Assessment of shelf life of chrysanthemum (*Dendranthema* x *grandiflora* Tzelev.) **var. Marigold flowers as influenced by phenophase based irrigation and nutrition schedule**

Abstract

The present investigation was conducted in the Division of Flower and Medicinal Crops at the ICAR-Indian Institute of Horticultural Research, Bengaluru, to evaluate the influence of phenophase based irrigation and fertigation schedules on shelf life of chrysanthemum (*Dendranthema* x *grandiflora* Tzelev.) var. Marigold. The experiment comprised of three main plots (irrigation regimes) and five sub plots (nutrient regimes) and was laid out in split plot design with three replications. Irrigation regime at 0.8, 1.0 and 1.2 ER at vegetative, bud and flowering phases, respectively along with weekly fertigation of NPK @ 75:112.5:75 kg /ha (75% RDF) in three split doses of 40:20:20 % NPK during vegetative phase, 30:40:40 % NPK during bud phase and 30:40:40% NPK during flowering phase, recorded the maximum shelf life of flowers (12.15 days) whereas, the minimum shelf life (7.60 days) was observed in the irrigation regime at 0.6,0.8 and 1.0 ER at vegetative, bud and flowering phases, respectively along with conventional method soil application of recommended dose of fertilizer (100:150:100 Kg NPK/ha).The shelf life of flowers had significantly high positive association with the physiological parameters of the plant *viz.*, relative water content (0.728)**,** transpiration rate (0.201), single flower weight (0.559) and stomatal conductance rate (0.492). Whereas, the photosynthetic rate (0.214), diameter of the flower head (0.269) and estimated flower yield (0.047) were significantly and positively correlated with shelf life of flowers. However, the days taken for bud appearance (-0.250) was negatively associated with shelf life of flowers.

Key words: Chrysanthemum, phenophase, irrigation, fertigation , shelf life

Introduction

Chrysanthemum belonging to the family Asteraceae is very popular as loose flower, cut flower as well as potted plants. A final product of great quality is desirable in all economic activities, but when dealing with floriculture, this is vital. Nevertheless, this increase in quality must be accompanied by maximizing profits. According to Roude *et al.* (1991) aggregated value in the case of the chrysanthemum is intimately related to the aspect and quality of flowers, fertilization and irrigation can be managed so as to achieve greater productivity, quality and shelf life of the flowers (Nell *et al.*, 1997). The use efficiency of water and nutrients is improved by drip fertigation [17-19]. Fertigation with 80 per cent level of the recommended dosage of fertilizers recorded maximum weight of marketable flowers, compared to control and shelf life of chrysanthemum was significantly influenced by 80 per cent of RDF (120: 150: 100 kg NPK/ha) through fertigation (Reza *et al.*, 2011). In chrysanthemum var. Wilson's white, the maximum flower diameter and dry weight of flower per plant was recorded with 75 % level of irrigation among different water regimes applied i.e. (25%, 50%, 75% and 100%) (Sohier *et al.*, 2008). Most of the above-mentioned studies concentrated on only the effect of irrigation and fertigation irrespective of the phenological stages. The fertigation scheduling should be based on plant, soil-air, plant water relations and growth stage of plant (Sankaranarayanan, 2007). Hence, this study aimed to assess the influence of phenophase based irrigation and fertigation and it's the effect on shelf life of chrysanthemum cv. Marigold. In view of above facts, the experiment was conducted with the objective to study the effect of phenophase based irrigation and fertigation on shelf life of chrysanthemum cv. Marigold.

Materials and methods

The experiment was conducted for two seasons during the year 2018-19 and 2019-20 to study the effect phenophase based irrigation and fertigation on shelf life of chrysanthemum cv. Marigold grown under open conditions at Division of Flower and Medicinal Crops, ICAR-IIHR, Bengaluru. The soil at the experiment site was red sandy loam soil with a pH of 7.13 and EC of 0.30 dS m^{-1}. The experiment was laid out in split plot design (SPD) comprising three main plot treatments i.e., irrigation regimes and five sub plot treatments i.e., nutrient regimes with three replications. The treatment consists of main plot treatments at three phenophases i.e. I_1 – (0.8, 1.0 and 1.2 ER at vegetative, bud and flowering phases, respectively), I_2 - (0.6, 0.8 and 1.0 ER at vegetative, bud and flowering phases, respectively) and I_3-(0.8 ER each at vegetative, bud and flowering phases) and five sub plot treatments (F_1: 33.3:33.3:33.3 % NPK (vegetative phase), 33.3:33.3:33.3 % NPK (bud phase) 33.3:33.3:33.3 % NPK (flowering phase) @ 100:150:100 Kg NPK/ha (RDF), F_2: 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase) 30:40:40% NPK (flowering phase) @ 100:150:100 Kg NPK/ha (RDF), F_3: 33.3:33.3:33.3 % NPK (vegetative phase), 33.3:33.3:33.3 % NPK (bud phase) 33.3:33.3:33.3 % NPK (flowering phase @ 75:112.5:75 Kg NPK/ha (75% RDF), F_4: 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase) 30:40:40% NPK (flowering phase) @ 75:112.5:75 Kg NPK/ha (75% RDF),F_5: soil application of recommended dose of fertilizer (100:150:100 Kg NPK/ha) and F_1-F_4: 25% of fertilizer dose i.e. 100:150:100 and 75:112.5:75 kg NPK/ha was applied as basal dose along with farmyard manure at 20 t/ha along with basal doses were applied before transplanting according to the treatments. Thirty days old healthy and uniform rooted cuttings of chrysanthemum var. Marigold were transplanted in the main field at a spacing of 60×45 cm. The remaining dose of fertilizers was applied based on treatments through fertigation at weekly intervals with respect to phenophases of the crop from twenty-one days after transplanting up to

160 days. Drip irrigation was scheduled daily from transplanting till final harvest, as per the irrigation treatments based on the previous day open pan evaporimeter observations.

For studies on shelf life of flowers, fully opened flowers were harvested from each of the treatment combinations when all ray florets had expanded, precooled and kept in 150-gauge polyethylene package under room condition (Temperature 24-28^{o}C & RH 65-70%). Ten flowers per replication and in treatment were used to record the shelf life and it was expressed in days. Observations on the vegetative, floral and physiological parameters were recorded and correlated with the shelf life of the flowers to determine the level of influence of each of these parameters on the post- harvest keeping quality of the flowers. The statistical analysis in split-plot design as per the standard statistical procedures, SAS (SAS V 9.3, 2012) was done. The results have been presented and discussed at the probability level of five percent.

Results and Discussion

The data pertaining to the shelf life of chrysanthemum cv. Marigold have been analysed and presented below.

Influence of irrigation regimes

Irrigation regimes significantly influenced the shelf life of chrysanthemum var. Marigold.

The irrigation regime I_1 – (0.8, 1.0 and 1.2 ER at vegetative, bud and flowering phases, respectively) recorded the maximum shelf life of flowers (9.60 days) followed by I_3-(0.8 ER each at vegetative, bud and flowering phases) (9.50 days) and the minimum (9.14 days) was recorded in I_2 - (0.6, 0.8 and 1.0 ER at vegetative, bud and flowering phases, respectively) during the first year. During the second year, the maximum shelf life of flowers (9.92 days) was recorded in I_3followed by I_1(9.59 days) and the minimum was recorded in I_2 (9.46days). The maximum shelf life of flowers (9.72 days) was recorded in I_3followed by I_1 (9.61 days) and the minimum was recorded in I_2 (9.30 days) of pooled analysis of irrigation treatments (Table 1). The increase in shelf life might be due to constant evaporation replenishment at optimum levels during all the growth phases resulting in higher water availability to the plant. Availability of water in adequate amount leads to growth and development of plant, continued cell division and enlargement, progressive initiation of tissue and primordia. Daily irrigation through drip might create favourable soil water environment condition for crop growth and resulted in higher yield and improved quality. Yield and quality were enhanced as a result of keeping the soil water content at required level as was also reported by Vijayselvaraj (2007) in J. *grandiflorum*, Tsirogiannis *et al.*, (2010) in gerbera, Aydinsakir *et al.*, (2011) in carnation and Babu *et al.* (2018) in marigold. Superior quality of citrus was recorded in the irrigation regime with 80 % evaporation replenishment at different crop phenophases according to Shirgure *et al*. (2014) which is also in line with the present findings.

Influence of nutrient doses

Among the fertigation treatments, weekly fertigation of 75% of recommended dose of fertilizers i.e. 75:112.5:75 kg NPK/ha @ 40:20:20 % NPK during vegetative phase, 30:40:40 % NPK during bud phase and 30:40:40% NPK during flowering phase recorded maximum shelf life of flowers (11.83 and 12.03 days respectively, during the first and second year) and the minimum shelf life (7.73, 7.51 days respectively, during the first and second year) was recorded in F_5 – soil application of recommended dose of fertilizer (100:150:100 kg NPK/ha). In pooled analysis the maximum shelf life of flowers (11.95 days) was recorded in the treatment F_4 followed by F_3 (10.05 days) and minimum shelf life of flowers (7.63 days) was recorded in F_5 (Table 1). The increased shelf life might be attributed to the increased vegetative growth of plants supplemented with nitrogen fertilizers which might have enhanced turgidity of flowers by increasing the rate of photosynthesis and other metabolic activities. The vase life of chrysanthemum was increased by the application of 75 % of RDF as fertigation according to Ganesh *et al*. (2014) which might be attributed to continuous supply of nutrients would have helped in maintenance of turgor in the leaf and flower and in turn favoured the higher vase life of chrysanthemum. These results are also in conformation with the findings of Naik (2015) in marigold.

Interaction effect of irrigation and nutrient doses

Among the interaction effects of irrigation and fertigation treatments (Fig.1), the treatment combination I_1F_4 recorded the maximum shelf life of flowers (12.20 days) followed by I_2F_4(11.80 days) whereas, the minimum shelf life of flowers (7.40 days) was recorded in I_1F_5during the first year. During the second year the maximum shelf life (12.10 days) was observed in the treatment I_2F_4 followed by I_1F_4 (12.00 days) and minimum shelf life of flowers was recorded in I_2F_5 (7.00 days). In pooled interaction the maximum shelf life of flowers (12.15 days) was recorded in the treatment I_1F_4 followed by I_2F_4 (11.95 days) and minimum shelf life of flowers was recorded in I_2F_5 (7.60 days). Increase in shelf life was observed at lower levels of fertilizers in combination with higher water regimes at the flowering phase. Translocation of water-soluble nutrients through increased quantity of irrigation water would have improved the quality of flowers which ultimately increased the shelf life of chrysanthemum flowers. This is also in line with the findings of Kabariel (2011) in marigold.

Correlation of physiological, flowering and yield components with shelf life of flowers

The shelf life of flowers recorded a highly significant positive association (0.728) with relative water content, transpiration rate (0.201), single flower weight (0.559) and stomatal conductance rate (0.492); whereas, photosynthetic rate (0.214) and diameter of the flower head (0.269) had positive significant correlation with shelf life of flowers. The days taken for bud appearance (-0.250) however, was negatively associated with shelf life of flowers. With respect to the inter-correlations, the relative water content had significant positive correlation with total dry matter distribution (0.123), single flower weight (0.561) and diameter of the flower head (0.024). The photosynthetic rate registered highly significant positive correlation with total dry matter distribution (0.355) and single flower weight (0.035) The transpiration rate recorded positive significant correlation with days taken for bud appearance (0.594) and it was negatively correlated with stomatal conductance (-0.321),total dry matter distribution (-0.285),diameter of the flower head (-0.203) and days taken for bud appearance (-0.184). Stomatal conductance was significantly and highly positively correlated with diameter of the flower head (0.394) and recorded positively significant correlation with days taken for bud appearance (0.159). The total dry matter distribution was significantly positively correlated with single flower weight (0.073) and diameter of the flower head (0.411) and negatively correlated with days taken for bud appearance (-0.237). The diameter of the flower head had significant positive correlation with days taken for bud showing colour (0.093).

Higher relative water content during the different crop growth phases might have resulted in better turgidity and therefore resulting in lesser weight loss during storage, thereby enhancing the shelf life. Better stomatal conductance and photosynthetic rates, which is related to higher dry matter distribution, flower weight and flower diameter might have also contributed to increased shelf life of flowers. Abbaszadeh *et al.* (2008) also reported that the shelf life of flowers had a positive correlation with the relative water content. The highest positive direct effect towards shelf life of flowers was exerted via plant height followed by harvest index, flower weight, number of flowers per plant and photosynthetic rate as reported by Patel *et al.* (2018). The flowering trait, days taken for flower bud appearance (0.250) had negative association with shelf life of flowers (Misra *et al*., 2013).

Conclusion

In chrysanthemum var. Marigold irrigation regime at 0.8, 1.0 and 1.2 ER at vegetative, bud and flowering phases, respectively along with weekly fertigation of NPK @ 75:112.5:75 kg /ha (75% RDF) in three split doses of 40:20:20 % NPK during vegetative phase, 30:40:40 % NPK during bud phase and 30:40:40% NPK during flowering phase, recorded the maximum shelf life of flowers (12.15 days) whereas, the minimum shelf life (7.60 days) was observed in the irrigation regime at 0.6,0.8 and 1.0 ER at vegetative, bud and flowering phases, respectively along with conventional method soil application of recommended dose of fertilizer (100:150:100 Kg NPK/ha). Relative water content (0.728), transpiration rate (0.201), single flower weight (0.559) and stomatal conductance rate (0.492) recorded a highly significant positive association; whereas, photosynthetic rate (0.214) and diameter of the flower head (0.269) had positive significant correlation with shelf life of flowers.

References

1. Abbaszadeh, B., Ashourabadi, Sharifi, E., Lebaschi, M. H., Hajibagher Kandy, M. N. and Moghadami, F. 2008. The effect of drought stress on proline contents, soluble sugars,

chlorophyll and relative water contents of balm (*Melissa officinalis* L.). *Iranian Journal of Medicine and Aromatic Plants*.**23:** 504-513.

2. Aydinsakir, K., Tuzel, I.H. and Buyuktas, D. (2011). The effects of different irrigation levels on flowering and flower quality of carnation (*Dianthus caryophllus*L.) irrigated by drip irrigation. *African Journal of Biotechnology*. **10** (66): 14826-14835.
3. Babu, R.K., Sumangala, H.P., Rupa, T.R., Sangama and Sujatha, Nair, A. (2018). Effect of fertigation, irrigation and mulching on growth, flowering and yield parameters in African marigold. *International Journal of Current Microbiology and Applied Sciences*, **7**(3): 685-692.
4. Ganesh, S., Kannan, M. and Jawaharlal, M. 2014. Optimization of fertigation schedule for cut chrystanthemum (*Dendranthema grandiflora* Tzvelev). *Horticulture Flora Research Spectrum*, 3(4): 344-348
5. Kabariel, J. 2011. Standardization of integrated nutrient management for growth, yield and quality of African marigold hybrid L-3 grown as intercrop in Grand Naine banana. M.Sc. (Hort.) Thesis, submitted to Tamil Nadu Agricultural University, Coimbatore.
6. Misra, S., Mandal, T., Vanlalruati and Das, S.K. 2013.Correlation and Path Coefficient Analysis for Yield Contributing Parameters in Spray Chrysanthemum. *Journal of Horticulture Letters*, Volume 3, Issue 1, pp.-14-16.
7. Naik, R. M. 2015. Influence of nitrogen and phosphorus on flowering, N and P content of African marigold (*Tagetes erecta*L.) var. Cracker Jack. *Inter. J Farm Sci*; 5(1): 42-50.
8. Nell, T. A, Barrett, J. E, Leonard, R. T. 1997. Production factors affecting postproduction quality of flowering potted plants. *Hort. Science* 32: 817-819.

9. Patel, M.A., Chawla, S.L., Chauhan, D.A., Sudha Patil and Chhatrola, H.N. (2018). Character association and path analysis studies in marigold (*Tagetes spp.)* under the South Gujarat region. *Journal of Pharmacognosy and Phytochemistry*; **7(2):** 3576-3580.

10. Reza, H., Gopinath, G., Rajesh, A.M. and Yathindra, H. A. 2011. Response of chrysanthemum to mulching and fertigation. *Mysore Journal of Agricultural Sciences,* 45(2): 427-429.

11. Roude N, Nell T A, Barret V E. 1991. Nitrogen source and concentration growing medium and cultivar affect longevity of potted chrysanthemums. *Hort Science* 26: 49-52

12. Sankaranarayanan, K., Praharaj, C.S. and Bandyopadhyay, K.K. 2007. Water management practices to improve cotton production. Model Training course on cultivation of long staple cotton (ELS), Dec 15-22. pp: 171-182.

13. Shirgure, P.S., Srivastava, A.K. and Huchche, A. D. (2014).Water requirements in growth stages and effects of deficit irrigation on fruit productivity of drip irrigated Nagpur mandarin (*Citrus reticulata*). *Indian Journal of Agricultural Sciences*.**84**(3): 317-322.

14. Sohier, G. Sayed, Magda, M. Hassanien and Eman, A. Swedan. 2008. Effect of irrigation regimes on chrysanthemum flowering under nitrogen fertilization levels. *Journal of Agriculture & Environmental Science*s, 7(3).

15. Tsirogiannis, I, Katsoulas, N. and Kittas, C. 2010. Effect of Irrigation Scheduling on Gerbera Flower Yield and Quality. Horticulture Sciences. 45 (2): 265-70.

16. Vijayselvaraj, 2007. Standardization of irrigation and fertigation techniques in jasmine (*Jasminum grandiflorum*) var Co. 2. Ph. D (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

17. Clardy AE, Garton S. Effects of Nutrient and Growth Regulator Treatments on the Growth and Development of Marigolds. HortScience. 1996 Aug 1;31(4):679d-.

18. Vijayakumar S, Nair SA, Nair AK, Laxman RH, Kalaivanan D. Influence of phenophase based irrigation and fertigation schedule on vegetative performance of chrysanthemum (Dendranthema grandiflora Tzelev.) var. Marigold. Journal of Horticultural Sciences. 2021 Dec 31;16(2):222-33.

19. Petraglia A, Tomaselli M, Mondoni A, Brancaleoni L, Carbognani M. Effects of nitrogen and phosphorus supply on growth and flowering phenology of the snowbed forb Gnaphalium supinum L. Flora-Morphology, Distribution, Functional Ecology of Plants. 2014 Jun 1;209(5-6):271-8.

Table. 1. Interaction effect of phenophase based irrigation and fertigation scheduling on shelf life (days) of chrysanthemum var. Marigold

Treatm-ents	I year						II year						Pooled Mean					
	F_1	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**Mean**
I_1	10.50	8.40	9.50	12.20	7.40	**9.60**	9.00	8.00	11.10	12.00	7.87	**9.59**	9.75	8.20	10.30	12.15	7.63	**9.61**
I_2	9.60	8.50	7.60	11.80	8.19	**9.14**	9.09	8.98	10.12	12.10	7.00	**9.46**	9.35	8.74	8.86	11.95	7.60	**9.30**
I_3	9.20	8.30	10.90	11.50	7.60	**9.50**	8.79	10.10	11.10	11.98	7.65	**9.92**	9.00	9.20	11.00	11.74	7.65	**9.72**
Mean	**9.77**	**8.40**	**9.33**	**11.83**	**7.73**		**8.96**	**9.03**	**10.77**	**12.03**	**7.51**		**9.37**	**8.71**	**10.05**	**11.95**	**7.63**	
	SE. d			**CD (P=0.05)**			SE. d			**CD (P=0.05)**			SE. d			**CD (P=0.05)**		
I	0.02			**0.03**			0.10			**0.28**			0.05			**0.09**		
F	0.09			**0.18**			0.10			**0.20**			0.12			**0.30**		
I at F	0.16			**0.36**			0.04			**0.07**			0.08			**0.15**		
F at I	0.15			**0.32**			0.03			**0.06**			0.07			**0.14**		

Table. 2. Correlation of physiological flowering and yield components with shelf life (days) of chrysanthemum var. Marigold

Parameters	RWC	PSR	TR	SC	TDD	SFW	DIA	DTBA	DTBSC	SLF
RWC: Relative water content (%)	1									
PSR: Photosynthetic rate (μ mol (CO_2) m^{-2} s^{-1})	-0.407	1								
TR: Transpiration rate (m mol (H_2O) m^{-2} s^{-1})	0.126	0.103	1							
SC: Stomatal conductance (mol (H_2O) m^{-2} s^{-1})	0.462	-0.176	-0.321	1						
TDD: Total dry matter distribution (g)	0.123*	0.355**	-0.285	-0.072	1					
SFW: Single flower weight (g)	0.561*	0.035**	0.326	-0.426	0.073*	1				
DIA: Diameter of the flower head (cm)	0.024*	-0.464	-0.203	0.394**	0.411*	0.036	1			
DTBA: Days taken for flower bud appearance (Days)	-0.180	0.119	0.594*	0.159*	-0.237	0.325	-0.129	1		
DTBSC: Days taken for flower bud showing colour (Days)	0.165	0.145	-0.184	-0.547	0.268	0.083	0.093*	0.605	1	
SLF: Shelf life (Days)	0.728**	0.214*	0.201**	0.492**	0.068*	0.559**	0.269*	-0.250	0.195*	1

****Significant, CD @ 5%; *Significant, CD @ 1%**

Fig. 1. Interaction of irrigation and nutrient regimes on shelf life of chrysanthemum var. Marigold flowers (days)