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EFFECT OF PHOTOPERIOD, CULTIVAR AND NUMBER OF LATERAL SHOOTS ON VEGETATIVE GROWTH AND FLOWERING OF POINSETTIA

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SUMMARY

The effects of photoperiod and number of lateral shoots on vegetative growth, number of open central clusters, and percentage of fully colored bracts in five poinsettia cultivars were studied. The cultivars were grown at three different photoperiods; under short-day period (SD, 9 h) long-day (LD, 13 h) and natural day (ND, 11-h day length from the 15th to the 31st of Oct.; 10-h day length from the 1st to the 15th of Nov.; 9.5-h day length from the 15th to the 30th of Nov.; 9-h day length from the 1st to the 15th of Dec.). Vegetative growth was affected by cultivar but not by photoperiod or the number of laterals. Short-day conditions generally enhanced the opening of central cluster. Differences among cultivars were spotted in percentage of bract coloration and were greater under natural- and long-day treatments than under short-day treatment. Also in the time required for flower initiation and development, differences among cultivars were probably the reason for variations in bract coloration under same day-length conditions.

Key words: day length, poinsettia cultivars, vegetative growth

INTRODUCTION

Euphorbia pulcherrima Willd.ex Klotzsch, better known as poinsettia, has been a symbol of the Christmas season. The flower cultivators in Europe and North America develop colorful (red, mottled red, white and red & white) poinsettias in greenhouses to be sold during the Christmas time (Kannangara and Hansson, 1998). Today there are many new poinsettias cultivars that differ in the growth of habits, flowering period and bract color. Poinsettia is considered to be a long lasting pot plant with regard to capability of bracts and leaves, although there are quality problems associated with poor development of the flowers (cyathia) of the inflorescences and early cyathia abscission (Moe et al., 2006).

Poinsettia is a short-day plant (SDP), which naturally flowers in response to long nights (Wang et al., 2003). The generative development of poinsettia has three well-defined stages. The first stage is flower initiation and it depends on day length, the second stage is marked by the appearance of the first visible cyathium, and the third and final event begins with the development of the first visible open flower (Snipen et al., 1999). A critical day length for floral induction in poinsettia is about 12 h (Kristoffersen, 1994). Short days (10-10.5 h) are also required for the proper development of the bract color pigments (anthocyanins) of the transition leaves of the inflorescence (Moe et al., 2006).

Photoperiod has a qualitative or quantitative effect on flower induction and the development of some plant species. Light quality can influence on internode length, flower initiation and flower development and light intensity had influence on photosynthesis and parameters of plant quality such as: branching, stem thickness, flower number and flower size (Runkle and Heins, 2005). A small change in photoperiod can mean the difference between vegetative growth and rapid flowering (Runkle, 2002).

In this paper, we show how the effect of photoperiod (day length) influenced on vegetative growth, number of open central cluster, and percentage of fully colored bracts of five poinsettia cultivars thinned to 3, 4, and 5 lateral shoots.

MATERIAL AND METHODS

Five poinsettia cultivars Cortez White, Christmas Dream, Christmas Wish, Christmas Season and Marble Star (Selecta Klemm GmbH & Co.KG, Stuttgart, Germany) were received on 8th Oct. from a commercial nursery. Cultivars were thinned by hand to 3, 4, or 5 lateral shoots (laterals) and placed on benches at a density of 30 x 30 cm.

On 15th October, a short-day period (SD, 9 h) was provided by pulling 0.07 mm thick black/white PE film (Eiffel-Fontanellato, Parma, Italy), with the black side outside, over the plants at 4:30 p.m. and removing the film at 7:30 a.m. the next morning. The long-day (LD, 13 h) photoperiod was achieved by providing supplemental light from 5:30 p.m. to 8:30 p.m. to plants covered from 5:30 p.m. to 7:30 a.m. the next day, using the same coverage as for the short-day treatment. Supplemental light was provided by 18 W incandescent lights (18 W/ 77, Osram L, Munich, Germany) mounted 100 cm above the plants in two rows at spacing of 70 x 100 cm. The third treatment (control) included plants under natural photoperiod conditions (ND, 11-h day length from the 15th to the 31st of Oct.; 10-h day length from the 1st to the 15th of Nov.; 9.5-h day length from the 15th to the 30th of Nov.; 9-h day length from the 1st to the 15th of Dec.).

From the middle of October to the end of November, plants were fertilized four times with a nutrient solution of pH 5.5 and EC 1.7 dSm^{-1} using Terroflex-T (18 N, 8 P_2O_5, 25 K_2O, 3.5 MgO + microelements, Doctor Tarsa, Antalya, Turkey). The irrigation rate depended on the size of the plant and the environmental conditions in the greenhouse. The amount of applied nutrient solution ranged from 0.15 L to 0.45 L per plant daily with a leaching fraction of 15% to 25%. The nutrient solution was provided to the end of November, and thereafter plants were irrigated with water adjusted to pH 5.5 by means of 0.1 M sulfuric acid (H_2SO_4) until the end of the experiment. Nutrient solution was delivered via a drip system with four-outlet emitters of 3 $L \cdot h^{-1}$ capacity (Toro Company, El Cajon, Calif.) with one spigot placed in each pot.

Plant height (from the substrate surface to the top of the plant), plant diameter (average of two measurements taken at the widest and narrowest diameters) and diameter of the lateral shoot (the most developed lateral shoot on each plant was marked) were measured on 9th Dec. On 29th Nov. and 9th Dec. we determined the number of open central cluster per plant (central cluster of greenish-yellow flower clusters called central cluster) and evaluated the percentage of fully colored bracts (bracts colored from 90% to 100% of the area).

The experiment was set up according to a split-split plot design with day length as the main plot, cultivar as the sub-plot and number of laterals as a sub-sub plot. Data were subjected to mixed model analysis of variance (ANOVA) using PROC MIX of the SAS software package to determine the significance of the effects of the main factors (photoperiod, cultivar, and laterals), as well as the presence of interaction. When the effects were significant, mean separation was performed by LSD at $P \leq 0.05$.

RESULTS AND DISCUSSION

Photoperiod had no effect on plant height or diameter or stem diameter of the lateral shoot (data not shown).

Table 1 Effect of cultivar on plant height and diameter, and lateral shoot stem diameter of poinsettia plants on 9th Dec

Tablica 1. Djelovanje sorate na visinu i promjer biljke te promjer lateralnog izboja božićne zvijezde izmjerene 9. prosinca

Treatment *Tretman*	Plant height (cm) *Visina biljke(cm)*	Plant diameter (cm) *Promjer biljke (cm)*	Lateral shoot stem diamete (mm) *Promjer lateralnog izboja (mm)*
Cultivar-*Sorte*			
Cortez White	26.4 b	44.7 a	10.5 a
Christmas Dream	25.2 b	39.7 b	7.1 a
Christmas Wish	31.2 a	39.5 b	7.8 a
Christmas Season	26.9 b	44.7 a	8.9 a
Marble Star	24.2 b	43.1 a	8.9 a

[a)]Means within column for each main factor followed with different letters are significantly different by LSD test at $P \leq 0.05$.

[a)]Vrijednosti u istom redu za svaki glavni faktor označene različitim slovom su značajno različite pri LSD testu kod $P \leq 0.05$.

Plants with five laterals were taller than plants thinned to four laterals, and no other significant effect of the number of laterals on vegetative growth was observed (data not shown). However, we found a significant impact of the cultivar on plant height and diameter (Table 1). The plant height of Christmas Wish was greater than that of other cultivars, while Cortez White, Christmas Season and Marble Star had larger plant canopy diameters than Christmas Dream and Christmas Wish (Table 1). This implies the importance of the cultivar's role in the vegetative growth of poinsettia, as was suggested previously (Goreta et al., 2007).

The number of open central cluster per plant on 29th Nov. was affected by photoperiod and cultivar (Table 2). Short-day conditions enhanced the opening of central cluster compared to natural and long-day photoperiods. Among the cultivars, Christmas Season had more open central cluster per plant than Christmas Wish or Marble Star. On 9th December the interaction between photoperiod and cultivar suggested that the photoperiod had a different impact on the number of opened central cluster in the tested cultivars (Table 2).

Under natural day length, more opened central clusters were observed in Christmas Season compared to the other cultivars, whereas in Marble Star central cluster were not open (Fig. 1A).

Short-day conditions promoted the opening of central cluster in almost all cultivars compared to natural-day conditions, whereas under long-day treatment central cluster were open in all cultivars except Christmas Wish. Furuta (1954) found that chrysanthemums will eventually become reproductive under longer photoperiods, but flowering is not uniform and often buds do not develop normally. The number of laterals affected cyathium opening, as well, with fewer central clusters opened in plants with 5 laterals compared to those with 3 or 4 (Table 2).

Photoperiod, cultivar and their interaction impacted the percentage of fully colored bracts on both evaluation dates (Table 2). Under short-day conditions, Christmas Wish and Marble Star had already achieved 100% fully colored bracts on 29 Nov. (Fig. 1B).

On 9th Dec. Christmas Wish under short- and long-day treatment achieved 40% more fully colored bracts then under natural-day conditions, while Marble Star achieved 100% fully colored bracts under all photoperiod treatments (Fig. 1C). Our results suggested that bract coloration is less sensitive to day length in Marble Star than in other cultivars.

The differences in the percentage of bract coloration among cultivars were, in general, greater under natural- and long-day treatments than under short-day treatment (Fig. 1B and C). Under short-day treatment, the minimum bract coloration was 75%. Short days (10-10.5 h) are required for the proper development of bract color pigments (anthocyanins) of the transition leaves of the inflorescence (Moe et al., 2006).

Table 2 Main effects of photoperiod, cultivar and number of lateral shoots on number of open central cluster and coloration of bracts of poinsettia plants on 29th Nov. and 9th Dec

Tablica 2. Djelovanje fotoperioda, sorte i broja lateralnih izboja na broj otvorenih centralnih klastera-cijatija i obojenosti brakteja zabilježeno 29. studenog i 9. prosinca

Treatments *Tretmani*	Open central cluster (no./plant) *Otvoren centralni klaster - cijatij (br./biljci)*		Fully colored bracts (%) *Potpuno obojane brakteje (%)*	
	29th Novembe r	9th December	29th November	9th December
Photoperiod - *Fotoperiod*				
natural-day *prirodni dan*	0.2 b	0.2 b	68 b	74 b
short-day *kratki dan*	0.4 a	0.8 a	82 a	91 a
long-day *dugi dan*	0.1 b	0.4 b	71 ab	77 b
Cultivar- *Sorte*				
Cortez White	0.3 ab	0.7 a	42 c	47 d
Christmas Dream	0.2 ab	0.3 bc	63 b	76 c
Christmas Wish	0.1 b	0.1 c	84 a	85 bc
Christmas Season	0.4 a	0.6 a	84 a	94 ab
Marble Star	0.1 b	0.5 ab	94 a	100 a
No. of lateral shoots *Br. lateralnih izboja*				
3	0.3	0.5 a	76	82
4	0.2	0.6 a	71	79
5	0.1	0.3 b	73	80
Significance *Signifikantnost*				
Photoperiod (P) Fotoperid	**	*	*	**
Cultivar (C) *Sorta*	*	**	***	***
No. of shoots (S) *Br.lateralnih izboja*	NS	*	NS	NS
P x C	NS	*	***	***
P x S	NS	NS	NS	*
C x S	NS	NS	NS	NS
C x P x S	NS	NS	NS	NS

a)Means within column for each main factor followed with different letters are significantly different by LSD test at $P \leq 0.05$.

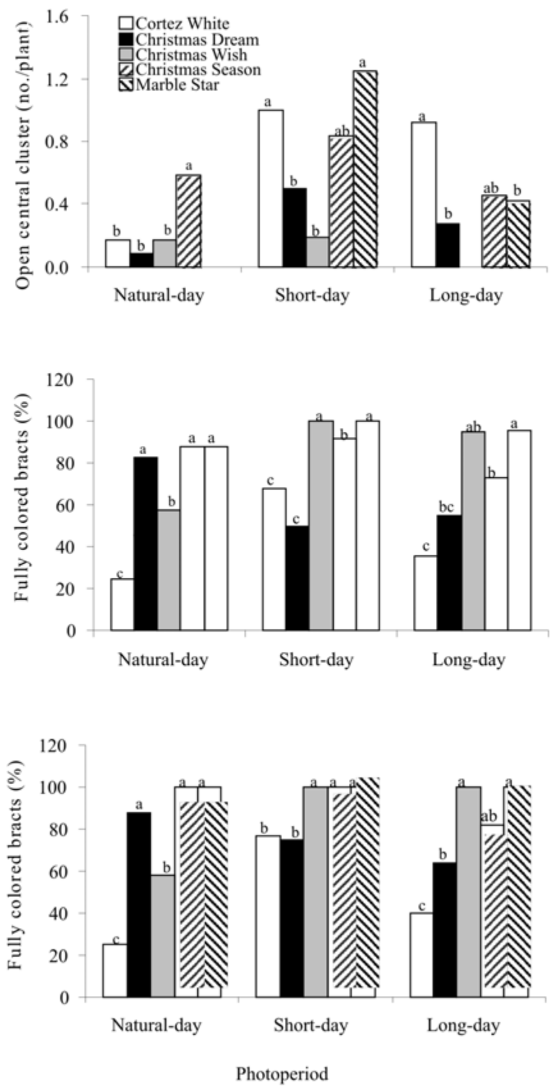
b)Significant effects are denoted as: NS, *, **, ***, nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

a) Vrijednosti u istom redu za svaki glavni faktor obilježene različitim slovom su značajno različite pri LSD testu kod $P \leq 0.05$.

*b) Značajnost je označena kao : NS, *, **, ***, pri $P \leq 0.05$, 0.01, 0.001.*

Fig 1 Effect of cultivar on number of open central cluster per plant on 9th Dec. (A) and percentage of fully colored under natural, short and long day photoperiod on 29th Nov. (B) and on 9th Dec. (C). Means with different letters are significantly different according to LSD test at $P \leq 0.05$

Slika 1. Djelovanje sorate na broj otvorenih cijatija dana 9. prosinca (A) i obojenost brakteja pod utjecajem prirodnog, kratkog i dugog dana zabilježeno 29. studenog (B) i 9. prosinca (C). Vrijednosti obilježene različitim slovom su značajno različite pri LSD testu kod $P \leq 0.05$



The differences among cultivars in the time required for flower initiation and development are probably the reason for variations in bract coloration under the same day-length conditions. On 9th Dec. Cortez White had the lowest percentage of fully colored bracts compared to other cultivars under natural and long day lengths, while this cultivar was similar to Christmas Dream under short-day conditions on both dates (Fig. 1B and C). However, the same cultivar (Cortez White) had among the highest number of open central cluster under short- and long-day treatments (Fig. 1A). A different response was found for Marble Star and Christmas Wish. Marble Star under natural- and Christmas Wish under long-day treatment achieved 100% fully colored bracts, but for the same treatment, we observed no open central cluster. Wang (2003) suggested that the processes leading to the appearance of first color and that leading to the formation of a visible bud are not the same and, according to our results, they are cultivar-dependent also.

CONCLUSIONS

Vegetative growth of poinsettia was affected by cultivar but not by photoperiod or the number of laterals. Short-day conditions generally enhanced the opening of central cluster. Differences among tested poinsettia cultivars were spotted in percentage of bract coloration and were greater under natural - and long-day treatments than under short-day treatment. In the time required for poinsettia flower initiation and development, differences among cultivars were the reason for variations in bract coloration under same day-length conditions.

UTJECAJ FOTOPERIODA, SORATA I BROJA LATERALNIH IZBOJA NA VEGETATIVNI RAST I CVATNJU BOŽIĆNE ZVIJEZDE

SAŽETAK

U radu je praćen utjecaj fotoperioda i broja lateralnih izboja na vegetativni rast, obojenje brakteja te broj otvorenih centralnih klastera cvijeta (cijatija) kod pet sorata božićne zvijezde. Sorte su uzgajane pri tri različite dužine dana: kratki dan (KD, 9 h) dugi dan (DD, 13 h) i prirodni dan (PD; 11-h dužina dana od 15. do 31. listopada.; 10-h dužina dana od 1. do 15. studenog.; 9.5-h dužina dana od 15. do 30. studenog; 9-h dužina dana od 1. do 15. prosinca.). Vegetativni rast bio je pod utjecajem sorte. Kratki dan utjecao je na povećan broj cijatija. Bolja obojenost brakteja zabilježena je kod biljaka uzgajanih pod utjecajem prirodnog i produženog dana nego kod biljaka uzgajanih pri kratkom danu. Vrijeme koje je potrebno za inicijaciju cvatnje svake pojedine sorte najvjerojatnije je bilo razlogom razlike postotka obojenja brakteja pod utjecajem iste dužine dana.

Ključne riječi: dužina dana, sorte, božićna zvijezda, vegetativni rast

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