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Effect of Artificial Short Day Conditions on Growth and Flowering of Chrysanthemum (*Chrysanthemum morifolium* Ramat.) Genotypes

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A B S T R A C T

In India, it is popular among the farmers as *Guldaudhi* is a commercial flower which is grown for cut flowers, loose flowers, pot mum as well as bedding plant. Flowering in *Chrysanthemum* morifolium Ramat. is photperiodically controlled and it is a qualitative short day plant. Under sub-tropical climatic conditions of North India, chrysanthemum produces flowers from October to December. Limited duration of flower production in chrysanthemum is a major bottleneck for the commercialization of this crop in this region. Thus the artificial short days play an important role in altering the flowering of chrysanthemum plants through the manipulations in the daily day length or photoperiod has been successfully used for production of chrysanthemum flowers throughout the year in many countries. Study was conducted to investigate the effect of artificial short day conditions during summer months on growth and flowering of spray type chrysanthemum genotypes. It was found that genotypes Banlgori Local and Yellow Delight are highly suitable for early induction flowering as these are having comparatively high tolerance towards heat delay for year round cultivation programmes using black outs to impose short day conditions.

Introduction

Florist's chrysanthemum (*Chrysanthemum morifolium* Ramat.) belongs to the family Asteraceae. This flower crop is popularly known with some other names in different parts of the world such as "Autumn Queen' or 'Queen of the East' (Koley and Sarkar, 2013). The word Chrysanthemum is derived from two Greek words that is '*chrysos'* means golden and '*anthos'* means flower (Gortzing and Gillow, 1964). In India, it is popular among the farmers as *Guldaudhi* is a commercial flower which is grown for cut flowers, loose flowers, pot mum as well as bedding plant. Flowering in *Chrysanthemum* morifolium Ramat.) is photperiodically controlled and it is a qualitative short day plant that requires 14.5 h photoperiod for flower initiation and 13.5 h light period for bud development (Runkle and Fisher, 2004). Under sub-tropical climatic conditions of North India, chrysanthemum produces flowers from October to December. Limited duration of flower production in chrysanthemum is a major bottleneck for the commercialization of

this crop in this region. Thus the artificial short days play an important role in altering the flowering of chrysanthemum plants as reported that the manipulations in the daily day length or photoperiod has been successfully used for production of chrysanthemum flowers throughout the year in many countries (Dutta and Gupta, 2012).

Materials and Methods

The experiment was conducted at department of floriculture and Landscaping, Punjab Agricultural University during 2015-16.

Experimental layout

The plants of 10 genotypes of belonging to spray type chrysanthemum, namely Banglori Local, Boris Becker, Reagan White,Kelvin Mandarin, NBRI Sunil, Reagan Emperor, Otome Pink, Jaya, Punjab Shyamli and Yellow Delight, were through the rooting of terminal cuttings during February –March The terminal cuttings measuring 2-3 cm long were treated with NAA (500 mg l^{-1}) for 30 sec and planted in propagation trays using burnt rice husk as rooting medium. The trays were placed under shading net and sprayed thrice with water daily, to maintain high relative humidity.

After two weeks, when the cuttings had produced sufficient roots, they were removed from the trays along with ball of burnt rice husk to prevent breaking of roots. The rooted cuttings were transplanted in the pots of 20 cm diameter containing mixture of garden soil and well rottened farm yard manure (2:1) along with diammonium phosphate @1kg per cubic feet. The pots were placed under artificially created short day conditions from 15th June to 15th August. The short days were provided as night extension by using black polythene(100 micron) sheet from civil twilight in the morning to 9.30 am everyday. There after the plants were be shifted to natural day length on 1st September.

The genotypes were subjected to pinching one month after planting.The observations were recorded on plant height, spread, number of branches per plant, leaf area index, number of stomata per unit area, leaf weight ratio, days taken for bud appearance, days to flowering, flower size, anthocyanin and carotenoids content, duration of flowering, number of flowers per plant and vase life

Statistical analysis

Experiment was laid out with three replications consisting five pots each in completely randomized design. The effect of artificially created short days was noted down on flowering and vegetative parameters at the time of bud emergence. Statistical analysis was performed using SAS software and the means were compared using Duncan Multiple Range Test (DMRT) at 5% level of significance (Duncan, 1955)

Results and Discussion

Effect of artificial short days on plant height, spread and number of branches

In *Chrysanthemum morifolium* genotypes (spray type), the photoperiodic treatments significantly ($p<0.05$) influenced the plant height, plant spread and number of branches per plant were recorded at time of visible bud appearance (Table 1)

The highest plant height (85.33 cm, 86.00 cm) was observed in genotype Boris Becker which was at par with genotype Punjab Shyamli (82.33 cm, 82.33 cm) in 2015 and 2016, respectively. Whereas, the minimum plant height was observed in genotype Banglori Local (63.00 cm, 65.33 cm) which was at par with genotype Kelvin Mandarin (67.33 cm,

68.00 cm), Yellow Delight (65.33 cm, 65.33 cm), Reagan White (65.00 cm, 65.67 cm), Otome Pink (64.00 cm, 65.67 cm) and Reagan Emperor (64.00 cm, 66.33 cm) in 2015 and 2016, respectively. The findings are in accordance with those as have been reported by (Dutta and Gupta, 2012). While classifying the *Chyrsanthemum* genotypes for year round cultivation using artificial short days.

Effect of artificial short days on leaf area index, number of stomata per unit area and leaf weight ratio

The short day treatments showed non-significant ($p<0.05$) affect on the Leaf area Index and number of stomata per unit area in *Chrysanthemum morifolium* spray type genotypes (Table 2).

The highest leaf area index (0.321 and 0.317) was observed in genotype Banglori Local in 2015 and 2016, respectively. Whereas, minimum leaf area index (0.183 and 0.207) was observed in genotype Yellow Delight in 2015 and 2016, respectively. In case of number of stomata per unit area the highest number was 57.00 and 57.33 in genotype Otome Pink, whereas, the lowest number was 53.00 and 53.33 in genotype Boris Becker during 2015 and 2016, respectively.

The effect of short day treatments was significantly influenced the leaf weight ratio of all the genotypes. However, the highest leaf weight ratio was observed as 0.293 and 0.287 in genotype Otome Pink, whereas, the minimum leaf weight ratio was observed as 0.144 and 0.145 in genotype Kelvin Mandarin during 2015 and 2016, respectively.

The findings are in accordance with those as have been reported by Kaur (2014) while evaluating the *Chyrsanthemum* genotypes for morphological and physiological characteristics.

Effect of artificial short days on days taken for bud appearance, days to flowering and flower size

The short day treatments significantly ($p<0.05$) influenced the days taken for bud appearance, days to flowering and flower size in *Chrysanthemum morifolium* (spray type) genotypes (Table 3).

The maximum days taken for bud appearance (156.00, 160.67) was observed in genotype Reagan Emperor which was at par with genotype Regan white (154.00, 157.67), Boris Becker (155.33, 156.00) and Kelvin Mandrin (145.33, 152.33) in 2015 and 2016, respectively. Whereas, the minimum days taken for bud appearance was observed in genotype Yellow Delight (108.00, 100.67) in 2015 and 2016, respectively.

The effect of short day treatments was significantly among all the genotypes for days to flowering. The highest days to flowering (185.33, 186.00) were in genotype Reagan Emperor during 2015 and 2016, respectively.

The values were at par with genotype Boris Becker, Regan white, Kelvin Mandarin and Otome Pinkin 2015 and 2016.Whereas, the minimum days to flowering (132.67, 131.33) was observed in genotype Yellow Delight in 2015 and 2016, respectively.

Dutta and Gutpa (2012) have also reported the response of small flowered *Chrysanthemum* to artificial short days. They have classified the genotypes according to their response to short days. However, the delay in flowering of other genotypes may be attributed due to 'heat delay' as reported by Shibata and Kawata (1997). 'Heat delay' is reported to be severe problem in year around cultivation of *Chrysanthemum* which is caused by high temperature under blackouts (Furuta and Nelson 1953).

Table.1 Effect of artificial short-day conditions on plant height, spread and number of branches per plant in spray chrysanthemum

S. No.	Genotype	Plant height (cm)		Plant spread (cm)		Number of branches/plant	
		2015	2016	2015	2016	2015	2016
1	Banglori Local	63.00^{d}	65.33^{c}	13.33^{e}	13.33^{d}	2.00^{b}	2.00^{b}
2	Boris Becker	85.33^{a}	86.00^{a}	19.33^{ab}	18.67^{ab}	3.00^{b}	2.67^{b}
3	Reagan White	65.00^{d}	65.67^{c}	14.33^{de}	13.33^{d}	3.00^{b}	3.00^{b}
4	Kelvin Mandarin	67.33^{d}	68.00^{c}	15.00^{de}	15.00^{cd}	3.00^{b}	2.67^{b}
5	NBRI Sunil	73.00^{c}	75.00^{b}	15.00^{de}	15.33^{bcd}	2.33^{b}	2.67^{b}
6	Reagan Emperor	64.00^{d}	66.33^{c}	18.00^{abc}	17.00^{abc}	2.00^{b}	2.00^{b}
7	Otome Pink	64.00^{d}	65.67^{c}	20.33^{a}	20.00^{a}	2.00^{b}	2.00^{b}
8	Jaya	77.67^{bc}	78.00^{b}	16.67^{bcd}	17.00^{abc}	4.33^{a}	4.33^{a}
9	Punjab Shyamli	82.33^{ab}	82.33^{a}	14.00^{de}	15.00^{cd}	5.00^{a}	5.00^{a}
10	Yellow Delight	65.33^{d}	65.33^{c}	15.67^{cde}	15.67^{bcd}	2.00^{b}	2.00^{b}
Mean		70.70^{a}	71.77^{a}	16.17^{a}	16.03^{a}	2.87^{a}	2.83^{a}

Mean values in each column with the same letter are not significantly different at p < 0.05 according to DMRT. *Significant at p< 0.05

Table.2 Effect of short artificial short-day conditions on plant leaf area index, leaf weight ratio and number of stomata unit area in spray chrysanthemum

S. No.	Genotype	Leaf area index		Leaf weight ratio		Number of stomata per unit area	
		2015	2016	2015	2016	2015	2016
1	Banglori Local	0.32^{a}	0.32^{a}	0.170^{b}	0.167^{b}	56.67^{a}	57.33^{a}
2	Boris Becker	0.31^{ab}	0.30^{a}	0.184^{ab}	0.183^{ab}	53.00^{a}	53.33^{a}
3	Reagan White	0.25^{abc}	0.25^{a}	0.217^{ab}	0.213^{ab}	56.00^{a}	55.33^{a}
4	Kelvin Mandarin	0.25^{abc}	0.26^{a}	0.144^{b}	0.145^{b}	54.33^{a}	55.00^{a}
5	NBRI Sunil	0.25^{abc}	0.26^{a}	0.159^{b}	0.159^{b}	55.00^{a}	56.33^{a}
6	Reagan Emperor	0.25^{abc}	0.91^{a}	0.149^{b}	0.150^{b}	56.67^{a}	57.00^{a}
7	Otome Pink	0.23^{bc}	0.27^{a}	0.293^{a}	0.292^{a}	57.00^{a}	57.00^{a}
8	Jaya	0.32^{a}	0.30^{a}	0.192^{ab}	0.191^{ab}	56.67^{a}	57.33^{a}
9	Punjab Shyamli	0.31^{ab}	0.28^{a}	0.163^{b}	0.162^{b}	55.00^{a}	56.00^{a}
10	Yellow Delight	0.18^{c}	0.21^{a}	0.218^{ab}	0.217^{ab}	55.00^{a}	55.67^{a}
Mean		0.27^{a}	0.34^{a}	0.218^{a}	0.188^{b}	55.53^{a}	56.03^{a}

Mean values in each column with the same letter are not significantly different at p < 0.05 according to DMRT. *Significant at p< 0.05

Table.3 Effect of short artificial short-day conditions on days to bud appearance, flowering and flower size in spray chrysanthemum

S. No.	Genotype	Days taken for bud appearance		Days to flowering		Flower size (cm)	
		2015	2016	2015	2016	2015	2016
1	Banglori Local	117.00^{c}	110.00^{c}	134.67^{d}	133.67^{d}	5.33^{cd}	5.32^{cd}
2	Boris Becker	155.33^{a}	156.00^{a}	184.33^{a}	185.33^{a}	6.33^{abc}	6.30a^{bc}
3	Reagan White	154.00^{a}	157.67^{a}	184.00^{a}	183.00^{a}	7.00^{a}	7.05a
4	Kelvin Mandarin	145.33^{a}	152.33^{a}	174.67^{a}	181.67^{a}	3.67^{e}	3.65^{e}
5	NBRI Sunil	141.33^{b}	142.33^{b}	162.33^{bc}	163.33^{bc}	4.00^{e}	4.02^{e}
6	Reagan Emperor	156.00^{a}	160.67^{a}	185.33^{a}	186.00^{a}	6.67^{ab}	6.67a^{b}
7	Otome Pink	143.33^{b}	144.67^{b}	177.33^{a}	175.33^{a}	4.67^{de}	4.67^{de}
8	Jaya	131.00^{bc}	132.00^{bc}	156.67^{c}	155.67^{c}	7.00^{a}	7.12a
9	Punjab Shyamli	122.33^{c}	123.67^{c}	155.67^{c}	154.00^{c}	7.13^{a}	7.25a
10	Yellow Delight	108.00^{d}	107.67^{d}	132.67^{d}	131.33^{d}	5.67^{bcd}	5.58^{bcd}
	Mean	137.30^{a}	138.70^{a}	164.78^{a}	164.93^{a}	5.75^{a}	5.76^{a}

Mean values in each column with the same letter are not significantly different at p < 0.05 according to DMRT. *Significant at p< 0.05

Table.4 Effect of artificial short-day conditions on number anthocyanin and carotenoids in spray chrysanthemum

Sr. No.	Genotype	Anthocyanin content (mg/g)		Carotenoids content (mg/g)	
		2015	2016	2015	2016
1	Banglori Local	ND^{b}	ND^{b}	6.00^{f}	5.67^{f}
2	Boris Becker	9.00^{b}	9.32^{b}	46.33^{a}	45.67^{a}
3	Reagan White	ND^{b}	ND^{b}	23.00^{c}	22.67c
4	Kelvin Mandarin	1.00^{b}	1.31^{b}	5.67^{f}	5.67^{f}
5	NBRI Sunil	ND^{b}	ND^{b}	6.67^{f}	7.00^{f}
6	Reagan Emperor	1.33^{b}	1.34^{b}	30.00^{b}	29.33^{b}
7	Otome Pink	0.33^{b}	0.30^{b}	44.33^{a}	43.67^{a}
8	Jaya	42.00^{a}	41.67^{a}	3.33g	3.00^{g}
9	Punjab Shyamli	ND^{b}	ND^{b}	17.67^{d}	17.00^{d}
10	Yellow Delight	ND^{b}	ND^{b}	10.33^{e}	10.00^{e}
	Mean	4.96^{a}	5.39^{a}	19.33^{a}	18.97^{a}

Mean values in each column with the same letter are not significantly different at p < 0.05 according to DMRT. *Significant at p< 0.05
ND – Not detected

Table.5 Effect of short artificial short-day conditions on duration of flowering, number of flowers per plant and vase life in spray chrysanthemum

Sr. No.	Genotype	Duration of flowering (days)		Number of flowers/plant		Vase life (Days)	
		2015	2016	2015	2016	2015	2016
1	Banglori Local	22.33^{c}	23.00^{c}	27.20^{b}	12.00^{d}	7.00^{ef}	7.00e^{f}
2	Boris Becker	25.33^{b}	24.33^{b}	13.33^{de}	14.33^{cd}	6.33^{f}	6.33^{f}
3	Reagan White	26.67^{b}	25.67^{b}	15.33^{d}	22.67^{bc}	10.67^{a}	10.00^{a}
4	Kelvin Mandarin	28.67^{b}	28.33^{b}	25.67^{b}	22.67^{bc}	10.33^{ab}	10.00^{ab}
5	NBRI Sunil	30.00^{a}	29.33^{a}	25.33^{b}	22.00^{bc}	7.67^{def}	7.67^{def}
6	Reagan Emperor	30.00^{a}	28.61^{a}	23.67^{b}	21.67^{bc}	10.33^{ab}	10.33^{ab}
7	Otome Pink	29.00^{b}	29.67^{a}	19.67^{c}	21.67^{bc}	8.33^{bc}	8.33^{bc}
8	Jaya	26.00^{b}	25.33^{b}	27.67^{b}	28.67^{a}	9.67^{bc}	9.67^{bc}
9	Punjab Shyamli	32.67^{a}	31.33^{a}	45.33^{a}	45.33^{a}	9.67^{bc}	9.00^{bc}
10	Yellow Delight	21.33^{c}	22.67^{c}	24.67^{b}	15.33^{cd}	8.67^{cde}	8.33^{cde}
Mean		27.20^{a}	26.83^{a}	24.79^{a}	22.63^{a}	8.87^{a}	8.67^{a}

Mean values in each column with the same letter are not signi^{f}icantly di^{ff}erent at $p < 0.05$ according to DMRT. *Significant at $p< 0.05$

Shibata and Kawata (1997) have mentioned heat tolerance in some genotypes of *Chrysanthemum*, so while creating artificial short days using black polythene (100 micron) has lead to increase in termapture inside the polythene upto 40^{o}C. Based on the observations it was found that genotypes Banglori Local and Yellow Delight were tolerant to 'heat delay' as compared to other genotypes under study.

The short day treatments significantly affect the flower size of all genotypes. The highest value (7.13 cm, 7.25cm) was in genotype Punjab Shyamli which was at par with genotype Jaya (7.00 cm, 7.12 cm) and Regan White (7.00 cm, 7.05 cm) during 2015 and 2016. The minimum flower size (3.67 cm, 3.65 cm) was found in genotype Kelvin Mandarin which was at par with NBRI Sunil (4.00 cm, 4.02cm) during 2015 and 2016. The findings are in accordance with those as reported by Gupta and Dutta (2012). They have also reported variation in flower size in response to artificial short days.

Effect of artificial short days on anthocyanin and carotenoids content

The short day treatment significantly ($p<0.05$) influenced the anthocyanin content, carotenoids content in *Chrysanthemum morifolium* (spray type) genotypes (Table 4).

The maximum anthocyanin content (42.00 mg/g, 41.67 mg/g) was observed in genotype Jayain 2015 and 2016, respectively. Whereas, the minimum anthocyanin content was in genotype during 2015,

The highest carotenoids content (46.33 mg/g, 45.67 mg/g) was in genotype Boris Becker in 2015 and 2016, respectively. Whereas, minimum carotenoids content (3.33 mg/g, 3.00 mg/g) was observed in genotype Jayaduring2015and 2016, respectively. The variations in anthocyanin and carotenoids contents have also been documented by Shisa *et al.,* (2017) and Park *et al.,* (2015).

Effect of artificial short days on duration of flowering, number of flowers per plant and vase life

The effect of artificial short day treatments significantly ($p<0.05$) influenced the duration of flowering, number of flowers per plant and vase life in *Chrysanthemum morifolium* (spray type) genotypes (Table 5).

The maximum duration of flowering (32.67, 31.33) was observed in genotype Punjab Shyamli in 2015 and 2016, respectively. The value was at par with genotypes NBRI Sunil, Reagan Emperor and Otome Pink, whereas, the minimum duration of flowering was 21.33 in genotype Banglori Local during 2015, however, the value was 16.67 in genotype Yellow Delight during 2016. However, Banglori Local and Yellow Delight were at par during during two years.

The highest number of flowers per plant was 45.33 in genotype Pujab Shyamli in 2015 and 2016, whereas, minimum number of flowers per plant (13.33) was observed in genotype Boris Becker in 2015 and 12.00 in genotype Banglori Local during 2016.Chrysanthemum genotypes exhibit considerable variable in flower vase life and number of flowers per plant which are genetically determined characteristics (Larson 1992, Dutta 2006, Dutta and Gupta 2012).

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