Plant Archives Vol. 25, No. 1, 2025 pp. 2242-2248 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.324

STUDIES ON THE EFFICACY OF PLANT DENSITY AND GROWTH REGULATORS ON FLOWER YIELD AND QUALITY OF POTTED ANNUAL ZINNIA (*ZINNIA ELEGANS* JACQ.)

A. Monika Sri Nagini[1*], Rajasekhar Marri[2], K. Kaladhar Babu[3], G. Jyothi[4] and P. Gouthami[5]

[1]Department of Floriculture and Landscape Architecture, College of Horticulture, Mojerla, Dist.- Wanaparthy, Telangana State – 509382, India

[2]Sri Konda Laxman Telangana State Horticultural University, Mulugu. Dist.- Siddipet – 502279, Telangana, India

[3]Department of Floriculture and Landscape Architecture, College of Horticulture, Rajendranagar, Hyderabad – 500030, Telangana, India

[4]Floricultural Research Station - Rajendranagar, Hyderabad – 500030, Telangana, India

[5]Department of Crop Physiology, College of Horticulture, Mojerla, Dist.- Wanaparthy, Telangana, India

*Corresponding author E-mail:- monikaatchuta5@gmail.com

(Date of Receiving : 05-02-2025; Date of Acceptance : 10-04-2025)

ABSTRACT

Zinnia (*Zinnia elegans* L.) is a vibrant ornamental species widely cultivated for its colorful blooms and aesthetic appeal in landscapes and in pots in households. Optimizing the plant density and application of suitable growth regulators are crucial for enhancing flower yield and quality for enhanced cultivation. To investigate the effect of plant density and growth regulators on flower yield and quality of potted zinnia an experiment was carried out at College of Horticulture, Mojerla, SKLTSHU, during December 2022 to March 2023. The experiment was laid out in FCRD with two factors of which first factor consists of two levels of plant densities and second factor consists of seven levels of sprays of growth regulators. The results revealed that three plants per pot with cycocel at 2000 ppm increased the number of days for flowering and Four plants per pot with cycocel at 1500 ppm resulted in higher number of flowers with maximum flower diameter, fresh weight, dry weight and highest longevity of flowers. Four plants per pot with cycocel at 1500 ppm was found best for all flower yield and quality parameters.

***Keywords*:** Anti-gibberellins, cycocel, paclobutrazol, plant density, zinnia.

Introduction

A member of Asteraceae family, *Zinnia* is a genus of annual and perennial flowering plants with roughly 20 species. The most popular and quite well known annual in the genus is *Zinnia elegans* (syn. *Zinnia violacea*). Zinnia flowers have vivid, single colour with strong stalks and extended vase life.

Zinnia elegans is also known as the youth and age plant, common zinnia, and elegant zinnia. The genera bear the name of Johann Gottfried Zinn, a German botanist, and it represents tenacity, generosity, and friendliness. It is believed that it originated in Mexico and regions of Central and South America. Rapid urbanization, lack of free space for planting and changing lifestyles has increased the demand for potted plants in India. They provide cost-effective decoration, space-efficient gardening and cooling effects. It is important to study the performance of existing varieties available in market and to identify the precise number of plants per pot to look attractive. Controlling plant size and producing compact plants with more blooms is one of the most important aspects in ornamental plant production.

Plant size can be limited by various methods such as genetic control, environmental conditions and use of plant growth retardants (Cowling, 2010). Plant growth retardants are commonly applied to limit stem elongation and to produce more compact plants with high quality blooms.

Cycocel (CCC) is a growth regulator from with a quaternary ammonium compound that prevents gibberellin biosynthesis (Taiz and Zeiger, 2006; Megersa *et al*., 2018). The use of growth retardants is recommended to reduce the height and improve the qualitative and quantitative characteristics of zinnia flower. (Karimi *et al*., 2020). Paclobutrazol has been reported to be very effective for dwarfing a wide range of crops (Lever *et al.*, 1982; Menhenett and Hanks, 1982). It is used primarily for the reduction in extension of shoot growth, increase the root growth, produce uniform compact plants, with enhancement of foliage colour and flowering in certain species.

Material and Methods

The experiment was conducted in a polyhouse at Floriculture block of College of Horticulture, Mojerla, Wanaparthy district in Factorial Completely Randomized Design with two replications and two factors with the first factor consisting of two levels of Plant densities (P_1-Three plants per pot, P_2-Four plants per pot) and second factor comprising of seven levels of growth regulators (R_0-No spray, R_1-Cycocel @ 1000 ppm, R_2-Cycocel @ 1500 ppm, R_3-Cycocel @ 2000 ppm, R_4-Paclobutrazol @ 60 ppm, R_5-Paclobutrazol @ 90 ppm and R_6-Paclobutrazol @ 120 ppm).

Seed was sown in plug trays filled with a mixture of cocopeat and vermicompost and seedlings were transplanted after 21 days of sowing into pots containing potting mixture of red earth, vermicompost, FYM and cocopeat in the ratio of 1:1:1:1. First spray of growth regulators was done at 3-4 leaf stage and second spray was done 25 days after first spray. Data was recorded to record the influence of growth regulators and plant densities on flower yield and quality.

Results and Discussion

Days to flower bud initiation (days)

The data pertaining to the days to flower bud initiation is furnished in Table 1. The maximum number of days for flower bud initiation (26.95) was observed at a plant density of three plants per pot compared to four plants per pot (26.21). At a lower plant density, the plants have less competition for resources like space, light and soil nutrients which helps in more vegetative growth and take more time to enter into the reproductive phase, while at a higher plant density, plants have more competition for resources and entered into the reproductive phase quickly.

Cycocel @ 2000 ppm resulted in more number of days taken for flower bud initiation (27.95), which is on par with paclobutrazol at 120 ppm (27.60). Less number of days for flower bud initiation (25.48) were observed in control (no spray). Flowering is a complex physiological process controlled by many factors including photoperiod, light intensities, durations, environmental and physiological causes (Joiner and Harrison, 1967, Karunananda and Peiris, 2010). Shrisat *et al*. (2021) reported that plants treated with cycocel have taken higher number of days for flower bud initiation.

Days to 50% flowering (days)

Maximum number of days for 50% flowering (33.35) were observed at plant density of three plants per compared to four plants per pot (32.85) (Figure 1). This is because at higher plant density there is more competition for space, nutrients and moisture so that the plants entered into flowering phase quickly to avoid competition.

Maximum number of days taken for 50% flowering (35.40) were noticed with cycocel at 2000 ppm and is followed by paclobutrazol at 120 ppm (34.50) and minimum number of days for 50% flowering (31.90) were observed in control (no spray). However, delayed flowering might be apparently the result of growth inhibition rather than direct effect upon flowering stimulus (Rezazadeh and Harkess, 2015). Khan *et al*. (2012) reported that plants treated with cycocel at 2000 ppm took maximum number of days for flower bud initiation thus increased the number of days for 50% flowering in marigold.

Number of days taken to full bloom (Days)

The data pertaining to the days to flower bud initiation is furnished in Table 2. Maximum number of days taken for full bloom (38.01) were observed at plant density of three plants per pot and minimum number of days taken for full bloom (37.38) were recorded at a density of four plants per pot.

Maximum number of days taken for full bloom (40.00) were recorded with cycocel at 2000 ppm which is followed by paclobutrazol at 120 ppm (38.80) and minimum number of days for full bloom (36.60) were observed with cycocel at 1000 ppm.

Among interaction effects maximum number of days taken for full bloom (40.40) were recorded with the treatment combination of P_1 R_3 (Three plants per pot + Cycocel at 2000 ppm).

Number of flowers per plant

Maximum number of flowers per plant (17.92) were recorded at plant density of four plants per pot (Table 3). Pandey *et al*. (2014) also observed more number of flowers per plant at higher plant density in marigold.

Among different concentrations of growth regulators highest number of flowers per plant (19.05) were recorded with cycocel at 1500 ppm. Whereas, the lowest number of flowers per plant (15.60) were recorded in control (no spray). It is a well-known fact that cycocel played a major role in the suppression of apical dominance, which resulted in increased biometric characteristics like more branches and leaves which might have resulted in production and accumulation of more photosynthates that were diverted to the sink (flower) resulting in more number of flowers with better weight and ultimately the yield (Mohd Ahmed *et al.,* 1988).

Among interaction effects of plant density and different concentrations of growth regulators, maximum number of flowers per plant (19.65) were observed with the treatment combination of P_2 R_2 (Four plants per pot + Cycocel at 1500 ppm).

Flower diameter (cm)

The effect of different plant densities on flower diameter was found to be statistically non-significant. Minimum flower diameter (3.37 cm) was recorded with cycocel at 2000 ppm while the maximum flower diameter (3.90 cm) was noticed in control (No spray) (Figure 2). El-Sharhorey *et al*. (2022) reported that flowers with less diameter were produced in plants treated with cycocel and paclobutrazol in zinnia.

The interaction effect of plant density and different concentrations of growth regulators on flower diameter was found to be statistically significant. Minimum flower diameter (3.16 cm) was recorded with the treatment combination of P_2 R_2 (Four plants per pot + Cycocel at 1500 ppm).

Fresh weight of flowers per plant (g)

Maximum fresh weight of flowers per plant (18.63 g) was noticed at the plant density of four plants per pot compared to density of 4 plants per pot (Table 4). Maximum fresh weight of flowers per plant that are closely spaced (60 plants per m2) was reported by Mirzaei *et al.* (2016) in marigold.

Highest fresh weight of flowers per plant was recorded at cycocel at 1500 ppm (21.16 g) while the lowest fresh weight of flowers per plant (15.48 g) was noticed in control (no spray). Osman *et al*. (2014) reported higher fresh weight of flowers in plants treated with cycocel in solidago.

Among interaction effects of plant density and different concentrations of growth regulators, maximum fresh weight of flowers per plant (21.30 g) was noticed with the treatment combination of P_2 R_2 (Four plants per pot + Cycocel at 1500 ppm).

Dry weight of flowers per plant (g)

From table 5 it can be seen that Maximum dry weight of flowers per plant (8.04 g) was recorded at the plant density of four plants per pot while the minimum fresh weight of flowers per plant (7.80 g) was observed at a density of three plants per pot.

Among different levels of growth regulators, highest dry weight of flowers per plant (9.79 g) while the lowest dry weight of flowers per plant (6.12 g) was noticed in control (no spray). Osman *et al*. (2014) reported higher dry weight of flowers in plants treated with cycocel and thus resulted in higher dry weight.

Among interaction effects of plant density and different concentrations of growth regulators, maximum flower longevity (24.00) was noticed with the treatment combination of P1 R2 (Three plants per pot + Cycocel at 1500 ppm).

Flower longevity on plant (Days)

Maximum flower longevity on plant (20.88) was observed at plant density of three plants per pot and the minimum flower longevity (19.69) was noticed at a density of four plants per pot (Figure 3).

Among the different concentrations of growth regulators, higher flower longevity on plant (22.25) was observed with cycocel at 1500 ppm and the lower flower longevity (19.60) was observed in control (no spray). The shelf life of flowers is also increased by cycocel application due to greater accumulation of photosynthetic utilization of minerals and translocation of assimilates (Kumar *et al*. 2014). Among interaction effects of plant density and different concentrations of growth regulators, maximum flower longevity (24.00) was noticed with the treatment combination of P_1 R_2 (Three plants per pot + Cycocel at 1500 ppm).

Table 1 : Effect of plant density and growth regulators on number of days to flower bud initiation in zinnia.

Growth regulators	Plant density		
	P_1	P_2	Mean
R_0	25.90^{f}	25.05^{g}	25.48^{c}
R_1	26.60^{de}	25.70^{fg}	26.15^{c}
R_2	27.00^{cd}	26.80^{d}	26.90^{b}
R_3	28.40^{a}	27.50^{bc}	27.95^{a}
R_4	26.10^{ef}	25.50^{fg}	25.80^{c}
R_5	26.70^{de}	25.60^{fg}	26.15^{c}
R_6	27.90^{ab}	27.30^{bcd}	27.60^{a}
Mean	26.95^{a}	26.21^{b}	
	S.E (m)±	**C.D. at 5%**	
P	0.08	0.25	
R	0.15	0.46	
P*R	0.22	NS	

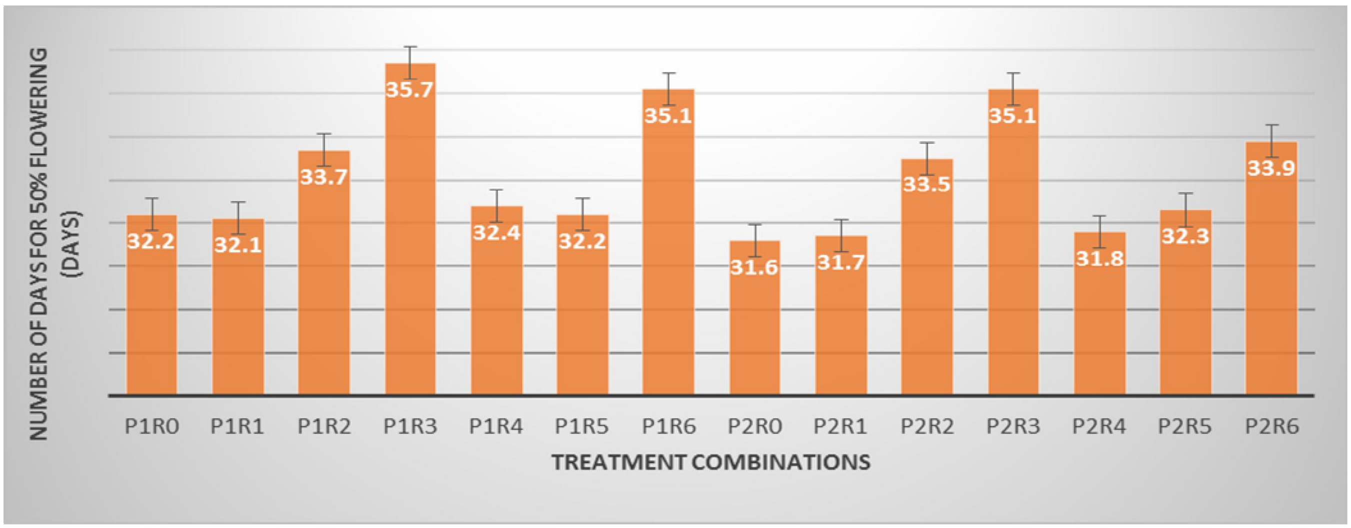

Fig. 1 : Effect of plant density and growth regulators on number of days to 50% flowering in zinnia.

Table 2 : Effect of plant density and growth regulators on number of days to full bloom in zinnia.

Growth regulators	Plant density		
	P_1	P_2	Mean
R_0	36.95^{ef}	36.30^{h}	36.63^{d}
R_1	36.80^{fg}	36.40^{gh}	36.60^{d}
R_2	38.50^{c}	37.90^{d}	38.20^{c}
R_3	40.40^{a}	39.60^{b}	40.00^{a}
R_4	37.30^{e}	36.20^{h}	36.75^{d}
R_5	36.80^{fg}	36.90^{ef}	36.85^{d}
R_6	39.30^{b}	38.30^{cd}	38.80^{b}
Mean	38.01^{a}	37.38^{b}	
	S.E (m)±	**C.D. at 5%**	
P	0.06	0.17	
R	0.10	0.31	
P*R	0.14	0.43	

Table 3 : Effect of plant density and growth regulators on number of flowers per plant in zinnia.

Growth regulators	Plant density		
	P_1	P_2	Mean
R_0	15.30^{i}	15.90^{h}	15.60^{e}
R_1	17.85^{e}	18.35^{bc}	18.10^{b}
R_2	18.45^{bc}	19.65^{a}	19.05^{a}
R_3	16.40^{g}	17.90^{de}	17.15^{d}
R_4	17.10^{f}	18.05^{cde}	17.58^{c}
R_5	18.30^{bcd}	17.00^{f}	17.65^{c}
R_6	18.30^{bcd}	18.55^{b}	18.43^{b}
Mean	17.39^{b}	17.92^{a}	
	S.E (m)±	**C.D. at 5%**	
P	0.05	0.15	
R	0.10	0.29	
P*R	0.13	0.40	

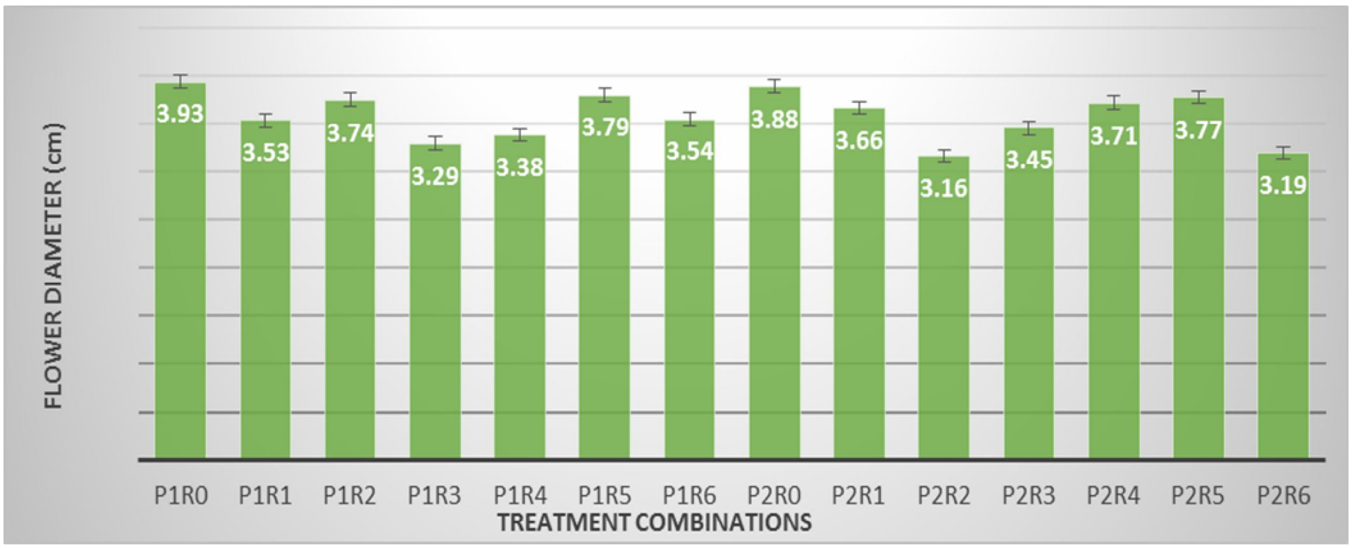

Fig. 2 : Effect of plant density and growth regulators on flower diameter (cm) in zinnia at full bloom stage.

Table 4 : Effect of plant density and growth regulators on fresh weight of flowers per plant (g) in zinnia.

Growth regulators	Plant density		
	P_1	P_2	Mean
R_0	15.95^{f}	15.02^{g}	15.48^{e}
R_1	17.00^{e}	18.14^{d}	17.57^{d}
R_2	21.01^{ab}	21.30^{a}	21.16^{a}
R_3	16.15^{f}	18.05^{d}	17.10^{d}
R_4	17.26^{e}	18.07^{d}	17.67^{d}
R_5	20.37^{b}	18.79^{d}	19.58^{c}
R_6	19.65^{c}	20.98^{ab}	20.32^{b}
Mean	18.20^{b}	18.63^{a}	
	S.E (m)±	**C.D. at 5%**	
P	0.09	0.27	
R	0.17	0.50	
P*R	0.23	0.70	

Table 5 : Effect of plant density and growth regulators on dry weight of flowers per plant (g) in zinnia.

Growth regulators	Plant density		
	P_1	P_2	Mean
R_0	6.05^{h}	6.19^{h}	6.12^{d}
R_1	6.83^{g}	8.01^{d}	7.42^{c}
R_2	9.62^{abc}	9.96^{a}	9.79^{a}
R_3	6.22^{h}	7.73^{de}	6.98^{c}
R_4	7.35^{efg}	6.99^{fg}	7.17^{c}
R_5	9.35^{bc}	7.49^{def}	8.42^{b}
R_6	9.14^{c}	9.87^{ab}	9.51^{a}
Mean	7.80^{b}	8.04^{a}	
	S.E (m)±	C.D. at 5%	
P	0.07	0.20	
R	0.12	0.36	
P*R	0.17	0.51	

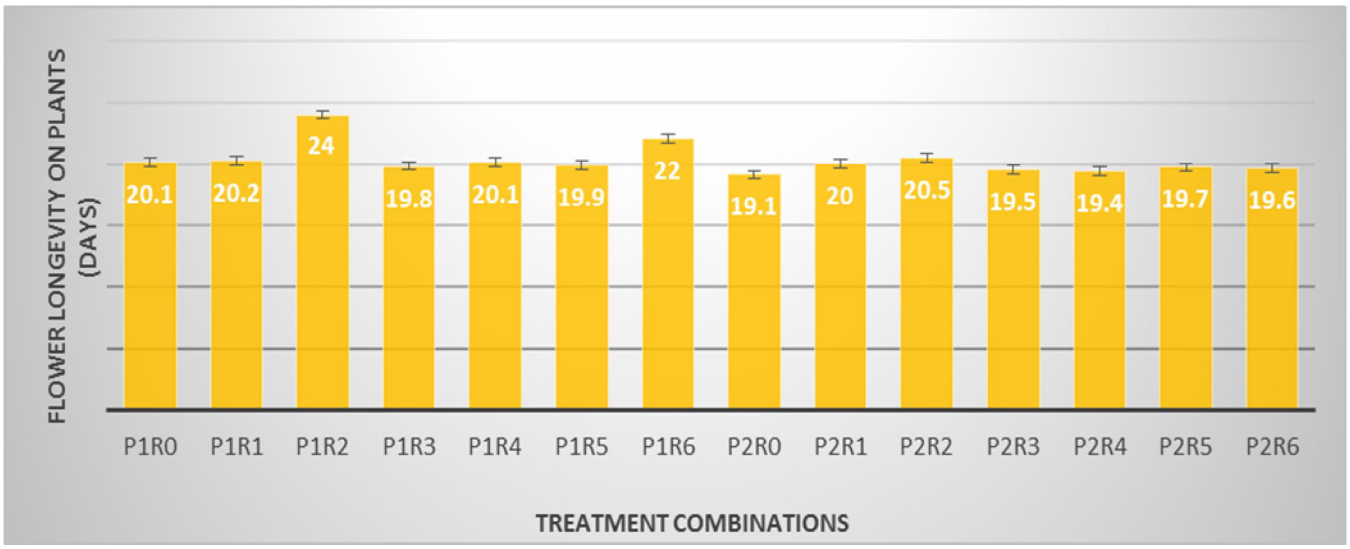

Fig. 3 : Effect of plant density and growth regulators on flower longevity (days) on plant in zinnia.

Conclusion

It can be interpreted from the experimental results that planting Three plants per pot + Cycocel spray @ 2000 ppm (P_1R_3) resulted in the maximum number of days for flowering bud initiation, 50% flowering and full blooming. Whereas, the higher number of flowers per plant, fresh weight of flowers per plant, and dry weight of flowers per plant were achieved with the treatment combination of Four plants per pot + Cycocel spray @ 1500 ppm (P_2R_2). Thus, the treatment combination had greater flower yield and quality followed by Four plants per pot + Paclobutrazol spray @ 120 ppm (P_2R_6).

Acknowledgements

The author is grateful to the Department of Floriculture and Landscaping, College of Horticulture, Mojerla, SKLTSHU for providing necessary facilities for conducting this study for her Master's programme.

References

Cowling, W. (2010). The challenge of breeding canola hybrids-new opportunities for WA growers. Western Australian Proprietary Limited. *Agribusiness Crop*.

El-Shanhorey, N. A and Adam, A. I. (2022). *Middle East Journal of Agriculture Research*, **11**(4), 1112-1121.

Joiner, J.N. and Harrison, D. D. (1967). Control of growth and flowering of Paul Mikkelsen poinsettias by growth retardants. In *Florida state Horticultural Society*, 416-420.

Karimi, M. (2020). Effect of cycocel and uniconazole on some morphological and biochemical properties of Zinnia. *International Journal of Horticultural Science and Technology*, **7**(1), 81-91.

Karunananda, D.P. and Peiris, S.E. (2010). Effects of pinching, Cycocel and B-nine treatments on branching habit of Pot Poinsettia (*Euphorbia pulcherrima* willd). *Tropical Agricultural Research*, **21**(3), 284 – 292.

Khan, M.I., Muzanil, S. Hasan, M.A. and Mathew, B. (2012). Effect of different levels of cycocel and malic hydrazide on growth and flowering of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. *Asian Journal of Horticulture*, **7**(2), 294- 296.

Kumar, S., Haripriya, K., Kumar, S and Kamalakannan, S. (2019). Effect of cycocel on growth, flowering and yield of nerium (*Nerium odorum* L.). *Journal of Pharmacognosy and Phytochemistry*, **8**(3), 2226-2228.

Lever, B.G. (1982). PP-333-a new broad spectrum growth retardant. *British Crop Protection Conference-Weeds*. Croydon, British Crop Protection Council. 1: 3-10

Megersa, H.G., Lemma, D.T. and Banjawu, D.T. (2018). Effects of plant growth retardants and pot sizes on the height of potting ornamental plants: A Short Review. *Journal of Horticulture*, **5**(220): 1-5.

Menhenett, R and Hanks, G. R. 1982. Comparisons of a new triazole retardant PP 333 with ancymidol and other compounds on pot-grown tulips. *Plant Growth Regulation*, **1**(3): 173-181.

Mirzaei, M., Zehtab-Salmasi, S., Nassab, A. D. M and Shaker-Kouhi, S. (2016). Effects of sowing date and plant density on marigold (*Calendula officinalis*) morphology and flower yield. *Journal of Medicinal Plants*, **4**(3): 229-232.

Mohd, A., Gauri, S., Muthoo, A. K., Ahmad, M and Shanker, G. (1988). Effect of paclobutrazol on growth and flowering of Cosmos (*Cosmos bipinnatus*). *Punjab Horticultural Journal*, **28**: 105-108.

Osman, A.R. (2014). Improving some quantitative and qualitative characteristics of *Solidago canadensis*" Tara" using cycocel and planting density under drip irrigation and lighting systems. *Life Science Journal*, **11**(6): 110-118.

Rezazadeh, A and Harkess, R.L. (2015). Effects of pinching, number of cuttings per pot and plant growth regulators on height control of purple firespike. *Horticultural Technology*, **25**(1): 71-75.

Shirsat, B.P., Malshe, K. V., Salvi, B. R., Mahadik, S. G and Pawar, C. D. (2021). Effect of plant growth regulators and pinching on flowering characters in gaillardia (*Gaillardia pulchella*). *The Pharma Innovation Journal*, **10**(11): 482-485.

Taiz, L and Zeiger, E. (2006). *Fisiologia vegetal*, Universitat Jaume I, **10**, 1265.