Effect of cultivars, growth regulators and photoperiods on production of potted chrysanthemum, *Dendranthema grandiflora* Tzvelev

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ABSTRACT

The study was conducted on two cultivars of chrysanthemum namely Ajay and UHFSChr-Collection 1 in pots containing a mixture of sand, soil and well rotten FYM (1:1:2 v/v). Seven growth regulator treatments viz control (distilled water), paclobutrazol (60 and 90 ppm), daminozide (2500 and 3000 ppm) and ethephon (500 and 750 ppm) were used and the experiment was replicated thrice. In general controlled photoperiod applied was found better for flowering over natural photoperiod. Findings revealed that cultivar Ajay was more suitable for growing as pot mum as compared to UHFSChr-Collection 1. However under natural photoperiodic conditions plants after pinching should be sprayed with paclobutrazol (60 or 90 ppm) or daminozide (2500 or 3000 ppm) in case of both the cultivars. Under controlled photoperiodic conditions growth regulator application was not necessary for the production of cultivar Ajay and cultivar UHFSChr-Collection 1 may be sprayed with paclobutazol (60 ppm) for quality pot mum production.

Keywords: Chrysanthemum; photoperiod; growth regulators; cultivars

INTRODUCTION

Popularly known as Guldaudi in India and Glory of the East or Mum in USA,chrysanthemum (*Dendranthema grandiflora* Tzvelev) is one among the top cut flowers and pot plants traded in the world. In addition its flowers are also used for making garlands, Venis, Gazras and religious offerings. It is native to northern hemisphere chiefly Europe and Asia and belongs to the family Asteraceae (Anderson 1987). Mums produce healthy blooms that come in a variety of shapes and colours and last for several weeks. Their dense canopy creates a thick blanket of blooms perfect for planting in gardens, landscape beds or large pots. The demand for potted chrysanthemum has increased in the last few years primarily because of its suitability as potted plant. Increasing urbanization and population are putting pressure continuously on the pot plant industry as space in the cities is shrinking and people are forced to satisfy their gardening desire by growing plants in pots on the terraces of multistorey buildings. Chrysanthemum is classified as a short day plant and cannot normally form flower buds when the day length exceeds 14.5 hours and develop them when it exceeds 13.5 hours. It is traditionally regarded as an autumn flower. However by using simple lighting or black out system day length (night length) can be altered and the flowering time precisely controlled. Photoperiodic control of the growth and flowering of chrysanthemum makes it possible to cultivate this crop all year round. By lengthening a short day through supplementary illumination or shortening a long one through shading/ blackout one can keep the plants in the vegetative or the generative stage and thus delay or bring forward their blooming (Ram 1991, Pathak 2002).

Plant growth retardants reduce both the rate of cell division and cell elongation (Ghosh and Rao 2015). As far as use of growth regulators on chrysanthemum is concerned commonly used chemicals on this crop are phosphon-D, phosphon-S, B-9, ancymidol, cycocel, Amo-1618, maleic hydrazide, paclobutrazol and ethephon etc. These all growth retardants yield variable results with the cultivar and the growing condition.

MATERIAL and METHODS

The investigations were carried out at the experimental farm of the Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh located at an elevation of 1276 m amsl at a latitude of 30^{o}51'0'' North and longitude of 77^{o}11'30'' East during 2014-16. The area falls under the mid-hill zone of Himachal Pradesh. The climate here in general is sub-temperate to sub-tropical characterized by mild summer and relatively cool and dry winter. The annual rainfall ranges between 800-1300 mm. The study was conducted on two commercial spray type cultivars of chrysanthemum namely Ajay and UHFSChr-Collection 1. Firstly the mother block of chrysanthemum cultivars was maintained for quality cutting production. The plants for carrying out the experiment were propagated by shoot tip cuttings of 8-10 cm length taken from healthy and disease-free mother plants. These cuttings were dipped in a solution of mancozeb (0.2%) plus carbendazim (0.1%) for half an hour and a slanting cut was given at the node after removing basal leaves of each cutting. The cut ends were quick-dipped in a solution of NAA (500 ppm) before planting of cuttings for rooting in moist sand filled in the beds of propagation chamber. These were planted in such a manner so that they do not touch each other. Just after planting the beds were irrigated thoroughly. The cuttings were maintained under artificial misting till rooting.

The potting medium was prepared by mixing soil, sand and well rotten farmyard manure in the ratio of 1:1:2 (v/v). Before filling up of the pots about one inch bottom layer of small pebbles was placed in the them to ensure proper drainage. The pots were filled with the prepared medium up to the rim. The rooted cuttings of uniform size were planted (one plant per pot) in plastic pots of six inch size. Pots were irrigated thoroughly immediately after planting. These were irrigated manually throughout the experimentation from planting till termination of the experiment. Intercultural operations like hoeing, weeding, removal of dried, dead and diseased leaves and shoots, spraying against insect pests and diseases etc were also done depending upon the requirement. In addition to the mixing of well rotten farmyard manure in the growing medium plants were fertilized fortnightly with a water soluble fertilizer (2 g/l) having NPK in the ratio of 19:19:19 (a product of KAMIRA, Finland, Marketed in India by Vardhaman Fertilizers, Pune, Maharashtra). The application of this solution was done at the rate of 500 ml per pot which was started after pinching and continued till flowering. The plants were sprayed until runoff with growth regulators (distilled water, paclobutrazol 60 and 90 ppm, daminozide 2500 and 3000 ppm and ethephon 500 and 750 ppm) when the breaks were 8-10 cm long. After one week of spraying growth regulators the plants were transferred to short day conditions. To provide artificial short days inverted 'U' shaped metallic tunnels (3 x 1.5 x 1.5 m) completely covered with 200 micron HDPE (high density poly ethylene) white from outer side and black from inner side were placed over the pots for 16 hours daily (5 pm to 9 am). The artificial and/or natural short days were counted up to the stage till 50-60 per cent flower buds on a plant showed colour. Natural photoperiodic treatment was given by exposing the plants to natural photoperiodic conditions inside the naturally-ventilated polyhouse from planting to flowering. For data analysis factorial CRD with three factors namely cultivars, photoperiods at 2 levels each and growth regulators at 7 levels were adopted and biometric observations on plant growth were analysed.

RESULTS and DISCUSSION

Data pertaining to days to reach the stage when 50-60 per cent flower buds showed colour, plant spread and number of sprays per plant are presented in Table 1. Days taken to reach the stage when 50-60 per cent flower buds showed colour differed significantly due to cultivars. In general lesser days were taken to reach the stage when 50-60 per cent flower buds showed colour in cultivar UHFSChr-Collection 1 (144.54 days) as compared to Ajay (150.84 days). The results are in agreement with those obtained by Pathak (2002) and Usha (2010) while screening different cultivars of chrysanthemum for year-round flower production. Similarly lesser days were taken to reach the stage when 50-60 per cent flower buds showed colour was noticed much earlier under controlled photoperiod (133.43 days) as compared to natural photoperiod (161.96 days). Similar variations due to photoperiod have also been noted by Dhiman et al (2017). Among different growth regulator treatments 50-60 per cent flower buds colour showing stage was earliest (144.99 days) in plants sprayed with paclobutrazol (60 ppm). However both concentrations of ethephon showed significant delay in the days taken to reach the stage when 50-60 per cent flower buds showed colour with maximum delay when plants

Table 1. Effect of growth regulators and photoperiod on days to reach the stage when 50-60 per cent flower buds show colour, plant spread and number of sprays per plant of chrysanthemum cultivars Ajay and UHFSChr-Collection 1

Growth regulator	Growth regulator x cultivar		Mean	Growth regulator x photoperiod	
	Ajay	UHFSChr-Collection 1		Controlled photoperiod	Natural photoperiod
50-60% flower buds show colour					
Control (distilled water)	149.46	142.97	146.21	130.82	161.60
Paclobutrazol (60 ppm)	151.58	138.40	144.99	133.18	156.80
Paclobutrazol (90 ppm)	148.67	142.32	145.50	129.27	161.74
Daminozide (2500 ppm)	150.09	144.27	147.18	132.24	162.12
Daminozide (3000 ppm)	149.77	144.97	147.37	132.47	162.27
Ethephon (500 ppm)	151.70	147.61	149.65	135.43	163.87
Ethephon (750 ppm)	154.63	151.25	152.94	140.58	165.30
Mean	150.84	144.54	-	133.43	161.96
Plant spread (cm)					
Control (distilled water)	21.70	20.05	20.88	20.23	21.52
Paclobutrazol (60 ppm)	21.00	20.77	20.88	18.54	23.23
Paclobutrazol (90 ppm)	20.56	20.92	20.74	18.84	22.64
Daminozide (2500 ppm)	22.65	20.85	21.75	19.60	23.90
Daminozide (3000 ppm)	21.57	21.20	21.39	19.43	23.34
Ethephon (500 ppm)	21.93	21.66	21.80	20.93	22.66
Ethephon (750 ppm)	21.90	21.69	21.80	20.80	22.79
Mean	21.62	21.02	-	19.77	22.87
Number of sprays/plant					
Control (distilled water)	7.20	7.79	7.50	7.20	7.79
Paclobutrazol (60 ppm)	7.04	8.13	7.59	7.04	8.13
Paclobutrazol (90 ppm)	6.21	8.47	7.34	6.21	8.47
Daminozide (2500 ppm)	6.99	7.30	7.15	6.99	7.30
Daminozide (3000 ppm)	7.22	7.40	7.31	7.22	7.40
Ethephon (500 ppm)	7.30	7.44	7.37	7.30	7.44
Ethephon (750 ppm)	7.43	7.02	7.23	7.43	7.02
Mean	7.06	7.65	-	7.06	7.65

Cultivar x photoperiod

Cultivar	50-60% flower buds show colour		Plant spread		Number of sprays/plant	
	Controlled photoperiod	Natural photoperiod	Controlled photoperiod	Natural photoperiod	Controlled photoperiod	Natural Photoperiod
Ajay	135.48	166.21	20.31	22.93	6.95	7.16
UHFSChr-Collection 1	131.38	157.70	19.23	22.81	7.16	8.15

$CD_{0.05}$

	50-60% flower buds show colour	Plant spread	Number of sprays/plant
Cultivar	1.68	0.51	0.36
Photoperiod	1.68	0.51	0.36
Growth regulator	3.14	NS	NS
Growth regulator x cultivar	NS	NS	0.95
Growth regulator x photoperiod	NS	1.34	NS
Cultivar x photoperiod	2.38	NS	0.51

sprayed with ethephon 750 ppm (152.94 days). Interaction between cultivar and photoperiod showed earliest days taken to reach the stage when 50-60 per cent flower buds showed colour in cultivar UHFSChr-Collection 1 (131.38 days) under controlled photoperiod whereas maximum in case of Ajay (166.21 days) under natural photoperiod. The difference between cultivars to photoperiodic conditions may be attributed to their genetic makeup due to which these might have behaved differently under different photoperiodic conditions. Similar behaviors of chrysanthemum cultivars have also been depicted by Ram and Sehgal (1993). The finding also showed delayed flowering due to higher concentration of ethephon 750 ppm under controlled photoperiodic conditions indicating its suitability for flower regulation in these cultivars.

Plant spread was measured at the time of peak flowering. Variations in plant spread due to cultivars, photoperiods and the interaction, growth regulator x photoperiod were found to be significant. However growth regulators and the interactions growth regulator x cultivar, cultivar x photoperiod and cultivar x photoperiod x growth regulator were found to be non-significant. Generally plant spread of 1.5 to 2.5 times to the diameter of the pot is desirable for pot culture. Therefore pot spread at the time of peak flowering in 6 inch diameter pot should be between 22.5 to 37.5 cm. The more plant spread was noticed in cultivar Ajay (21.62 cm) as compared to UHFSChr-Collection 1 (21.02 cm). The plant spread was noticed more under natural photoperiod (22.87 cm) as compared to controlled photoperiod (19.77 cm). It may be because of the effect that the plants kept under natural photoperiodic conditions were exposed to more number of long days which might have favoured vegetative growth. Interaction between growth regulators and photoperiod revealed that maximum plant spread was noticed with daminozide (2500 ppm) under natural photoperiod (23.90 cm). The minimum plant spread was noticed with paclobutrazol (60 ppm) under controlled photoperiod (18.54 cm).

Variations in number of sprays per plant due to cultivars, photoperiods and the interactions growth regulator x cultivar and cultivar x photoperiod were found to be significant. However variations due to growth regulators and the interactions growth regulator x photoperiod and cultivar x photoperiod x growth regulator were found to be non-significant. The more number of sprays per plant noticed in cultivar UHFSChr-Collection 1 (7.65) as compared to Ajay (7.06), may be due to differences in the genetic makeup of these which has also been observed by Ram (1991) and Pathak (2002) that might be due to inherent genetic factors (Hemlata et al 1992). The number of sprays per plant was noticed more under natural photoperiod (7.65) as compared to controlled photoperiod (7.05). Natural photoperiod ie long days promote vegetative growth in the plants. Similar variations have also been noted by Ram (1991) and Sultanpuri (2013). Interaction between growth regulators and cultivars revealed maximum number of sprays per plant in cultivar UHFSChr-Collection 1 (8.47) sprayed with 90 ppm paclobutrazol. This treatment was found to be at par with control and paclobutrazol (60 ppm) (7.79 and 8.13 respectively) in cultivar UHFSChr-Collection 1. The minimum number of sprays per plant was noted in plants of cultivar Ajay (6.21) sprayed with 90 ppm paclobutrazol. This treatment was found to be at par with paclobutrazol (60 ppm) and daminozide (2500 ppm) (7.04 and 6.99 respectively) in case of Ajay and ethephon (750 ppm) in case of UHFSChr-Collection 1. Interaction between cultivars and photoperiods showed maximum number of sprays per plant in cultivar UHFSChr-Collection 1 (8.15) under natural photoperiod. Under controlled photoperiod the minimum number of sprays per plant was in case of Ajay (6.95). Paclobutrazol has been shown to be anti-gibberellin. It might be expected that this compound could break apical dominance in plants. Klein and Leopold (1953) also observed loss of apical dominance and increase in lateral breaks. The present investigations indicated that the effectiveness of paclobutrazol in increasing the number of shoots depends upon environmental factor and again the response varies with cultivar as it is also evident from the findings of Cathey (1975).

Data pertaining to number of flowers per spray are presented in Table 2. The more number of flowers per spray noticed in cultivar Ajay (9.14) as compared to UHFSChr-Collection 1 (5.97) may be due to differences in the genetic constitution of the cultivars. As far as number of flowers per spray is concerned maximum number of flowers per spray (8.18) was noticed in plants sprayed with paclobutrazol 90 ppm. In contrast minimum number of flowers per spray (6.76) was noticed in plants sprayed with ethephon 750 ppm. Paclobutrazol at 50 ppm has also been reported to produce highest number of flowers under both artificial short day and long day conditions (Velmurugan and Vadivel 2003). Interaction between growth

Table 2. Effect of growth regulators and photoperiod on number of flowers per spray and pot presentability of chrysanthemum cultivars Ajay and UHFSChr-Collection 1

Growth regulator	Growth regulator x cultivar		Mean	Growth regulator x photoperiod	
	Ajay	UHFSChr-Collection 1		Controlled photoperiod	Natural photoperiod
Number of flowers per spray					
Control (distilled water)	10.07	6.20	8.14	7.62	8.66
Paclobutrazol (60 ppm)	9.01	5.79	7.40	7.44	7.35
Paclobutrazol (90 ppm)	10.48	5.87	8.18	7.68	8.68
Daminozide (2500 ppm)	9.32	6.15	7.73	7.65	7.81
Daminozide (3000 ppm)	8.93	6.13	7.53	7.42	7.64
Ethephon (500 ppm)	8.47	5.78	7.13	7.45	6.81
Ethephon (750 ppm)	7.68	5.84	6.76	6.96	6.55
Mean	9.14	5.97	-	7.46	7.64
Pot presentability (Score out of 100)					
Control (distilled water)	91.67	84.31	87.99	89.78	86.19
Paclobutrazol (60 ppm)	93.26	86.05	89.65	90.22	89.09
Paclobutrazol (90 ppm)	91.30	86.39	88.85	88.32	89.39
Daminozide (2500 ppm)	92.32	85.46	88.89	88.94	88.84
Daminozide (3000 ppm)	92.92	85.82	88.67	88.82	88.92
Ethephon (500 ppm)	89.52	82.31	85.91	85.47	86.36
Ethephon (750 ppm)	86.85	81.37	84.11	84.20	84.03
Mean	91.77	84.53	-	87.96	87.54

Cultivar x photoperiod

Cultivar	50-60% flower buds show colour		Plant spread	
	Controlled photoperiod	Natural photoperiod	Controlled photoperiod	Natural photoperiod
Ajay	8.86	9.41	90.73	91.22
UHFSChr-Collection 1	6.06	5.87	85.19	83.86

$CD_{0.05}$

	50-60% flower buds show colour	Plant spread
Cultivar	0.43	0.50
Photoperiod	NS	NS
Growth regulator	0.80	0.94
Growth regulator x cultivar	1.13	NS
Growth regulator x photoperiod	NS	1.32
Cultivar x photoperiod	NS	0.70

regulators and cultivars revealed maximum number of flowers per spray in plants of cultivar Ajay (10.48) sprayed with paclobutrazol (90 ppm). In contrast plants of UHFSChr-Collection 1 (5.78) showed minimum number of flowers per spray when sprayed with ethephon 500 ppm. All growth regulator treatments except control in both cultivars showed different effect on this parameter in case of Ajay than UHFSChr-Collection 1 indicating need to record and document the responses of these chemicals separately for cultivars. This could be generally due to different chemical constitution of growth regulators as they have different effect on cultivars. The reduction in yield due to ethephon in the present studies generally conformed with the results of Shanmugam et al (1973) and Nagarjun et al (1988).

Table 3. Interaction effect of growth regulator x cultivar x photoperiod on pot presentability of chrysanthemum cultivars Ajay and UHFSChr-Collection 1

Growth regulator	Pot Presentability (score out of 100)			
	Ajay		UHFSChr-Collection 1	
	Controlled photoperiod	Natural photoperiod	Controlled photoperiod	Natural photoperiod
Control (distilled water)	92.30	91.03	87.26	81.35
Paclobutrazol (60 ppm)	92.80	93.17	87.63	84.47
Paclobutrazol (90 ppm)	89.57	93.06	87.07	85.72
Daminozide (2500 ppm)	92.15	92.49	85.73	85.18
Daminozide (3000 ppm)	91.95	91.88	85.68	85.95
Ethephon (500 ppm)	89.67	89.37	81.27	83.35
Ethephon (750 ppm)	86.68	87.02	81.72	81.03

$CD_{0.05}$
Cultivar x Photoperiod x Growth regulator= 1.87

Data pertaining to pot presentability are presented in Tables 2 and 3. Variations in pot presentability due to cultivars, growth regulators and their interaction viz growth regulator x photoperiod, cultivar x photoperiod and cultivar x photoperiod x growth regulator were found to be significant. However variations due to photoperiods and interaction between growth regulator x cultivar were found to be non-significant. Keeping all the important flowering and vegetative characters suitable for pot mums in view pot presentability was calculated by giving scores to pots of each treatment out of 100. Data presented in Table 2 reveal that pot presentability varied significantly due to cultivars. In general more pot presentability was noticed in cultivar Ajay (91.77) as compared to UHFSChr-Collection 1 (84.53). This may be due to differences in the genetic makeup of these which has also been observed by Pathak (2002). Maximum pot presentability (89.65) was noticed in plants sprayed with paclobutrazol 60 ppm. All other treatments including control and both concentrations of ethephon showed significant scores with minimum pot presentability when plants were prayed with ethephon 750 ppm (84.11). Similar variations have also been noted by Pathak (2002) and Usha (2010).

Interaction between growth regulators and photoperiods revealed maximum pot presentability with paclobutrazol (60 ppm) under controlled photoperiod (90.22). The minimum pot presentability was noticed with ethephon (750 ppm) under natural photoperiod (84.03). Interaction between cultivars and photoperiods revealed maximum pot presentability in cultivar Ajay (91.22) under natural photoperiod whereas minimum in UHFSChr-Collection 1 (83.86) under natural photoperiodic conditions. Interaction between cultivar x photoperiod x growth regulator indicated that maximum pot presentability was obtained with paclobutrazol (60 ppm) in cultivar Ajay under natural photoperiod (93.17). The minimum pot presentability was in ethephon (750 ppm) in cultivar UHFSChr-Collection 1 under natural photoperiod (81.03). Similar variations have also been noted by Pathak (2002) and Usha (2010).

CONCLUSION

It is concluded that cultivar Ajay is more suitable for growing as pot mum as compared to UHFSChr-Collection 1. However under natural photoperiodic conditions plants after pinching should be sprayed with paclobutrazol (60 or 90 ppm) or daminozide (2500 or 3000 ppm). Under controlled photoperiodic conditions growth regulator application is not necessary for the production of cultivar Ajay and cultivar UHFSChr-Collection 1 may be sprayed with paclobutazol (60 ppm) for quality pot mum production.

REFERENCES

Anderson RL 1987. Reclassification of genus chrysanthemum. HortScience **22(2):** 313.

Cathey HM 1975. Comparative plant growth-retarding activities of ancymidol with ACPC, phosphon, chlormequat and SADH on ornamental plant species. HortScience **10(3):** 204-216.

Dhiman SR, Gupta YC, Thakur P, Kashyap B and Sharma M 2017. Response of different chrysanthemum cultivars under natural and controlled photoperiodic conditions for pot mum production. Journal of Hill Agriculture **8(3):** 283-287.

Ghosh S and Rao VK 2015. Effect of growth retardants on quality production of pot mums. Journal of Hill Agriculture **6(1):** 16-23.

Hemlata B, Patil AA and Nalwadi 1992. Variability studies in chrysanthemum. Progressive Horticulture **24(1-2):** 55-59.

Klein WH and Leopold AC 1953. The effects of maleic hydrazide on flower initiation. Plant Physiology **28(2):** 293-298.

Nagarjun D, Reddy VP, Rao MR and Reddy EN 1988. Effect of growth regulators and potassium nitrate on growth, flowering and yield of chrysanthemum (*Chrysanthemum indicum* L). South Indian Horticulture **36(3):** 136-140.

Pathak N 2002. Screening of chrysanthemum cultivars for year round flower production. PhD Thesis, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India.

Ram S 1991. Studies on year round flower production in chrysanthemum. MSc Thesis, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India.

Ram S and Sehgal OP 1993. Studies on year round flower production in pot chrysanthemum. I. Effect of controlled photoperiod and growth retardants on vegetative growth. Journal of Ornamental Horticulture **1(2):** 21-27.

Shanmugam A, Muthuswamy S and Madava Rao VN 1973. A study on the effect of growth substances of chrysanthemum (*Chrysanthemum indicum* L). Madras Agriculture Journal **60(1):** 1-5.

Sultanpuri A 2013. Effect of number of plants per pot, pot spacing and photoperiod on production of potted chrysanthemum (*Dendranthema grandiflora* Tzvelev). MSc Thesis, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India.

Usha 2010. Screening of newly evolved selection of chrysanthemum for off-season flower production. MSc Thesis Thesis, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India.

Velmurugan S and Vadivel E 2003. Effect of photoperiod and paclobutrazol on year round production in chrysanthemum. South Indian Horticulture **51(1-6):** 51-59.