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BRIEF COMMUNICATION

Photoperiodic induction of flowering in green and photobleached *Chenopodium rubrum* L. ecotype 184 - a short-day plant

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Abstract

Chenopodium rubrum L. ecotype 184 is a qualitative short-day plant with critical length of the night of eight hours that must be exceeded in order to flower: Five days after sowing, the plants were exposed to a various number of inductive cycles (14/10 h of dáy/night cycle) to test the optimal photoperiodic conditions for flowering. In our experimental conditions the plants flowered with high percentage after more than four received inductive cycles, but there was no flowering below that. The plants grown on the herbicide Norflurazon (photobleached plants) showed different photoperiodic characteristics. There was negligible flowering of photobleached plants in the same experimental conditions as for the green ones.

The *Chenopodium rubrum* L. plant is particularly valuable for studies of photoperiodic induction of flowering. The plant is used as a model for testing various aspects related to flowering such as changes in the growth pattern of organs (Ullmann *et al.* 1980), involvement of phytohormones in flowering process (Krekule *et al.* 1989), the effects of florigenic extracts from flowering tobacco plants (Seidlová *et al.* 1990), the action of direct electric current on flowering (Adamec *et al.* 1989, Macháčková *et al.* 1990) and electrophysiological studies of flower induction (Adamec and Krekule 1989).

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It is generally accepted that phytochrome is the primary photoreceptor for flower induction both of long-day and short-day plants (Cleland 1984). As the phytochrome is screened by chlorophyll, herbicide Norflurazon (Sandoz 9789) was used for complete destruction of chloroplast pigments and thus production of photobleached plants. It was shown that Norflurazon affects growth and metabolism of plants, but has no effect on phytochrome reactions and flowering (Jaben and Deitzer 1979, Gorton and Bris 1980, Ćulafić *et al.* 1983, Heyde and Rombach 1988).

The aim of this study was to define optimal conditions for flowering of *Chenopodium rubrum* L. ecotype 184 as early as in the cotyledonary stage and to show participation of phytochrome in induction of flowering. We investigated how the increasing number of induction cycles influenced the growth changes of vegetative organs and flowering in green and Norflurazon-treated plants.

Seeds of *Chenopodium rubrum* L. ecotype 184 (50° 10'N; 106° 35'W) were a gift of Prof. E. Wagner, originally obtained from Prof. B. Cumming's laboratory. Uniform germination of the seeds was obtained according to procedure described previously (Živanović *et al.* 1988). Following the germination the plants were aseptically tranferred into the culture tubes (five plants per tube). Each tube was filled with 6 cm^{-3} 0.62% agar medium in Hoagland's solution No. 1 modified with 10 μg g-1 NaFeEDTA (pH 5.5). Photobleached plants were obtained by supplementing Hoagland's solution with 10 μM herbicide Norflurazon (*Sandoz 9789*) and 0.4 M glucose.

Before the onset of the inductive treatment the plants were kept under non-inductive conditions (18/6 h day/night cycle) in phytotron. Light was provided by white fluorescent tubes (4 × 20W, *Tesla*) in combination with incandescent bulbs (60W, *Tesla*).

Five days after sowing, the plants were exposed to various photoperiodic conditions. The number of inductive cycles (14/10 h of day/night cycle) varied from one to eight. After finishing the photoperiodic treatment the plants were transferred to non-inductive conditions for seven days after which following criteria were determined: length of hypocotyl, length of cotyledon blade and percentage of flowering. An one-way analysis of variance (Student's *t*-test) was performed by means of computer program *Statgrafics.* The significance of differences between non-induced and induced plants as for length of hypocotyl was evaluated at a 95% level. The results are expressed as the mean value ±S.E.

We have tested 824 green and 149 photobleached plants subjected to various photoperiodic treatments. There were eight types of photoperiodic treatments tested where the number of inductive cycles successively increased from one to eight. Each photoperiodic treatment lasted for fifteen days and after that the parameters were determined (Table 1).

Length of hypocotyl was changed with the number of inductive cycles. It was lower after 1, 2 and 8 cycles, higher after 3, 4, 5 and 7 cycles; no significant change was found after 6 cycles (Table 1). Length of cotyledon blade did not show any appreciable differences in relation with the number of inductive cycles. Flowering of the plants showed strong dependence on the number of inductive cycles. There was no flowering of the plants below five inductive cycles. Norflurazon-treated photobleached plants had significantly reduced growth: hypocotyl reached about

24% and cotyledon blade about 31% of those of green plants. Also flowering was severely reduced as compared with the green plants (Table 1). The relationship between the number of inductive cycles, length of hypocotyl and percentage of flowering shown by *Chenopodium rubrum* L. ecotype 184 in our experimental conditions correspond well with many studies confirming relationship between photoperiodic induction of flowering and growth pattern of vegetative organs. Thus in *Chenopodium rubrum* L. ecotype 374 (Krekule 1989) and *Chenopodium murale* L. ecotype 197 (Pavlová *et al.* 1989) overall growth changes, such as hypocotyl elongation and leaf growth inhibition, due to inductive photoperiodic treatment were described. Younger plants of *Chenopodium murale* L. ecotype 197 (Pavlová *et al.* 1989) and *Chenopodium rubrum* L. ecotype 374 (Seidlová and Opatrná 1978) displayed a reduced time of transition from the vegetative to the reproductive phase. Under our conditions of cultivation and photoperiodic treatment, plants older than five days also showed decreased flowering capacity (Živanović and Vučinić 1991) and changes of length of cotyledons were not significant with the number of inductive cycles, as was also the case with *Chenopodium murale* L. ecotype 197 (Pavlová *et al.* 1989).

Table 1. *Chenopodium rubrum* L. ecotype 184 - length of hypocotyl and cotyledon, and percentage of flowering plants exposed to various numbers of inductive cycles and analyzed on the 15th day from the start of photoperiodic treatment.

Parameters	Control	Green plants								Photobleached plants
Number of plants	51	50	96	120	100	75	56	88	188	149
Number of inductive cycles	0	1	2	3	4	5	6	7	8	8
Length of hypocotyl ± S.E.	11.3 ±1.6	8.6 ±1.2	9.2 ±0.9	14.6 ±1.3	13.9 ±1.4	12.2 ±1.4	10.4 ±1.4	14.6 ±1.6	9.2 ±0.7	2.2 ±0.2
Length of cotyledons ± S.E.	5.2 ±0.7	5.2 ±0.7	5.1 ±0.5	5.4 ±0.5	4.9 ±0.5	4.9 ±0.6	4.1 ±0.6	6.4 ±0.7	5.2 ±0.4	1.6 ±0.1
Percent of flowering	0	0	0	0	0	93.3	100.0	100.0	96.8	1.3

Photobleached plants displayed modified photoperiodic response as compared with green controls in the same conditions. The herbicide Norflurazon affected both the overall growth of the plants and the induction of flowering. This was not the case with *Pharbitis nil* (Heyde and Rombach 1988), *Spinacia oleracea* (Ćulafić *et al.* 1983) and *Zea mays* (Gorton and Briggs 1980). It is difficult to say at the moment whether Norflurazon affected phytochrome system in our plants. Taking into account that plants in our experimental conditions have a reduced capacity of complete differentiation of flowers, Norflurazon might have inhibited the realization of received induction rather than the induction of flowering itself. Moreover, the inhibitory effect on flowering might be connected with general growth inhibition.

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