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Proserpinaca: Photoperiodic and Chemical Differentiation of Leaf Development and Flowering[1]

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Summary. *Proserpinaca palustris* L. produced juvenile leaves on 8-hour photoperiods, adult leaves on 12-hour photoperiods, and adult leaves and flowers on 14-hour photoperiods. Treatment of plants growing on 8- and 14-hour photoperiods with gibberellic acid caused stem elongation and inhibited flowering. The treated plants on 8-hour photoperiods produced adult-like leaves.

The semiaquatic angiosperm, *Proserpinaca palustris* L., when maintained on long days, grows erect and produces lanceolate-serrate (adult) leaves, and this is normally followed by floral initiation. Plants on short days tend to grow prostrate, produce highly divided (juvenile) leaves, and do not flower (1). The stem growth response and leaf type produced are modified by temperature with a tendency of plants on short days to grow erect and produce less divided leaves at higher temperatures (1,7). Gibberellic acid treatment causes plants on short days to grow erect and produce leaves with more mesophyll area (7).

The effects of gibberellic acid on leaf shape in other plants are variable. For example, the adult leaf form appears sooner in 1 species of morning glory (3) and 1 species of *Eucalyptus* (6) following treatment with gibberellic acid, while treatment of English ivy with gibberellic acid results in a reversion to the juvenile leaf type in some plants (5). Application of gibberellic acid usually results in flowering of rosette-type long-day plants maintained under non-inductive photoperiods (4). This may be an indirect effect, however, in that it stimulates stem elongation which precedes flowering.

Experimental separation of the processes of adult leaf formation and floral initiation by varying the photoperiod and by treatment with gibberellic acid is described in this paper.

Plants which had been maintained on 9-hour photoperiods and thus producing juvenile leaves were suspended in beakers with the roots in nutrient solution (2). Ten plants, 5 in each of 2 beakers, were given each treatment. Plants were treated with the potassium salt of gibberellic acid (Merck and Co. Inc., Rahway, N. J.) by dipping the shoot systems in 1.0, 10.0, and 100.0 mg/l gibberellic acid containing Dynawet (Dow Chemical Co., Midland, Mich.) at 6 drops per liter. Control plants were dipped in the Dynawet solution. Illumination in the plant growth chambers was with cool white fluorescent lamps with supplementary light from incandescent bulbs. Light intensity at plant level was around 500 ft-c. Temperatures during the light period were 27 ± 1° and during the dark periods were 21 ± 1°. Average increments in stem growth were determined for each group and observations were made on the orientation of the stem, the type of leaf, and the number of nodes with flower buds, if any. The duration of the first experiment was 35 days, while the second was 26 days.

In the first experiment critical photoperiods for adult leaf formation and flowering were approximated by subjecting the plants to photoperiods of 8, 10, 12 or 14 hours. Previous results with less precise temperature control were confirmed in that all plants on photoperiods of 12 and 14 hours produced adult leaves while flower buds were produced only by plants on the 14-hour photoperiod. Hence, the critical photoperiod for adult leaf formation was 10 to 12 hours while that for floral initiation was 12 to 14 hours. Flower buds were formed only in axils of adult leaves. At the temperatures used here, the plants grew erect or semi-erect on all photoperiods.

The effects of gibberellic acid on plants maintained on 8- and 14-hour photoperiods were determined in the second experiment. The treated plants on the 8-hour photoperiods grew erect with an increasingly greater response in stem elongation and development of leaves toward the adult type (figs 1 and 2). No flower buds were formed. Gibberellic acid also stimulated stem growth of plants on the 14-hour photoperiod, but the response was not as great. There was a decrease in flowering with an increasing concentration of gibberellic acid (fig 1). The shape of the adult leaves as formed on the control plants was not affected, but leaves of plants treated with 10.0 and 100.0 mg/l gibberellic acid tended to be somewhat larger than those of the controls. In summary, an increasing concentration of gibberellic acid caused an increasing elongation in all cases, an increasing mesophyll

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growth on 8-hour photoperiods, and decreasing floral initiation on 14-hour photoperiods.

Experiments similar to this one were conducted in a greenhouse with similar results. In 1 greenhouse experiment, treatment of flowering plants with 10.0 and 100.0 mg/l gibberellic acid caused production of short peduncles on the normally sessile axillary flowers. Abortion of anthers was common at these concentrations. Gibberellic acid at 10.0 and 100.0 mg/l soon caused cessation of flowering in these plants. Some inhibition of flowering also occurred in plants treated with 0.1 and 1.0 mg/l gibberellic acid.

In the work reported here, adult leaf formation and floral initiation were separated experimentally on the basis of day length, since adult leaves were produced on a 12-hour photoperiod while adult leaves and flowers were produced on a 14-hour photoperiod. There was also a differential response to gibberellic acid in that it stimulated the formation of an adult-type leaf while it inhibited flowering completely at the higher concentration. *Proserpinaca palustris* is a long-day plant (1) in which flowering is clearly inhibited by treatment with gibberellic acid.

Wallenstein and Albert reported that some leaves of *Proserpinaca palustris* growing on short days and treated at the tips with 1 μg of gibberellic acid increased in mid-blade width (7). Under the conditions of my experiments, plants treated with the higher concentrations of gibberellic acid showed a striking and consistent increase in mesophyll area, approaching the adult leaf in shape. The differences here are probably due to the fact that I dipped the plants in the gibberellic acid solutions and repeated the treatments twice while they applied gibberellic acid to the stem tips in a single treatment. No effects of gibberellic acid on flowering in *Proserpinaca palustris* were mentioned by these authors.

The suggestion of Wallenstein and Albert that there is some kind of phytochrome control over stem elongation and development of adult leaves is logical, since both of these responses are drastically affected by photoperiod. The results here lead to the conclusion that any effect of phytochrome control on leaf shape and stem growth may be on gibberellins or some processes enhanced by gibberellins, as the effects of long photoperiods on these vegetative growth patterns can essentially be replaced with exogenous gibberellic acid. As in long-day rosette plants, application of gibberellic acid causes responses which are associated with development toward the flowering condition. In my experiments with *Proserpinaca palustris,* however, gibberellic acid inhibited the actual floral induction at all concentrations used.

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