PHOTOPERIOD - A GROWER MANAGEMENT TOOL FOR CONTROLLING PLANT GROWTH AND DEVELOPMENT

Photoperiod, which combines the Greek roots for light and duration of time, is the duration of daylight, or the number of hours of light in a 24-hour period. The number of hours of light during a day is referred to as "photoperiod".

In the broadest sense, the photoperiodic response is to either increasing or decreasing daylength. "The important point is that the photoperiod response is not to some arbitrary long or short day (e.g., 8 or 16 hours), but to increasing or decreasing daylength" (Salisbury, 1982).

As our understanding of plant responses to daylength (nightlength) has increased, we have come to realize that it is the length of the uninterrupted dark period that is the critical factor: the "critical night" is the length of the dark period that must be exceeded to induce a shortday response or inhibit a long-day response. Night interruption (also called night-break) by lighting to interrupt the dark period for brief intervals will result in the same plant response as would a long light period, or long daylength. The critical factor is the length of an uninterrupted dark period rather than the length of the light period.

In virtually all cases, plant responses are not triggered by photoperiod alone: plants may have several back-up or fail-safe mechanisms controlling a response, for example the interaction of photoperiod and temperature in the autumn syndrome.

Plant responses to changing photoperiod maintain the plant in synchrony with its environment and prolong its survival. For example, as we move in latitude away from the equator toward one of the poles, the short days of fall that precede winter's low temperatures induce bud dormancy and condition the plant to survive low temperatures.

Plant responses to changes in daylight duration (photoperiod) help us mark the passage of seasons. We are aware of how photoperiod changes with season and with latitude. As long ago as 1852, the suggestion was made that the natural distribution of plants (provenance) was at least partly due to latitudinal variations in photoperiod patterns (Henfrey, 1852).

The importance of provenance and photoperiod on plant growth was confirmed by Hanover and Hart (1979). They evaluated the effect of photoperiod on growth of Norway spruce seedlings from seed collected at two different latitudes. Seedling shoot growth from seed collected at 63° North Latitude (Finland) terminated when daylength fell below 20 hours but seedling shoot growth from seed collected at a more southern location, 49° North Latitude (Germany),
continued until daylength was less than 16 hours. The earlier termination of shoot growth of seedlings from seed collected at the more northern latitudes triggered earlier development of plant winter hardiness to coincide with the earlier onset of winter low temperatures that would occur at that more northern provenance. Provenance can be important in a nursery production scheme. **Plants native to northern climates are more photoperiodic responsive than the same species native to southern areas.** One use of this provenance-related photoperiodic difference would be to grow juvenile northern Red Maple cuttings in protected environments under continuous light. They would continue to grow, "Reaching 5 feet from 6 inch cuttings in one season" (Chapman, 1982).

As growers of nursery plants we have long been aware of provenance and seasonal effects on plant growth and development: Daylength, or photoperiod, is a major factor controlling provenance and seasonal responses. **Photoperiod influences virtually every aspect of a plant's life cycle, and plant responses to photoperiod are so numerous that it is impossible to give an exhaustive list.** However, selected examples of plant responses to photoperiod include: Seed germination, stem elongation, leaf expansion and number, stomatal density on leaves, leaf succulence, anthocyanins in leaves, chlorophyll in leaves, tillering in grasses, branching, rooting of cuttings, bulb formation, flowering, the autumn syndrome usually resulting from photoperiod and temperature interaction (leaf abscission, reduced production of chlorophyll and increased production of other pigments, dormancy and reduced stem elongation, cold resistance), and resumption of growth in spring.

With most photoperiod responses there is generally a critical nightlength at which a transition occurs from one response to another. Examples include flowering versus vegetative growth, seed germination vs seed dormancy, or active plant growth vs dormancy.

The use of long photoperiods (long days/short nights) to extend the growth period of nursery plants has been proven effective by Hanover (1976) for 20 species of conifers and 52 species of broadleaved woody plants. Hanover in 1977 used photoperiodic lighting to extend the natural daylength thereby extending the growth period of blue spruce seedlings. The accelerated-optimal growth (AOG) techniques increased seedling height by 81%. Hanover and Hart (1979) stated, "Perhaps the key element in programming tree growth throughout a production cycle is the use of extended photoperiod or night-interruption with light."

**If photoperiod is so important, why is it not more extensively managed by nursery growers?** A perspective on the importance of photoperiod to growers is provided by Whalley (1977). "From a practical viewpoint, for the production of nursery stock, manipulation of photoperiod has not become a panacea for any one particular operation in plant production, nor has it had the influence on cropping systems that has been seen with floricultural crops such as Chrysanthemum ... **This is probably due, in part to the wide range of species grown, as very few nurserymen grow one single crop, and to the fact that even where responsive species are grown, daylength treatments may not always fit into a production system.**"

However, **when we as growers take over more control**--we introduce plants from one geographical area (provenance) to another, we produce plants out-of-season, and we control more of the plant environmental factors during production--it becomes critical that we
understand how specific environmental factors such as daylength affect the plant's growth and development. For example, plant growth may be inadvertently induced if daylengths are extended beyond their normal ranges at any time during the growing season - especially during the autumn and spring seasons. Street lights and other artificial lights often produce photoperiodic responses in landscape plants. This was shown in 1937 when *Abelia grandiflora* plants close to street lights continued rapid shoot growth well into autumn until shoots were killed by frost. Cathey and Campbell (1973) have prepared lists of species that are particularly sensitive to daylength extension by artificial lighting.

**Literature cited:**


Hanover, James W. and John W. Hart. 1979. Accelerated-optimal-growth of woody ornamental plants (based upon a talk presented by Dr. Hanover, August 24, 1979, at the Ornamentals Northwest Seminars, Portland, OR).


**Additional reading:**


"Two weeks of short days (8 hours) inhibited shoot growth and promoted the onset of dormancy in seedlings of European birch. Seedlings in long days (8 hour daylength plus 2 hours of supplemental light in the middle of the dark period) grew rapidly. Daylength did not effect the rate of root growth."

Blue spruce seedlings enter dormancy within 4 weeks under photoperiods of 12 hours or less. Dormancy is prevented under 12-hour photoperiods with 2-hour light breaks given in the middle of the 12-hour dark period or when grown with 16 hour or greater daylengths. An internal timing mechanism, the plant's phytochrome system, controls dormancy induction, seed germination, flowering, internode elongation and many other "seasonal" plant responses.


"A state of imposed dormancy can be induced in blue spruce seedlings under long days by nitrogen stress and moisture stress. When the stress is relieved, imposed dormancy is removed and seedlings break bud within 2 weeks."

The duration of growth in conifer and other hardwood species can be controlled by environmental factors other than photoperiod including temperature, moisture, and nutrient levels. Environmental factors in addition to light, i.e. temperature, moisture, fertilization, can interact with light to induce dormancy.


"This paper reviews the effects of photoperiod on rooting, growth, and dormancy of woody perennial plants ... The physiological aspects accompanying changes in daylength are discussed."


Low intensity lighting is inexpensive to install and maintain. Its use in propagation of rhododendrons appears to be a practical method to improve rooting on a commercial basis. Low intensity lighting may allow propagation at a time of year that is generally regarded as unfavorable for rhododendrons.

An additional 8 hours light (8 p.m. to 4 a.m.) from low intensity, incandescent lighting promoted rooting of cuttings of *Rhododendron catawbiense* (Michaus), 'Sonata', 'Unique', and 'Mrs. G. W. Leak'. Cuttings were inserted during the first week of February into the propagation beds; root development was evaluated after 16 weeks at which time 100% of the 'Sonata' cuttings were rooted.


This is a comprehensive reference book on the subject of photoperiodism with emphasis on photoperiodic responses and classifications of ornamental plants.

7) GROWTH OF TEN SPECIES OF ORNAMENTAL TREE SEEDLINGS EXPOSED TO DIFFERENT PHOTOPERIODS. 1983. T. K. Broschat and H. M. Donselman (Univ. of

Of the ten species studied, 8 were tropical and 2 were temperate (*Acer rubrum* L. and *Quercus virginiana* Mill. *Acer rubrum* grew continuously under long photoperiods during the autumn and winter, but all growth ceased when natural daylength became shorter than 10.8 hours. Providing long daylength throughout the autumn and winter months in southern Florida (or other protected environment) results in substantial increases in annual growth of *Acer rubrum*. *Quercus virginiana* showed virtually no response to photoperiod, but temperatures below 15°C prevented growth. The phenomenon of greater growth in the spring by plants that received natural daylengths during fall and winter compared to those under long daylength was noted in *Quercus virginiana*. Although long daylength conditions did not promote growth during the cooler winter months, it perhaps prevented natural changes in endogenous chemical growth substances from occurring, thus reducing growth rate the following spring.


"The role of light in *Alstroemeria* flowering is not fully understood. Our data indicate that long photoperiod (16 hour photoperiod from natural 8-hour day extended with low intensity incandescent lighting) as well as supplementary lighting (16 hours daily of high intensity, photosynthetically active lighting) enhanced flowering when low temperature was given first. Photoperiods of 10, 12, 14, 16, 18, 24 hours (8-hour natural day and low-intensity light extension) resulted in greatest increase in number of flower stems with photoperiod of 16 hours.

9) **DEVELOPMENTAL RESPONSES OF ZINNIA TO PHOTOPERIOD**. 1983. Thomas H. Boyle and Dennis P. Stimart (Hort. Dept., Univ. of Maryland, College Park, MD 20742).

"Currently, cut flower production of zinnias is restricted to outdoor areas during the summer and its use as a potted plant has been limited. Our observations indicate that high-quality zinnias can be produced during natural short daylength photoperiods of winter months by controlling photoperiod."

Providing a minimum of 20-25 days of long photoperiod lighting after transplanting resulted in high plant quality (rigid stems, large flower diameter, maximum petalage). The greatest plant response occurred with 12- to 14-hour photoperiods. D day continuation (as opposed to night break or predawn lighting) was most effective


This book is readable and presents information that can be readily applied by the grower. It has two major sections: SUPPLEMENTARY LIGHTING (relatively large amounts of light for twelve or more hours per day to increase plant photosynthesis) and PHOTOPERIODIC LIGHTING (relatively low light levels, sometimes as little as one or two hours per night, to regulate plant development).
Chapters included in part one, supplementary lighting, are: natural radiation in winter, the role of light in supplementary lighting, lamps for supplementary lighting, factors affecting the efficacy of supplementary-lighting systems, and crops.
Chapters included in part two, photoperiodic lighting, are: daylength responses, promoting long-day effects, suitable lamps, application to specific crops.
Five appendices are included: lamp characteristics and maintenance, designing a lighting installation, economies of supplementary and photoperiodic lighting, use of a light meter, temperature and other selected conversion factors.


12) **LIGHTING FOR PLANT GROWTH.** 1972. Elwood D. Bickford and Stuart Dunn. 221 pages. The Kent State University Press. This is one of the most comprehensive textbooks on the subject. While some technological changes have occurred since 1972, the basic principles, which are very well presented by Bickford and Dunn, have not changed.

---

**Pesticide Use** - Due to constantly changing laws and regulations, no liability for the suggested use of chemicals in this Newsletter is assumed by the ONW Newsletter. Pesticides should be applied according to label directions on the pesticide container.

**Permission to Reprint** material appearing in the ONW Newsletter is granted with the request that you credit the source: Ornamentals Northwest Newsletter, date, volume, issue, page numbers. Do not excerpt or reprint in such a manner as to imply the author's endorsement or criticism of a product or concept.

**Nondiscrimination** - The information in the Ornamentals Northwest Newsletter is provided with the understanding that no discrimination is intended and that listing of commercial products implies no endorsement by the authors. Criticism of products or equipment is neither intended nor implied.