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Effect of covering materials on off-season cut flower production in chrysanthemum (*Dendrathema grandiflora*)

PALMSEY M SANGMA[1], SITA RAM DHIMAN[2], PRIYANKA THAKUR[3] and Y C GUPTA[4]

Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230

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ABSTRACT

Studies on the effect of covering material on off-season cut flower production of chrysanthemum (*Dendranthema grandiflora* Tzvelev) were carried out at the experimental farm of the Department of Floriculture and Landscape Architecture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during 2011 in naturally ventilated polyhouse. The experiment was carried out using three types of covering materials (viz. tarpaulin, high density polyethylene (HDPE) and black sateen cloth) and four cultivars each of standard (Purnima, Yellow Star, Tata Century and White Star) and spray (Ajay, Birbal, Nanako and White Bouquet) varieties. Findings revealed that HDPE was the best alternative covering material to tarpaulin as optimum plant height (83.33 cm), plant spread (40.54 cm), maximum number of cut stems (4.21), duration of flowering (33.54 days) and earliest flower bud formation (91.07 days) and flowering were obtained in plants under HDPE. Flowering was earlier under controlled photoperiod than natural photoperiod. Peak flowering was earliest (140.36 days) in plants under HDPE* cover as compared to plants under natural photoperiodic conditions which took maximum number of days (176.19), to come to peak flowering. The varieties were assigned to different response group under controlled photoperiodic conditions with HDPE. All the varieties tested were found suitable for off-season flower production.

Key words: Chrysanthemum, Covering materials, HDPE, Photoperiod, Response group

Chrysanthemum (*Dendranthema grandiflora* Tzvelev), is one of the commercially important cut flower, loose flower and pot plant in world trade. In India, chrysanthemum occupies a place of pride both as commercial crop and as a popular exhibition flower. The spray cultivars are used for making garlands in our country while standard varieties are mostly used as cut flowers. Its wide popularity is due to its large number of cultivars in respect of growth habit, size, colour, shapes of blooms, long lasting blooms and excellent keeping quality as cut flower.

Post (1931) used black sateen cloth for induction of artificial short days for production of early blooms in chrysanthemum, and concluded, that stems of flowers forced, bloomed earlier than normal, were shorter than those of normal treatment. Darkening also increased the number of stems per plant but decreased the number of flowers per stem. Poesch (1931) reported that plots shaded with entire white shades and followed with entire black shades showed a marked advantage in time of flowering over check, and complete black shading was found to be most satisfactory method for obtaining earlier blooms than normal season.

[2]e mail: sitaramdhiman@gmail.com, Department of Floriculture and Landscape Architecturel [3]e mail: priyanka.thakur@gmail.com, Regional Horticultural Research and Training Station, Dhaulakuan, Sirmour, Himachal Pradesh

Krause (1979) used black polyethylene to limit day length to 10 hr until all flower buds showed color on cultivars 'Blanche Poitevine' and 'Madame Bachon' resulted into compact and well branched plants. Sita Ram and Sehgal (1993) used dark tarpaulin to provide artificial short days 16 hr daily (5 PM to 9 AM) for successful induction of flowering, round the year in chrysanthemum.

Keeping this in view, different covering materials were used with the objectives to find out suitable alternative of tarpaulin cloth as covering material and suitable cultivar(s) for off-season flower production.

MATERIALS AND METHODS

Investigation involved four standard (Purnima, Yellow Star, Tata Century and White Star) and four spray (Ajay, Birbal Sahni, Nanako and White Bouquet) cultivars of chrysanthemum. Uniform rooted cuttings were selected and planted on 20 April 2011 on flat beds at 30 × 25 cm spacing from plant to plant and row to row. Experiment was laid in split plot design; covering materials as main plot (four) and variety as sub-plot (eight), with three replications and five plants per replication. Standard cultural operations were followed to all the treatments throughout the experiment.

Application of covering materials, viz. tarpaulin, HPDE (one side black and other side white) and black satin cloth, were designated as controlled photoperiod for artificial short

days, and natural photoperiodic conditions (treatment control) where plants were not covered with any covering material were used. Controlled photoperiodic treatments for artificial short days to the plants were started at a stage when the side shoots attained 30 cm growth post pinching. Artificial short days were provided from 7 June 2011 till 15 September 2011 with tarpaulin and HDPE; and in case of black satin cloth treatment artificial short days were started on 7 June 2011 and continued till 3 October 2011. Covering material were placed on semi-circular tunnel frames structures (3×1.5×1.5m) for 16 hr daily from 5:00 P.M till 9:00 A.M. The covering was continued till 60-75% flower buds on a plant showed color (Sita Ram and Sehgal 1993, Pathak 2002, Usha 2010). Natural photoperiod treatment was given by growing plants under natural photoperiodic conditions from planting till flowering.

RESULTS AND DISCUSSION

In general, covering materials successfully induced early flowering, than natural photoperiodic conditions. Plant height was maximum in plants covered with black satin cloth (110.78 cm) which attained sufficient vegetative growth whereas, minimum plant height recorded under tarpaulin (76.72 cm) which was found to be at par with HDPE (83.33 cm) (Table 1). In comparison, plants grown under natural photoperiodic conditions inside the polyhouse attained an average height (94.41 cm).

Plants grown under HDPE and tarpaulin had completely opaque conditions and were shorter as compared to plants growth under natural light conditions which was similar to reports by Sita Ram and Sehgal (1993), Nxumalo and Wahome (2010) and Usha (2010). This may be due to the fact that the plants kept under natural photoperiodic conditions were exposed to more number of long days which might have favoured vegetative growth. Black satin cloth gave contradictory result might be because it was slightly translucent instead of opaque and allowed certain amount of light to pass through and hence supported height growth as compared to plants in natural light conditions. Also foliage color was lighter as compared to those in natural photoperiod indicating lower chlorophyll content, the stems of the plants were also thick and succulent and internodes were longer; whereas, in the natural photoperiod the plants were sturdy and strong as the plants received sufficient amount and duration of light. Similar findings were observed by Singh *et al*. (2005).

Table 1 Effect of different covering materials on plant height (cm) of different cultivars of chrysanthemum

Cultivars	Covering materials				
	Natural photoperiod	Tarpaulin	HDPE	Black satin cloth	Mean
Purnima	87.25	87.20	87.64	115.40	94.37
Yellow Star	103.83	91.60	100.13	124.77	105.08
Tata Century	71.67	61.03	69.92	106.67	77.32
White Star	87.13	74.53	90.38	120.08	93.03
Ajay	97.91	76.50	77.40	102.52	88.58
Birbal Sahni	99.40	74.92	80.08	102.43	89.21
Nanako	130.90	90.22	93.77	117.40	108.07
White Bouquet	77.20	57.78	67.28	96.93	74.80
Mean	94.41	76.72	83.33	110.78	-
CD (P=0.05)	Covering materials			6.91	
	Cultivars			7.61	
	Covering materials × Cultivars			15.22	

Among cultivars, Nanako (108.07 cm), produced tallest plants, which was at par with Yellow Star (105.08 cm). In contrast, White Bouquet (74.80 cm) produced minimum plant height and was at par with Tata Century (77.32 cm).

Plant spread (cm) varied significantly due to covering materials and cultivars (Table 2). It was recorded that maximum plant spread (47.21 cm) was under natural photoperiodic condition (control), which was found to be at par with that of black satin cloth (46.83 cm). However, among the covering materials, minimum plant spread recorded under tarpaulin (38.57 cm) was found to be at par with that of HDPE (High density polyethylene) (40.54 cm). Among the cultivars belonging to spray and standard groups, cultivar Ajay (55.83 cm) exhibited maximum plant spread which was at par with Purnima (51.68 cm).

Light influences the vegetative growth in chrysanthemums through, number and rate of leaf production, stem length and morphology of leaves (Velmurugal and Vadivel, 2003). Plant spread was more in plants under natural photoperiod and plants under satin cloth cover. These plants had more number of days for vegetative growth as they came to flowering later than those under different covering materials which flowered earlier. Interaction effect showed that cv. Nanako had maximum plant height (130.90 cm).

In general, it was recorded that plants covered with HDPE (91.07 days) took minimum days for visible flower bud formation which was at par with tarpaulin (94.49 days) (Table 3). In contrast, maximum number of days for visible

Table 2 Effect of different covering materials on plant spread (cm) of different cultivars of chrysanthemum

Cultivars	Covering materials				
	Natural photoperiod	Tarpaulin	HDPE	Black satin cloth	Mean
Purnima	56.24	49.79	45.13	55.57	51.68
Yellow Star	43.04	33.52	38.30	44.16	39.75
Tata Century	34.27	32.25	33.52	37.03	34.26
White Star	40.23	36.47	40.12	45.67	40.62
Ajay	65.29	49.05	48.10	60.88	55.83
Birbal Sahni	46.78	31.93	35.71	34.33	37.19
Nanako	48.48	32.14	40.94	47.42	42.25
White Bouquet	43.33	43.42	42.55	49.63	44.73
Mean	47.21	38.57	40.54	46.83	-
CD (P=0.05)	Covering materials			5.65	
	Cultivars			4.49	
	Covering materials × Cultivars			8.99	

flower bud formation was recorded in natural photoperiod (control) (114.29 days). However, among different covering materials, maximum days were taken for visible flower bud when black satin cloth (98.65 days) was used as covering material.

Among the cultivars belonging to both spray and standard groups, cultivar Tata Century (90.92 days) took minimum number of days for visible flower bud formation which was at par with Purnima (91.76 days) and White Star (94.66 days). In contrast, Yellow Star (112.99 days) took maximum number of days for visible flower bud formation.

Plants under controlled photoperiod had less plant spread as exposure to short days decreased the leaf number and advanced floral bud formation as reported by Lee *et al*. (2001). Interaction showed that, the maximum values of plant spread of the cultivars in control and black satin cloth cover were at par with each other in all the cultivars except Birbal Sahni.

In controlled photoperiodic conditions, short days were counted from the date when artificial short days were started (i.e. from 7 July 2011), by using different covering materials, whereas, in natural photoperiodic conditions (control), short days were counted with effect from 28 August 2011, as day length on this day started becoming lesser than 14.5 hr. In general, it was observed that plants under controlled photoperiodic conditions required more number of short days to come to flowering as compared to natural photoperiodic conditions (control) (Table 4). The maximum number of short days were taken by plants under black satin cloth cover (91.21 days). However, minimum number of short days were taken by plants under natural photoperiodic conditions (control) (49.08 days). However, among the different covering materials, minimum number of short days were recorded under high density polyethylene (62.97 days), and it was at par with tarpaulin (64.08 days). Among the different cultivars, Ajay (76.18 days) took maximum number of days to reach at this stage. Minimum number of days taken by Tata Century (57.62 days) was at par with White Star (60.25 days).

Early flowering in plants under short day treatment was also reported by Velmurugal and Vadivel (2003), Usha (2010). This may due to fact that increase in short day exposure decreased the final leaf number and advanced the floral stage, suggesting a facultative response to photoperiodic cycles (Lee *et al*. 2001). Controlled photoperiod shortened the growing cycle more in late cultivars and less in early cultivars (Chmiel and Pagowski 2005, Cathey 1954). Interaction between cultivars and covering materials revealed that minimum number of days for visible bud flower formation was observed in Ajay (84.40 days) under HDPE.

Minimum number of short days were recorded under high density polythene (62.97 days) and was found to be at par with tarpaulin (74.08 days). Cultivar Ajay took maximum number of days to reach at this stage (76.18 days). Interaction

Table 3 Effect of different covering materials on days taken for visible flower bud formation of different cultivars of chrysanthemum

Cultivars	Covering materials				
	Natural photoperiod	Tarpaulin	HDPE	Black satin cloth	Mean
Purnima	90.00	91.13	92.00	93.91	91.76
Yellow Star	116.83	111.53	102.60	121.00	112.99
Tata Century	89.93	93.80	86.20	93.73	90.92
White Star	94.60	91.73	95.60	96.72	94.66
Ajay	137.00	86.91	84.40	89.32	99.41
Birbal Sahni	130.80	93.73	88.00	100.28	103.20
Nanako	127.17	93.75	91.65	104.75	104.33
White Bouquet	127.95	93.30	88.12	89.45	99.70
Mean	114.29	94.49	91.07	98.65	
CD (P=0.05)	Covering materials			3.62	
	Cultivars			5.62	
	Covering materials × Cultivars			11.11	

Table 4 Effect of different covering materials on number of short days required for peak flowering of different cultivars of chrysanthemum

Cultivars	Covering materials				
	Control (Natural photoperiod)	Tarpaulin	HDPE	Black satin cloth	Mean
Purnima	44.33	56.47	59.50	88.38	62.17
Yellow Star	44.25	71.13	69.33	101.60	71.58
Tata Century	40.87	58.75	53.25	77.60	57.62
White Star	44.83	57.80	56.62	81.75	60.25
Ajay	63.33	69.90	71.68	99.78	76.18
Birbal Sahni	53.87	70.53	69.00	90.13	70.88
Nanako	53.00	69.53	68.00	97.60	72.03
White Bouquet	48.19	58.50	56.34	92.87	63.98
Mean	49.08	64.08	62.97	91.21	
CD (P=0.05)	Covering materials			3.48	
	Cultivars			3.89	
	Covering materials × Cultivars			7.78	

Table 5 Effect of different covering materials on flower size (cm) of different standard cultivars of chrysanthemum

Cultivars	Covering materials				
	Control (Natural photoperiod)	Tarpaulin	HDPE	Black satin cloth	Mean
Purnima	11.79	9.08	8.93	11.98	10.44
Yellow Star	13.93	11.88	12.34	14.31	13.12
Tata Century	10.71	9.16	9.04	10.77	9.92
White Star	12.29	9.70	11.06	12.59	11.41
Mean	12.18	9.96	10.34	12.41	-
CD (P=0.05)	Covering materials			0.45	
	Cultivars			0.60	
	Covering materials × Cultivars			1.16	

Table 6 Effect of different covering materials on flower size (cm) of different spray cultivars of chrysanthemum

Cultivars	Covering materials				
	Natural photoperiod	Tarpaulin	HDPE	Black satin cloth	Mean
Ajay	3.55	3.84	3.86	4.60	3.96
Birbal Sahni	3.72	4.03	4.26	4.47	4.12
Nanako	2.96	2.91	2.98	3.60	3.11
White Bouquet	3.87	2.87	3.09	3.54	3.35
Mean	3.53	3.42	3.55	4.05	
CD (P=0.05)	Covering materials			0.16	
	Cultivars			0.14	
	Covering materials × Cultivars			0.27	

between cultivars and covering materials revealed that maximum number of short days for peak flowering were taken by cv. Yellow Star (101.60 days) when covered with black satin cloth.

Data presented in the Table 5 showed that flower size varied significantly due to covering materials and cultivars. In general, maximum flower size was recorded in plants covered with black satin cloth (12.41 cm), which was at par with natural photoperiodic condition (control) (12.18 cm). In contrast, minimum flower size of 9.96 cm recorded in plants covered with tarpaulin. Among the different standard cultivar, maximum flower size of 13.12 cm was recorded in Yellow Star cultivar, while, minimum flower size recorded in Tata Century (9.92 cm).

In general, all the spray cultivars covered with black satin cloth (4.05 cm) showed maximum flower size (Table 6). In contrast, minimum flower size of 3.42 cm recorded in plants covered with tarpaulin was found to be at par with natural photoperiodic condition (control) (3.53 cm) and with high density polyethylene (3.55 cm). Among the different spray cultivar, maximum flower size was recorded in cultivar Birbal Sahni (4.12 cm), while, minimum flower size was recorded in Nanako (3.11 cm). Interaction between covering materials and cultivars revealed that maximum flower size was recorded in cv. Ajay (4.60 cm) under black satin cloth.

In general, it was recorded that plants under controlled photoperiod, had maximum number of cut stems per plant as compared to the plants under natural photoperiodic conditions (control) (Table 7). Maximum numbers of cut stems per plant were recorded from plants covered with high density polyethylene (4.21) which was at par with tarpaulin (4.07) and black satin cloth cover (3.98). Minimum number of cut stems per plant was recorded in natural photoperiodic condition (control) (2.88).

Among the different cultivars, White Star (4.48) recorded maximum number of cut stems per plant which was at par with Ajay (4.46), Tata Century (4.17) and White Bouquet (4.06). Interaction between the covering materials and cultivars revealed that, maximum number of cut stems per plant was recorded in Tata Century (5.67) under tarpaulin.

The duration of flowering was longer in plants under controlled photoperiod as compared to plants under natural photoperiodic conditions (control) (Table 8). Maximum duration of flowering (33.89 days) was recorded in plants when tarpaulin was used as covering material, and it was found to be at par with high density polyethylene (33.54 days). Minimum duration of flowering recorded under natural photoperiodic conditions (control) (26.10 days), was at par with tarpaulin (28.54 days).

Among the different cultivars belonging to both spray and standard groups, cultivar Ajay (32.65 days) recorded maximum duration of flowering, which was at par with Yellow Star (32.37 days), White Star (32.12 days) and Purnima (30.33days), whereas, minimum duration of flowering recorded in Birbal Sahni (28.41 days) was found

Table 7 Effect of different covering materials on number of cut stems per plant of different cultivars of chrysanthemum

Cultivars	Covering materials				
	Control (Natural photoperiod)	Tarpaulin	HDPE	Black satin cloth	Mean
Purnima	0.73	4.33	4.33	4.47	3.47
Yellow Star	3.20	3.53	3.80	3.67	3.55
Tata Century	2.00	3.87	5.13	5.67	4.17
White Star	3.20	5.53	4.60	4.58	4.48
Ajay	3.93	5.17	5.13	3.60	4.46
Birbal Sahni	3.20	3.25	3.27	3.37	3.27
Nanako	2.85	2.47	3.00	3.00	2.83
White Bouquet	3.93	4.40	4.45	3.47	4.06
Mean	2.88	4.07	4.21	3.98	-
CD (P=0.05)	Covering materials			0.27	
	Cultivars			0.54	
	Covering materials × Cultivars			1.04	

Table 8 Effect of different covering materials on duration (days) of flowering of different cultivars of chrysanthemum

Cultivars	Covering materials				
	Control (Natural photoperiod)	Tarpaulin	HDPE	Black satin cloth	Mean
Purnima	30.27	30.33	30.12	30.62	30.33
Yellow Star	29.97	34.71	36.24	28.57	32.37
Tata Century	25.47	32.12	29.88	26.40	28.47
White Star	26.63	34.51	38.20	29.13	32.12
Ajay	22.80	37.11	37.08	33.62	32.65
Birbal Sahni	22.87	34.40	30.72	25.65	28.41
Nanako	25.27	32.64	33.47	28.63	30.00
White Bouquet	25.52	35.33	32.62	25.67	29.79
Mean	26.10	33.89	33.54	28.54	-
CD (P=0.05)	Covering materials			2.45	
	Cultivars			2.50	
	Covering materials × Cultivars			5.00	

Table 9 Categorization of the different chrysanthemum varieties based on their response to short-day treatment under HDPE in Nauni, Solan conditions of Himachal Pradesh

Variety	Response Group (in weeks)
Purnima	9
Yellow Star	10
Tata Century	8
White Star	8
Ajay	10
Birbal Sahni	10
Nanako	10
White Bouquet	8

to be at par with Tata Century (28.47 days), White Bouquet (29.79 days), and Nanako (30.00 days). Interaction revealed that maximum duration of flowering was recorded in cv. White Star (38.20 days) under HDPE.

The eight cultivars of chrysanthemum were classified into response groups based on the number of short days required for flowering under HDPE cover at Nauni Solan condition, to know their suitability for flower forcing which will be beneficial for the farmers (Table 9). All the varieties were found suitable for flower forcing. As HDPE was effective for creating artificial short days and have the added advantage of being lighter in weight and ease in handling, it can be recommended in place of tarpaulin. .

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