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Optimization of nitrogen application and planting geometry for production of cut chrysanthemums (*Chrysanthemum morifolium* Ramat.)

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ABSTRACT

Nutrition and planting geometry are the two key factors affecting the production and quality of cut stems in chrysanthemum. The present investigation was undertaken to standardize the nitrogen nutrition and planting geometry for chrysanthemum var. "Yellow Star" cultivated for cut flowers. The data revealed the proportionate increase in plant height, chlorophyll content, days to bud appearance and days to 50% inflorescence anthesis and length of cut stem with increase in nitrogen dose and row spacing. However, flower diameter, number of flowers per stem, cut stem diameter, vase life, and water absorbed by cut flower decreased proportionately with increase in nitrogen dose and row spacing. Application of N@100 Kg ha^{-1} to chrysanthemum planted at 20x10 cm spacing produced cut stems of acceptable length, more number of flowers of bigger size and optimum postharvest longevity. The amount of nitrogen can be reduced to 1/3rd to grow cut chrysanthemums planted at twice the row spacing for longer cut stems of appreciable vase life.

Keywords: Chrysanthemum, fertilization, nitrogen, planting geometry, Yellow Star

INTRODUCTION

Chrysanthemum (*Chrysanthemum morifolium* Ramat.), commonly known as 'pot mums' belonging to the family 'Asteraceae' ranks third in world cut flower trade and has retained first position in China and Japan, being its primary centers of origin (Datta and Janakiram 2015). In India, chrysanthemum is cultivated in 28.32 thousand ha with an average annual production of 537.56 thousand MT (loose flowers) and 18.52 lakh (cut stems) (Anonymous 2022). The production of quality cut stems of chrysanthemum depends on several cultural practices, the most influential being the nitrogen (N) nutrition and availability of optimum space for the plants to manifest its vigorous vegetative and reproductive growth stages.

Chrysanthemum, being a heavy feeder requires N application in splits for the first seven weeks of its vegetative growth, that is essential for adequate accumulation of N in branches and leaves for utilization at later stage during reproductive phase (Crater, 1992). The analysis of mature leaf samples revealed 4.6-6.0% N, which is considerably less then accounted during the active growth period (Muniz *et al.,* 2009; Stern *et al.,* 2008). Most of the ornamental plants utilize either or both N-$NH_4^+$and N-NO_3^- depending upon their stage of growth and development (Bernstein *et al.,* 2005). The quality of chrysanthemum cut stems can be influenced by the N-NH_4^+/N-NO_3^-ratio that affect postharvest behaviour of cut stems (Ramos *et al.,* 2013). The availability of optimum space for proper growth and development of chrysanthemum is a key factor determining the quality and productivity of cut stems. An ideal planting geometry influence several factors such as the density of plants per unit area, light interception within the plant canopy, resource utilization, ease in performing various cultural operations, optimum ground to canopy ratio, suppression of weed growth and most important being the productivity of the crop.Optimum utilization of resources is the need of the hour to safeguard and effectively utilize the available resources for successful production of high value and low volume floriculture crops, in particular chrysanthemum.

However, information regarding N-nutrition and planting geometry in cultivation of cut chrysanthemum needs to be determined under the subtropical climatic conditions of India. The study is deemed as significant for the small and marginal flower growers, to yield maximum productivity of quality cut stems from limited land-holdings. Therefore, the present need-based investigation was undertaken to standardize the N nutrition and optimum planting geometry for cultivation of chrysanthemum var. “Yellow Star” for cut stems under subtropical conditions of North India.

MATERIALS AND METHODS

The experimental was conducted at the Research Farm (33°55' N latitude; 75°54' E latitude; 247m above msl receiving 700 mm annual rainfall), Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, during the year 2018. The relative humidity ranged between 63.0-76.0%. The mean minimum evaporation during the period of crop growth was recorded during November (2.1 mm) and maximum during July (129.9 mm). The soil texture was classified as sandy loam with pH 7.75, 7.79 and 7.82 recorded from 15 cm, 30 cm and 45 cm soil depth respectively.

The chrysanthemum variety “Yellow Star” was selected for the study as it is popular and commercially cultivated by flower growers for yielding cut flowers and for exhibition purpose. The flowers are yellow, with compact decorative type of inflorescence. Healthy disease free rooted cuttings of uniform height (3 inches) and age (25 days old) with well developed root system were planted during first week of August.

The treatments for planting geometry were designed at 3 spacing levels: S_1 (10×10 cm), S_2 (15×10 cm) and S_3 (20×10 cm) accommodating 100, 66 and 50 plants per square meter area respectively The treatments for N-doses comprised 4 differential applications: N_1 control (0 kg N ha^{-1}), N_2 reduced fertilizer (100 Kg ha^{-1}), N_3 conventional fertilizer (200 Kg ha^{-1}), N_4 excessive fertilizer (300 Kg ha^{-1}). The experiment comprised of 12 treatments executed in factorial randomized block design (FRBD), replicated thrice. The straight fertilizers *viz.* Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) were taken as the sources of N, P_2O_5 and K_2O, respectively. Entire dose of P and K were applied each @ 200 Kg ha^{-1} as basal dose and graded levels of N were applied in two splits doses. Two splits doses one 30 days after transplanting and other 45 days after transplanting.

Various growth characteristics such as plant height (measured at 30, 60 and 90 days after transplanting), leaf area and total chlorophyll content were recorded. Total chlorophyll content of leaves was determined using method purposed by Witham *et al.* (1971):

$$\text{Total chlorophyll (mg/g)} = \frac{20.2\,(A_{645}) + 8.02\,(A_{663})\ \text{Final volume of DMSO}}{1000 \times \text{weight of tissue}}$$

The floral characters such as days to flower bud appearance, days to 50 % flowering, flower diameter, number of flowers per stem, cut stem diameter and length of the cut stem were recorded and the average values were computed for data analysis. Data was subjected to statistical analysis by SPSS v. 22 (IBM) software.

RESULTS AND DISCUSSION

Plant height, leaf area and total chlorophyll content

The mean plant height recorded at 30, 60 and 90 DAP with respect to differential application of N-levels showed progressive increase with subsequent application of N, compared to control (Table 1). The mean plant height was recorded least in control, however, the percent increment in plant height with increasing N-levels was more pronounced in plants during first 30 DAP. The highest percent increment (40.6%) of plant growth during first 30 DAP can be attributed due to ample availability of space and sunlight for the plants to grow that were supplemented with higher doses of N-levels. Nitrogen is considered as an important factor for building plant biomass through photosynthesis and subsequent translocation of carbohydrates for vegetative growth (Evans and Clarke, 2019).The subsequent percent increase in plant height decreased relatively (29.1% and 22.4%) at 60 and 90 DAP respectively. The availability of space and competition for air and sunlight tend to become a limiting factor, resulting in decrease in plant growth during later period (Woodson and Boodley 1983). The N requirement of Chrysanthemum is highest during first 7 weeks after transplanting (Fernandes *et al.,* 2012), and N uptake thereafter tend to decrease (Yoon *et al.,* 2000). The further N requirement is pooled mostly from the accumulated nitrate in stems and the petioles (MacDonald *et al.,* 2013). Conversely, the mean plant height decreased progressively in the plants planted at narrower to wider spacing. However, the percent decrease in plant height was more pronounced at 30 DAP as compared to observations recorded at later monthly quarters. The plants planted at narrow spacing tend to compete for sunlight, as a consequence began to outgrowin length and appear taller compared to the plants planted at relatively wider spacing (Lavhaji, 2007).

The total chlorophyll content measured from the mature leaf tissue showed a significant 29.5% increment at the highest N-level (N4) compared to control. Similarly plants grown at wider spacing recorded 13.0% increase in chlorophyll content compared to plants grown at narrow spacing. Nitrogen, is an essential element for synthesis of amino acids and proteins, besides structurally important component of chlorophyll, and is considered essential for transportation of metabolites for synthesis of chlorophyll (Tucker, 2004).

The leaf area per plant was significantly influenced by the application of different N-levels and varying plant spacing (Table 2). The maximum leaf area/plant (1435.37 cm^2) was recorded in plants supplemented with N2 fertilizer treatment, and the minimum (992.67 cm^2) leaf area was measured in control. Further, planting distance also exhibited a significant effect on leaf area per plant. The plants planted at S3 spacing showed mean maximum leaf area (1266.80 cm^2) while the minimum leaf area (1172.69cm^2) was observed in plants planted at S1 spacing, irrespective of the N-levels. However, the interaction between N-level and spacing revealed non-significant differences for leaf area.

Flowering characteristics

Chrysanthemum plants delayed by 2.3 days to bud appearance with subsequent increase in N-levels (Table 3). However, the mean days taken to bud emergence at highest N-level was found insignificant compared to control plants. Plants planted at twice the row spacing showed 3.0 % delay in days to bud appearance compared to plants that were planted at narrower spacing. With the onset of short days, the accumulated leaf N is remobilized to developing buds to show color (Macz *et al.,* 2007). It has been proposed that N is not a decisive factor in initiation and development of floral primordia, but may alter (delay) the timing of its emergence (Withrow, 1945). Nitrogen affect the reproductive development of photosensitive short day plants (SDPs) that initiate buds with the onset of SDs, however, the split applications of N may slightly prolong the vegetative phase with the continuous synthesis and availability of accumulated photosynthates in the plant tissues which is utilized for flower bud growth and ultimately initiation of flowering.

With subsequent increase in application of N-levels, the mean number of days taken to 50% flowering were found delayed by one week at highest N-level, but was found insignificant compared to control (Table 3). However, plants planted at narrower spacing showed earliness in days to 50% flowering compared to plants at wider spacing. The application of higher N-level during early period of onset of SDs and cool nights delayed flower bud initiation, and subsequent stages of inflorescence anthesis indicating the potential affect of exogenous N in timing of transition of vegetative to reproductive phase rather than inhibiting the onset of flowering. The plants planted at wider spacing also exhibited delayed flowering due to less competition for space, sunlight, water and nutrients in soil, that aid in prolonging the vegetative phase and delayed flowering (Nagaraja, 2013).

The flower diameter showed 19.1% decrement at highest N-level, however, differed significantly with the mean diameter of flower that was recorded least in plants under control treatment. Chrysanthemum plants planted at twice the row spacing showed 9.23% increment in diameter of the flower compared to the plants that were planted at narrower spacing. The results present a contradictory observation to the synergistic effect of increasing N-level on flower diameter. The plants devoid of N dose (control) measured least flower diameter which was in accordance with the findings of Nell *et al.* (1989) and Adams *et al.* (1970) who reported reduction in flower diameter in chrysanthemum with lower N-levels.

The average number of flowers per stem recorded a significant decrease (44.7%) in the plants subjected to highest N-level. The control plots showed least number of flowers per stem which were found at par at highest N-level. However, the plants planted at wider spacing showed a significant 30.0% increment in number of flowers per stem compared to the plants planted at narrower spacing. The higher N doses likely induce succulence in plants with weak stems, causing reduction in flower number. The results are in accordance with observations made by Vijayakumar *et al.* (1988), recording greater number of China aster flowers at lower (300 kg N ha^{-1}) N doses.

The diameter of cut stem recorded 22.3% decrement at higher N level, that differed significantly compared to control measured with least diameter of the cut stem (Table 4). Plants raised at wider spacing showed 11.57% increase in cut stem diameter, however, the increment was found non-significant compared to the plants grown at narrower spacing. The N application increased the diameter of cut stems that tend to become heavily lignified resulting in higher girth of stems (Withrow, 1945).

Post-harvest characteristics

The mean length of cut stem was measured least in plants under control (no N application). The stem length showed 7.58% increment in plants at highest N-level and was found statistically significant compared to stem lengths recorded in plants under control treatment. However, the mean length of stems showed a significant reduction (6.99%) in the plants that were grown at wider spacing. The higher N-levels resulted in more cell elongation and differentiation of the vascular tissues that caused increase in length of cut stems.

The cut stems harvested from plots applied with N2-fertilizer dose reported mean 45.6% increase in vase life compared to the control pot recording mean minimum vase life (14.8 days) (Fig1). However, the cut stems taken from plants grown at different spacing revealed improvement (15.5%) in mean vase life (Fig 2). The higher N increased the conductance that is a determining factor in enhancing the longevity of the cut stems (Roude *et al.,* 1991). Higher conductance resulted in damaging of the root system thereby limiting the water uptake. Adequate availability of N during growth period maintains the level of carbohydrates that determines the post harvest longevity of cut stems (Drüge, 2000). However, excess N is detrimental for the post harvest longevity of cut stems due to accumulation of excess salts and production of endogenous ethylene (Roberts *et al.,* 1984) that reduced the vase life of cut stems.

Total water absorbed by cut stem showed 34.6% decrement with subsequent additions of N. The cut stems harvested from plants devoid of N showed least uptake of water, that was less (18.2%) than the water absorbed by the cut stems at highest N nutrition. The interaction effect of N and plant spacing enhanced the water absorption, the highest water absorption was recorded in cut stems harvested from chrysanthemum plants raised at wider spacing. The water absorbed by the cut stems is proportionate to their longevity. However, as stated above, the water uptake by cut stems decreased due to build up of excess salts with subsequent higher applications of N, supported from the findings of Nell *et al.* (1989); proposed to terminate N fertilization in chrysanthemum 3 weeks prior to flowering to reduce the conductance and increase the longevity of cut stems.

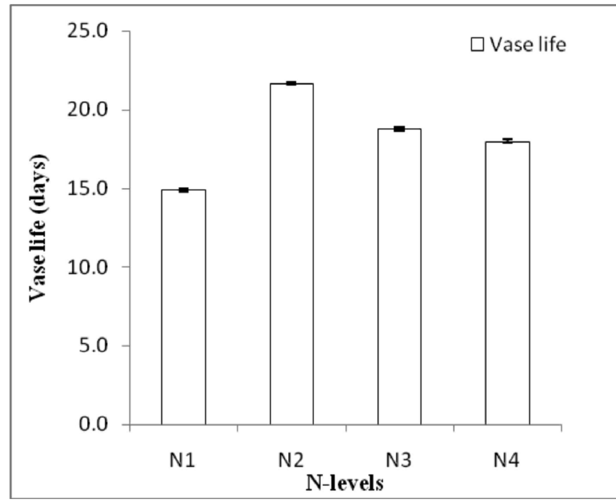

Fig. 1 : Response of N nutrition on vase life of cut stems
*error bars represent standard error (SE±0.071)

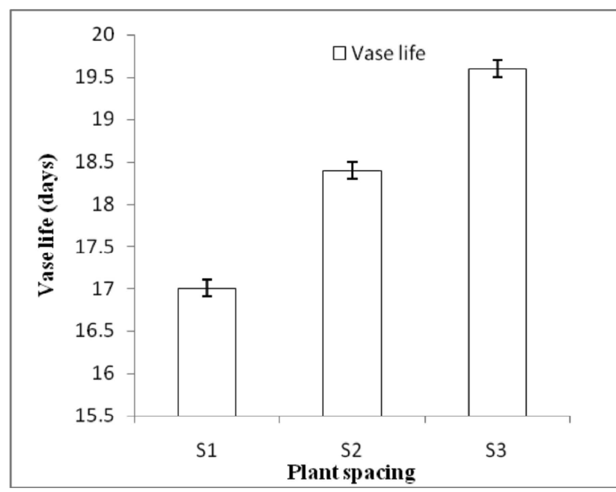

Fig. 2 : Response of plant spacing on vase life of cut stems
*error bars represent standard error (SE±0.1)

Table 1 : Response of varying N-levels and plant spacing on vegetative characters of chrysanthemum

N- level	Plant height (cm) 30 DAT				Plant height (cm) 60 DAT				Plant height (cm) 90 DAT			
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
N1	13.1	11.7	10.8	11.8 a	48.8	46.9	44.4	46.7	72.0	66.6	63.3	67.3 a
N2	15.1	13.6	12.1	13.6 b	53.0	78.9	49.9	51.6	78.9	76.8	72.5	76.1 b
N3	16.7	14.0	13.5	14.7 c	56.9	54.3	53.5	54.8	81.3	79.6	76.2	79.0 c
N4	18.2	16.4	15.2	16.6 d	62.1	60.3	58.6	60.3	84.9	82.7	79.5	82.4 d
Mean	15.7 a	13.9 b	12.9 c		55.2	60.1	51.6		79.2 a	76.4 b	72.8 c	
Significance of fixed factors												
N	*				NS				*			
S	*				NS				*			
N x S	NS				NS				NS			

Each value represent a mean of n = 3 replicates.; ns: not significant; Different letters within a column indicate significant differences between values at *: $p < 0.05$

Table 2 : Response of varying N-levels and plant spacing on chlorophyll content and leaf area of chrysanthemum

N- level	Chlorophyll content (mg/g)				Leaf area (cm^2)			
	S1	S2	S3	Mean	S1	S2	S3	Mean
N1	0.80	0.91	1.03	0.91 a	948.13	986.33	1043.56	992.67 a
N2	1.31	1.42	1.55	1.4 b	1117.41	1170.00	1214.18	1167.19 b
N3	1.51	1.62	1.71	1.6 c	1242.76	1293.57	1343.07	1293.13 c
N4	1.66	1.77	1.84	1.7 d	1382.45	1424.33	1466.37	1424.38 d
Mean	1.32 a	1.43 b	1.53 c		1172.69 a	1218.56 b	1266.80 c	
Significance of fixed factors								
Nitrogen (N)	*				*			
Spacing (S)	*				*			
N x S	NS				NS			

Each value represent a mean of n = 3 replicates.; ns: not significant; Different letters within a column indicate significant differences between values at *: $p < 0.05$

Table 3 : Response of varying N-levels and plant spacing on flowering characters of chrysanthemum

N- level	Days to flower bud appearance				Days to 50 % flowering				Flower diameter (cm)				Number of flowers/stem			
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
N1	93.0	95.3	97.0	95.1 a	110.3	111.6	112.0	111.3 a	8.1	8.7	9.0	8.6 a	4.6	5.2	6.2	5.3 a
N2	87.6	89.3	90.3	89.1 b	100.0	102.3	103.6	102.0 b	11.6	12.6	13.2	12.5 b	10.2	11.9	13.0	11.0 b
N3	88.6	90.6	91.3	90.2 c	104.6	106.6	108.3	106.5 c	11.3	11.9	12.2	11.8 c	8.3	10.5	11.4	10.1 c
N4	91.0	93.0	94.6	92.8 d	107.3	108.0	108.6	108.0 d	10.5	10.9	11.1	10.8 d	7.6	8.3	9.4	8.4 d
Mean	90.0 a	92.0 b	93.3 c	-	105.5 a	107.1 b	108.1 b		10.3 a	11.0 b	11.3 b		7.6 a	8.9 b	10.0 c	
Significance of fixed factors																
Nitrogen (N)	*				*				*				*			
Spacing (S)	*				*				*				*			
N x S	NS				NS				NS				NS			

Each value represent a mean of n = 3 replicates; ns: not significant; Different letters within a column indicate significant differences between values at *: $p < 0.05$

Table 4 : Response of varying N-levels and plant spacing on post-harvest characters of cut stems

N- level	Cut stem diameter (mm)				Length of cut stem (cm)				Total water absorbed by cut stem (ml)				Weight of cut stem (g)			
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
N1	3.1	3.4	3.7	3.4 a	66.0	60.7	56.9	61.2 a	61.6	69.0	73.9	68.1 a	48.2	54.7	59.6	54.2 a
N2	7.2	7.4	7.8	7.5 b	74.0	71.0	70.0	71.7 b	110.3	124.5	135.4	123.4 b	80.7	87.2	92.6	86.8 b
N3	6.1	6.4	6.7	6.4 c	75.2	73.9	71.5	73.5 b	86.4	91.1	98.3	91.9 c	72.4	76.6	80.1	76.4 c
N4	5.6	6.0	6.2	5.9 d	78.7	76.9	73.4	76.3 c	83.7	87.0	93.3	88.0 d	66.2	70.8	75.2	70.8 d
Mean	5.5 a	5.8 b	6.1 c		73.4 a	70.6 a	67.9 b		85.5 a	92.9 ab	100.2 b		66.9 a	72.3 b	76.9 c	
Significance of fixed factors																
Nitrogen (N)	*				*				*				*			
Spacing (S)	*				*				*				*			
N x S	NS				NS				NS				NS			

Each value represent a mean of n = 3 replicates.; ns: not significant; Different letters within a column indicate significant differences between values at *: $p < 0.05$

CONCLUSION

It can be concluded that application of N@100 Kg ha^{-1} to chrysanthemum plants planted at 20x10 cm spacing accommodating 50 plants per square meter yielded best quality cut stems of acceptable length and optimum post-harvest longevity. Thus, compared to the conventional practice of N application (300 Kg ha^{-1}) adopted by farmers, the amount of N can be reduced to $1/3^{rd}$ to grow cut stems of chrysanthemums planted at twice the row spacing for optimum growth and flowering. The application of lower dose of N will likely reduce the production cost and lessen the environmental impact of leaching of N without compromising on quality and yield of chrysanthemum for commercial cultivation.

REFERENCES

Anonymous, 2017. Advanced estimation of area and production of chrysanthemum in India.https://www.apeda.in/agriexchange/india%20 production/India Productions. aspx? hscode =102 accessed on 2 May 2020.

Adams, P., Graves, C.J. and Winsor, G.W., 1970.Nutrition of year-round chrysanthemums in peat and sand. Annual Report of Glasshouse Crops Res. Inst., 1969, pp.90-93.

Bernstein, N., Ioffe, M., Bruner, M.,Nishri, Y., Luria, G.,Dori, I.,Matan, E., Philosoph-Hadas, S., Umiel, N. and Hagiladi.A., 2005. Effects of supplied N form and quality of *Ranunculus asiaticus* flowers. *Hort. Sci.,* **40**: 1879-86.

Crater, D.A., 1992.Potted Chrysanthemums.In *Introduction to Floriculture*; 2nd. Edition.; Larson, R.A. (Ed.).; Academic Press: New York, pp.249-287.

Datta, S. K. and Janakiram, T., 2015. Breeding and genetic diversity in *chrysanthemum morifolium* in India: A review. *Indian J. Agric. Sci.,* **85**(11): 1379-1395.

Drüge, U. 2000. Influence of pre-harvest N supply on post-harvest behaviour of ornamentals: importance of carbohydrate status, photosynthesis and plant hormones. *Gartenbauwissenschaft,* **65**(2): 53-4.

Eastwood, T. 1952. Forcing créole lilies at different levels of soil nitrate. *Pr. Am. Soc. Hortic. Sci.,* **59**: 531-41.

Evans, J.R., Clarke, V.C., 2019. The nitrogen cost of photosynthesis, *J. Exp. Bot.*, **70**(1): 7-15,

Fernandes, E. P., Rezende, C. F. A., Leandro, W. M., Frazao, J. J. and Barbosa, J. M. 2012. The accumulation of N, phosphorus and potassium in cut chrysanthemum (*Dendranthema grandiflorum*) cv. Jospithoven. Semin. *Ciênc. Agrár.,* **33**: 2939.

Lavhaji, K. G. 2007 Effect of N application and spacing on growth and yield of seasonal chrysanthemum (*Chrysanthemum coronarium*). MSc. thesis. Mahatma Phule Krishi Vidyapeeth, Ahmednagar, India.

MacDonald, W. N., Blom, T. J.,Tsujita, M. J. and Shelp, B.J., 2013. Review: Improving N use efficiency of potted chrysanthemum: Strategies and benefits. *Can. J. Plant Sci.,* **93**(6): 1009-16

Macz, O., Paparozzi, E.T. and Stroup, W.W. 2007.The Effect of N and sulfur application on pot chrysanthemum production and post-harvest performance. I. Leaf N and sulfur concentrations. *J. Plant Nutr.,* **(24):** 111-29.

Muniz, M.A., Barbosa, J.G.,Grossi, J.A.S.,Orbes, M.Y. and Sa, P.G., 2009. Production and quality of pot chrysanthemum ferti-irrigated with different nitrate/ammonium relations.*Bioscience Journal,* **25**: 75-82.

Nagaraja, C. K., 2013. Effect of spacing and nutrition on growth and yield of annual chrysanthemum *Chrysanthemum coronarium L.* M.Sc. thesis, University of Horticultural Sciences, Bagalkot, India.

Nell, T.A., Barrett, J. E. and Leonard, R.T., 1989. Fertilization termination influences postharvest performance of pot chrysanthemum. *Hort. Sci.,* **24 (6):** 996-98.

Roberts, J.A., Tucker, G.A. and Maunders, M.J., 1984. Ethylene and foliar senescence. In: J.A. Roberts and G.A. Tucker (Eds.), Ethylene and Plant Development. Easter School in Agricultural Science, Nottingham, Butterworths, London, pp. 267-273.

Ramos, L., Andreas, B., Herrada, B.M.P., Arenas, T. L. and Becker, S.J., 2013. Effects of N form and application Rates on the growth of petunia and N Content in the substrate. *Commun. Soil Sci. Plant Anal.*, **44**: 473-479, 2013.

Roude, N., Nell, T. A. and Barrett, E. J., 1991. Longevity of potted chrysanthemums at various N and potassium concentrations and NH_4: NO_3 ratios. *Hortic. Sci.,* **26**:163-65.

Sharma, N. and Bala, M., 2020. Effect of different holding solutions on post-harvest keeping quality of chrysanthemum cut stems. *Agric. Res. J.,* **57**(3): 379-384.

Stern, K. R., Bidlack, J. E. and Jansky, S. H., 2008. Introductory Plant Biology., New York, USA: McGraw-Hill Companies.

Tucker, M., 2004.Primary Nutrients and Plant Growth. - In: Essential Plant Nutrients (SCRIBD, Ed.). North Carolina Department of Agriculturae.

Vijayakumar, K. T., Patil, A. A. and Hulmaniet, N.C. 1988.Effect of plant density and N on growth characters and flower yield of China aster (*Callistephus chinensis* Nees) cv. Ostrich Plume Mixed. *South Ind. Hort.,* **36**: 318-320.

Witham, F.H., Blaydes, D.F. and Devlin, R.M., 1971. Experiments in Plant Physiology, Van Nostrand, New York.

Withrow, A.P., 1945. Interrelationship of nitrogen and photo-period on the flowering, growth, and stem anatomy of certain long day and short day plants. *Butler Univ. Bot. Studies*, **7**(1): 5.

Woodson, W. R., & Boodley, J. W. (1983). Accumulation and partitioning of nitrogen and dry matter during the growth of chrysanthemum. *HortScience*, **18**(2): 196-197.

Yoon, H. S., Goto, T. and Kageyama, Y., 2000. Mineral uptake as influenced by growing seasons and developmental stages in spray chrysanthemums grown under a hydroponic system. *J. Japanese Soc. Hortic. Sci.,* **69**: 255-60.

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