration of paclobutrazol underscores the significance of careful and deliberate cultivation practices in achieving superior aesthetic qualities in potted plants.

Shape

In the evaluation of shape attributes, meticulous attention is given to the features associated with stems and foliage in plants, employing a scoring mechanism for precise assessment. This scoring system, capped at a maximum of 20 points, accentuates the paramount importance within the broader evaluation framework. The focal point lies in the recognition and significance attributed to well-defined, robust, and flourishing plant formations, elevating them as pivotal elements in the overall appraisal process.

In shape attributes, characters related to stems and foliage are screened and scored accordingly.The scoring system for shape characteristics allocated a maximum of 20 points, emphasizing the significance of well-formed and healthy plant structures in the overall assessment.

Stems and foliage

In the evaluation of shape and foliage related attributes, a thorough examination of stems and foliage was conducted to detect the presence of pests, diseases and any signs of damage such as bruises. Remarkably, the treatment that stood out with the highest score of 19.48 points was the one characterized by the absence of any pinching coupled with the application of 50 ppm paclobutrazol (P3R1). The plausible explanation for this performance lies in the well-balanced height and robust growth of stems observed in this treatment. The sturdy development of stems not only contributed to the overall structural integrity of the plants but also resulted in a harmonious and aesthetically pleasing form. This observation underscores the importance of careful cultivation practices and the strategic use of growth regulators in achieving optimal plant shapes, ultimately influencing the overall visual appeal and health of the cultivated specimens.

Form

The assessment of form-related characteristics encompassed key factors such as plant height, plant spread and the overall appearance of the plant as a cohesive entity. In this screening process, a cumulative maximum score of 40 points was assigned to these parameters, constituting a significant portion of the total score of 100. This approach acknowledges the interconnectedness of height, spread, and overall plant appearance in shaping the aesthetic and qualitative attributes

of the cultivated plants, thereby guiding the selection process towards the attainment of well-rounded and visually appealing outcomes.

Plant height

Although, zinnia had a good potential to be a potted plant, it's usage as a potted plant was restricted due to its disproportionate look when planted in a pot. It is majorly due to long plant height with more internodal length.

The highest score for plant height, reaching 9.79 points, was achieved through the application of double pinching with 100 ppm of paclobutrazol. This optimized plant height can be attributed to the paclobutrazol's role in inhibiting gibberellin biosynthesis, which leads to constrained internode growth and restricted cell elongation, as described in the study by Laermann*et al.* in 1992. The reduction in plant height through pinching is likely due to the removal of apical meristematic tissue, resulting in the inhibition of apical dominance, as noted by Mutlu and Agan in 2015. Consequently, this alteration directs plant metabolites away from vertical growth and towards horizontal growth and prevented plant from looking disproportionate in pot with more plant height.

Plant spread

A pot looks more presentable when all the circumference of the plant is completely filled with the foliage and flowers of the plant. In the present investigation, the maximum score was observed to obtain by the treatment with Double pinching and 100 ppm of paclobutrazol with 9.72 score.Pinching led to an increase in plant spread in both directions because it redirected plant metabolites away from meristematic tissues, effectively transitioning from vertical growth to horizontal growth. The repetitive removal of portions of the main branch allowed axillary buds to break free from the inhibitory effects of apical dominance, encouraging their growth and resulting in more branching and increased plant spread in both the East-West and North-South directions. This phenomenon aligns with findings reported by Kumar *et al*. (2013) in chrysanthemums and Singh *et al*. (2019) in marigolds.

A possible explanation is that paclobutrazol suppressed the apical bud, making sufficient auxin available to lateral buds. As these lateral buds sprouted, they produced more branches, ultimately contributing to an expanded plant spread. This observation is in line with similar results reported by Pinto *et al*. (2003) in zinnias and Latimer *et al*. (1991) in zinnias, impatiens and marigolds.

Plant appearance as a whole

The entire plant underwent a comprehensive screening process to assess parameters such as senescence, overall freshness and the presence of mechanical, disease or pest-induced damage. Subsequently, scores were assigned based on the observed conditions, with the treatment involving double pinching and the application of 100 ppm paclobutrazol (P2R2) securing the highest score of 19.39. In contrast, the treatment receiving no intervention, implying no pinching or spraying, recorded the lowest score at 13.03.

The superior score obtained in the treatment with double pinching and 100 ppm of paclobutrazol indicates a heightened level of aesthetic appeal. This outcome can be attributed to the synergistic effects of double pinching, which promotes a well-branched and balanced growth pattern, and paclobutrazol, known for its role in regulating plant growth and mitigating senescence.

To properly visualize the scores of different treatments and different parameters, a heat map and a data bar is used and given in table 3. For visualizing the scores of different parameters of the treatments, a heat map is used with a scale of maximum 20 points and minimum of 0 points. Notably, treatments with the highest scores are represented in a deep green hue, gradually transitioning to lighter shades as the scores decrease. Specifically, a score of 15 is depicted in a light green colour, with the intensity diminishing into yellow as the score approaches 10. As the score further descends to around 5, the light red colour is used and eventually reaching a deep red hue when the score reaches zero. This colour gradient serves as a visual aid, offering a detailed representation of the varying scores and their magnitudes across different treatments and parameters.

Table 3. Heat map and Data bar used to represent the score of different treatments

Treatment	Flowering			Shape	Form			Total score for 100
	No: of flowers	Flower size (cm)	Flower colour	Stems and foliage	Plant height (cm)	Plant spread (cm)	Plant appearance as a whole	
P1R1	14.07	5.54	9.33	19.14	9.47	5.24	17.99	80.78
P1R2	14.21	7.01	9.47	14.22	9.66	9.14	18.45	82.16
P1R3	14.28	7.47	7.88	14.24	5.59	5.86	15.04	70.36
P1R4	14.81	7.48	7.74	14.06	5.33	5.66	13.18	68.26
P2R1	17.1	5.14	9.94	19.1	5.46	9.49	19.08	85.31
P2R2	19.14	7.03	7.47	14.87	9.79	9.72	19.39	87.41
P2R3	17.24	7.98	7.28	14.27	5.04	9.12	14.44	75.37
P2R4	17.59	7.28	7.34	14.59	5.71	5.97	14.8	73.28
P3R1	11.21	7.03	7.15	19.48	9.21	9.1	14.08	77.26
P3R2	11.75	7.87	9.84	14.14	9.03	9.33	17.17	79.13
P3R3	11.24	5.84	7.33	14.91	9.15	5.87	13.08	67.42
P3R4	11.97	5.97	7.77	9.74	5.91	5.94	13.03	60.33

20
15
10
5
0

Further, for representing the overall pot presentability scores, a data bar is used. A bar with more bar length is said to have maximum score and vice versa indicating the best treatment (P2R2) double pinching with 100 ppm of paclobutrazol with more bar length and for control with no pinching and no spray has less bar length.

Benefit-Cost ratio:

The data presented in Figure 1 elucidates the mean values of the Benefit-Cost (B:C) ratio, specifically in relation to the impact of pinching and different concentrations of paclobutrazol. Notably, the highest B:C ratio of 1.40 was observed in P2R2, where double pinching was combined with 100 ppm of paclobutrazol. Following closely, P2R3, representing the combination of double pinching with 150 ppm of paclobutrazol, exhibited a respectable B:C ratio of 1.34. On the contrary, the minimum B:C ratio of 0.66 was recorded in P3R4, where no pinching and no spray (control) were applied.

The substantial B:C ratio observed in P2R2 can be attributed to the enhanced visual appeal of the potted plants, which likely resulted in a higher market value. The practice of double pinching, coupled with the optimal concentration of 100 ppm paclobutrazol, appears to have positively influenced the economic returns compared to other treatments. These findings underscore the economic implications of specific cultivation practices and growth retardant applications in optimizing the benefit-to-cost ratio in horticultural production.

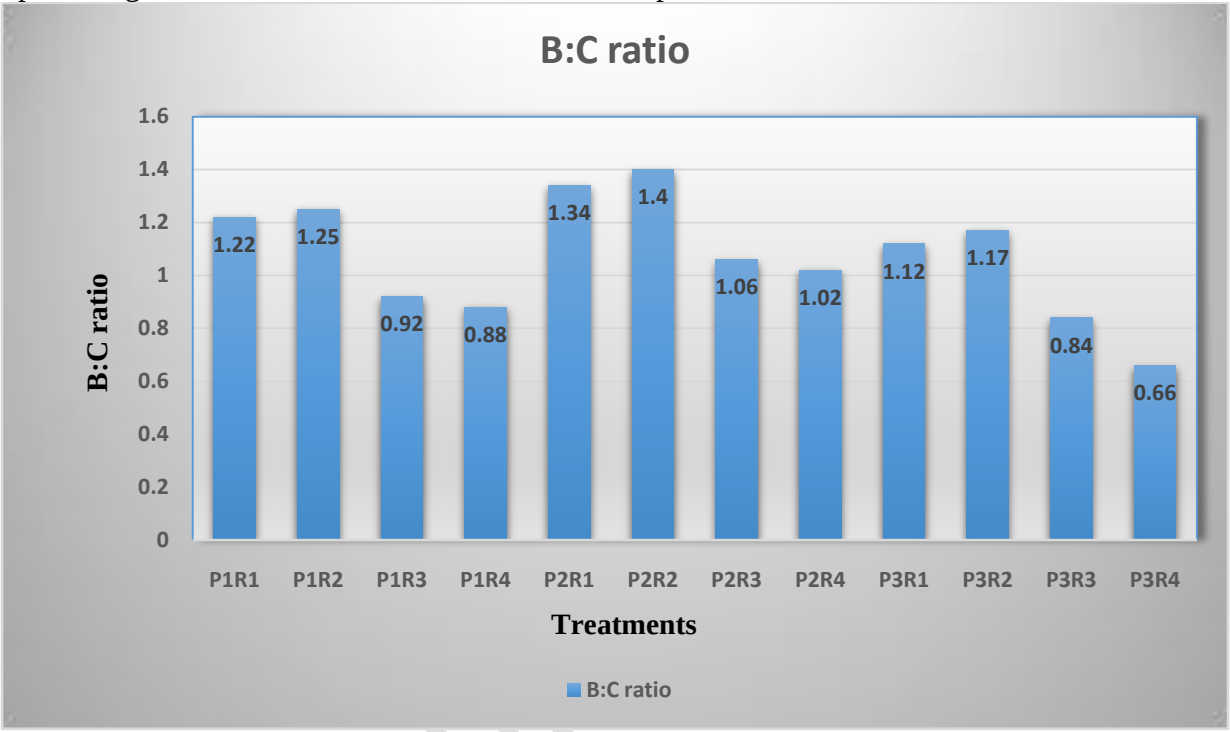

Figure 1. Graphical representation of B:C ratio

CONCLUSION:

The findings of the research underscored the superiority of the treatment involving double pinching and 100 ppm paclobutrazol spray, achieving an outstanding total score of 87.41 out of a total score of 100. This particular combination demonstrated optimal outcomes across various parameters related to flowering, form, and shape characters.

In contrast, the control group, devoid of both spray and pinching interventions, exhibited the lowest score at 60.33. This stark contrast in scores emphasizes the pivotal role of the applied treatments in influencing and maximizing the overall presentation of potted zinnias. The assessed benefit-cost ratio also proved to have commercial benefits with the treatment

The experiment not only establishes a clear preference for the double pinching and paclobutrazol treatment but also underscores the significance of deliberate horticultural practices in elevating the pot presentability of zinnia plants. The nuanced approach of the experimental treatment has proven to be instrumental in achieving a harmonious balance of flowering, form, and shape characteristics, contributing to a visually striking and aesthetically pleasing display.

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