# How Does Daylength Affect Flowering of Spring Annuals?

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**Introduction:**

Flower induction of many plant species is synchronized during the year by using changes in day or night length (Garner and Allard, 1920), i.e. flowering can be photoperiodic. Photoperiodic flowering responses can be divided into three general groups (Thomas and Vince-Prue, 1997): short-day plants (SDP), in which flowering is hastened or promoted by longer nights than days; long-day plants (LDP), shorter nights than days promote or hasten flowering; and day-neutral plants (DNP), which flower irrespective of day/night. SDP and LDP photoperiodic groups can be further divided into those species that require a specific minimum or maximum photoperiod for flowering to occur (obligate or qualitative requirement) or those in which flowering is hastened by a specific minimum or maximum photoperiod (facultative or quantitative requirement) (Thomas and Vince-Prue, 1997). Intermediate day plants (IDP) flower only when the daylength is neither too long nor too short (Thomas and Vince-Prue, 1997). These species are rarer and do not represent a significant number of floriculture species.

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The emphasis on scheduling bedding plant flowering has greatly increased. The increased emphasis on scheduling is driven primarily by demands of mass marketers for consistency in product and the presence of flowers when plants are marketed. Similarly, the average consumer prefers to see what the flower looks like when they are purchasing a plant, i.e. flowering plants are a marketing tool. In addition, increased price pressures have led growers to look for methods to hasten flowering and reduce production costs. A lack of application of photoperiod to manipulate growth and flowering of current spring annuals has, in part, been due to the lack of information identifying the photoperiodic classifications of each species.

Clearly, knowledge of how photoperiod and irradiance influence flowering in bedding plants has the potential to decrease flowering time and improve flowering. This paper continues a method developed by Erwin and Warner (2001) to screen plants for response to photoperiod and irradiance.

The results signify the largest study of its kind of floriculture bedding plants since the late 1950's! This research was funded by a number of organizations including the Richard E .Widmer Fund and the Minnesota Nursery and Landscape Association. The second paper in this series will identify how light intensity affects flowering of various herbaceous spring crops.

**Materials and Methods:**

Seed or various species were germinated in a soilless media (Sungrow Sunshine LG3 Germinating Mix, SunGro Horticulture Inc., Bellevue, WA USA) under periodic mist (5 sec every 10 min). Air temperature was maintained at 22-24±2 C. After the seedlings had germinated and cotyledons were horizontal to the media surface seedlings were selected for uniformity and transplanted into 8.9 cm square pots (525 cm3) containing soilless media (Sungrow Sunshine SB300 Universal Mix). Five-seven seedlings of each species were then placed under each of the eight different lighting environments (see below) in a greenhouse maintained at day and night air temperatures 22 and 17C (2000-2001) or 20C and 16C (2001-2002), respectively. Experiments were carried out from October through May of each of the last 2-3 years. Lighting treatments used are shown below:

Plants were watered as needed and fertilized continuously through the irrigation water with a balanced fertilizer (Miracle-Gro Excel 15-5-

15 Cal-Mag, The Scotts Co., Marysville, OH, USA) at a rate of 14.3 mM N. Irradiance and air temperature at plant level were recorded every two minutes under each lighting treatment using a datalogger (Campbell CR10X, Campbell Scientific Inc., Logan, Utah, USA), every ten minutes average readings were recorded on a computer data file. Data were collected on date of first flower and leaf number below the first flower when the first flower opened. Shoot dry mass was also recorded. Plants were classified as 'non-flowering' if flowering did not occur after 16 weeks from placement in greenhouse. Plant placement was randomized under each lighting treatment.

From this experiment we were able to determine how both daylength and light intensity (or irradiance) affected flowering of each of these species. The photoperiod information is presented below. The effect of light intensity on each of these species will be presented in the next bulletin.

**Results:**

Many common bedding plants are photoperiodic! Although this was not a complete surprise, I think we haven't given this fact as much attention as it deserves! Because flowering of many of these plants is affected by daylength, we can program bedding plants to flower just as we commonly program chrysanthemums, poinsettias, and many other potted plants. A complete list of those species studied and their respective photoperiodic groups are shown on pages 8-9 (Table 1).

The challenge is how to take this information and apply it to greenhouse bedding plant production in a way that makes sense. Clearly, these treatments would probably be applied when plants were young and still in the plug trays. We have been making schedules that you can use to precisely schedule each of your crops to flower. This information will be coming out here and in Greenhouse Grower magazine.

Let's consider how we might use this information! If we know that long-days stimulate flowering we can light plants early to insure that flowering occurs when we want. For instance, although Lavatera is a great plant it is rarely sold because it is never in flower in May and people don't see the flowers. If you provide early long-days, you can have early flowering in Lavatera. In contrast, you can get early flowering of cosmos, zinnia, and Gomphrena by providing early short-days. The only crop we currently regularly give a short-day treatment in commercial bedding plant production is African Marigold because if it does not receive short-days it will not flower. In contrast, plug growers now light most crops. This may be helpful with some species, but may induce premature

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## LIGHTING TREATMENTS

(average light levels were from 2001-2002 years only):

1.) Short-day (8 hour photoperiod, ambient daylight 0800-1600 HR, average 12.7 moles m-2 d-1, average air temperature at plant level 19.8 C).
2.) Short-day + 50 µmol m-2 s-1 using high-pressure sodium lamps from 0800-1600 HR (+1.44 moles m-2 d-1, temperature 19.9 C)
3.) Short-day + 100 µmol m-2 s-1 using high-pressure sodium lamps from 0800-1600 HR (+2.88 moles m-2 d-1, temperature 20.4 C)
4.) Short-day + 150 µmol m-2 s-1 using high-pressure sodium lamps from 0800-1600 HR (+4.32 moles m-2 d-1, temperature 20.8 C)
5.) Long-day (natural photoperiod + night interruption lighting from 2200-0200 HR using incandescent lamps (2 µmol m-2 s-1), temperature 19.5 C)
6.) Long-day + 50 µmol m-2 s-1 using high-pressure sodium lamps from 0600-0000 HR (+3.24 moles m-2 d-1, temperature 20.2 C)
7.) Long-day + 100 µmol m-2 s-1 using high-pressure sodium lamps from 0600-0000 HR (+6.48 moles m-2 d-1, 20.1 C)
8.) Long-day + 150 µmol m-2 s-1 using high-pressure sodium lamps from 0600-0000 HR (+9.72 moles m-2 d-1, 22.0 C)

**Many common bedding plants are photo-periodic! Although this was not a complete surprise, I think we haven't given this fact as much attention as it deserves!**

**Table 1.** The effect of photoperiod on flowering of several herbaceous spring annual crops in temperate North America. Photoperiodic groups are obligate long-day plant (OLDP; plants must have long-days to flower), facultative long-day plant (FLDP; long-days hasten flowering), obligate short-day plant (OSDP; plants must have short-days to flower), facultative short-day plant (FSDP; short-days hasten flowering), and day-neutral plant (DNP; daylength does not affect flowering). Treatments were applied for 16-20 weeks only. Table complied from information presented in Erwin et al., 2000, Erwin and Warner, 2001, Erwin, 2000, and Mattson, 2002.

| Common Name | Latin Name | Photoperiodic Group |
|---|---|---|
| Strawflower | *Acroclinium roseum* L. | OLDP |
| Ageratum | *Ageratum houstonianum* L. 'Blue Danube' | FLDP |
| Amaranthus | *Amaranthus hybridus* L. 'Pygmy Torch' | DNP |
| Ammi | *Ammi majus* L. | OLDP |
| Dill | *Anethum graveolens* L. 'Mammoth' | OLDP |
| Snapdragon | *Antirrhinum majus* Schott. 'Floral Showers Crimson' | FLDP |
| Asperula | *Asperula arvensis* L. 'Blue Mist' | OLDP |
| Calendula | *Calendula officinalis* 'Calypso Orange' | FLDP |
| Chinese Aster | *Callistephus chinensis* | OLDP |
| Carpanthea | *Carpanthea pomeridiana* L. 'Golden Carpet' | DNP |
| Catananche | *Catananche caerula* L. Per. 'Blue' | OLDP |
| Plumed Celosia | *Celosia plumose* L. 'Flamingo Feather Purple' | OSDP |
| Bachelor's Buttons | *Centaurea cyanus* L. 'Blue Boy' | OLDP |
| Centranthus | *Centranthus macrosiphon* Boiss. | DNP |
| Cleome | *Cleome hasslerana Chodat*. 'Pink Queen' | FLDP |
| | 'Rose Queen' | DNP |
| Cup and Saucer Vine | *Cobea scandens* Cav. | DNP |
| Collinsia | *Collinsia heterophylla* Buist | FLDP |
| Convolvulus | *Convulvulus tricolor* L. 'Blue Enchantment' | DNP |
| Cosmos | *Cosmos bipinnatus* Cav 'White Sensation' | FSDP |
| Cosmos | *Cosmos bipinnatus* Cav 'Diablo' | FSDP |
| Dianthus | *Dianthus chinensis* L. 'Ideal Cherry Picotee' | FLDP |
| African Daisy | *Dimorphotheca aurantiaca* DC. | DNP/FLDP |
| | 'Mixed Colors' | DNP |
| | 'Salmon Queen' | OLDP |
| Hyancinth Bean Vine | *Dolichos lablab* L. | OSDP |
| California Poppy | *Eschscholzia californica* Cham. 'Sundew' | FLDP |
| Fuchsia | *Fuchsia x hybrida* 'Dollar Princess' | OLDP |
| Gartenmeister Fuchsia | 'Gartenmeister' | DNP |
| Gazania | *Gazania rigens* L. 'Daybreak Red Stripe' | OLDP |
| Globe Amaranth | *Gomphrena globosa* L. 'Bicolor Rose' | FSDP |
| Sunflower | *Helianthus annus* 'Vanilla Ice' | FLDP |
| Helipterum | *Helipterum roseus* Hook. | OLDP |
| Impatiens | *Impatiens wallerana* | DNP |
| New Guinea Impatiens | *Impatiens hawkeri* | DNP |
| Moonflower | *Ipomea x multifida* 'Scarlet' | FSDP |
| Ipomopsis | *Ipomopsis rubra* Wherry 'Hummingbird Mix' | OLDP |
| Sweet Pea | *Lathyrus odoratus* L. 'Royal White' | OLDP |
| Lavatera | *Lavatera trimestris* L. 'Silver Cup' | OLDP |
| Legousia | *Legousia speculum-veneris* Chaix | OLDP |
| Leptosiphon | *Leptosiphon hybrida* Benth. | OLDP |
| Limnanthes | *Limnanthes douglasii* R. Br. | OLDP |

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|---|---|---|
| Statice | *Limonium sinuatum* (L.) Mill. 'Fortress Deep Rose' | FLDP |
| | 'Heavenly Blue' | FLDP |
| Linaria | *Linaria maroccana* Hook. F. | FLDP/DNP |
| Flax | *Linum perenne* L. | OLDP |
| Lobelia | *Lobelia erinus* L. Crystal Palace' | OLDP |
| Stock | *Mathiola longipetala* Venten. 'Starlight Scentsation' | DNP |
| Monkey Flower | *Mimulus x hybridus* L. 'Magic' | OLDP |
| Mina Vine | *Mina lobata* Cerv. | OSDP |
| Four O' Clock | *Mirabilis jalapa* L. | OLDP/DNP |
| Nemophila | *Nemophila maculate* Benth. Ex Lindl. 'Pennie Black' | DNP |
| Nemophila | *Nemophila menziesii* Hook. & Arn. | DNP |
| Nierembergia | *Nierembergia caerula* | OLDP |
| Flowering Tobacco | *Nicotiana alata* Link & Otto 'Domino White' | DNP |
| Love In The Mist | *Nigella damascena* L. 'Miss Jekyll' | OLDP |
| Basil | *Ocimum basilicum* | FLDP |
| Primrose | *Oenothera pallida* Lindl. 'Wedding Bells' | OLDP |
| Oregano | *Origanum vulgare* L. | DNP |
| Poppy | *Papaver rhoeas* L. | DNP |
| Petunia | *Petunia x hybrida* 'White Storm' | FLDP |
| | 'Fantasy Pink Morn' | OLDP |
| | 'Purple Wave' | OLDP |
| Phacelia | *Phacelia campanularia* A. Gray. | DNP |
| Phacelia | *Phacelia tanacetyifolia* Benth. | FLDP |
| Morning Glory | *Pharbitis nil* 'Violet' | FSDP |
| Platystemon | *Platystemon californicus* | OLDP |
| Polemonium | *Polemonium viscosum* Nutt. | OLDP |
| Reseda | *Reseda alba* | FLDP |
| Rudbeckia | *Rudbeckia hirta* L. 'Indian Summer' | OLDP |
| Salpiglossus | *Salpiglossus sinuata* | FLDP |
| Blue Salvia | *Salvia farinacea* Benth. 'Strata' | FLDP |
| Salvia | *Salvia splendens* F. Sellow ex Rhoem. & Schult. 'Vista Red' | FLDP/DNP |
| Creeping Zinnia | *Sanvitalia procumbens* Lam. | FSDP |
| Silene | *Silene armeria* L. | OLDP |
| | 'Elektra' | OLDP |
| African Marigold | *Tagetes erecta* | OSDP |
| French marigold | *Tagetes patula* | DNP |
| Signet Marigold | *Tagetes tenuifolia* | OSDP |
| Black-Eyed-Susan Vine | *Thunbergia alata* Bojer. | DNP |
| Mexican Sunflower | *Tithonia rotundifolia* Mill. 'Fiesta Del Sol' | FLDP |
| | 'Sundance' | FSDP |
| Tweedia | *Tweedia caerula* D. Don 'Blue Star' | DNP |
| Verbascum | *Verbascum phoeniceum* L. | DNP |
| Viguiera | *Viguiera multiflora* S.F. Blake | FLDP |
| Pansy | *Viola x wittrockiana* | FLDP |
| Zinnia | *Zinnia angustifolia* | DNP |
| Zinnia | *Zinnia elegans* Jacq. 'Exquisite Pink' | FSDP |
| | 'Peter Pan Scarlet' | FSDP |

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flowering which can reduce crop quality with other species such as asters.

How do we provide long-day treatments? The most economical way to provide long-day treatments is to give plants a night interruption lighting treatment from 10 pm to 2 am. In the past growers have usually used incandescent light bulbs. The problem with incandescent light bulbs is that they can stimulate stem elongation. Therefore, interrupting the night with either high pressure sodium lamps or with the new 'screw-in' fluorescent bulbs is preferred. A minimum of 10 footcandles of light is needed at plant level.

How do we provide short-day treatments? The easiest way to provide short days is to pull a reflective opaque cloth over plants at the end of the day and removing the cloth in the morning. In general, you want to only allow plants to have an 8-10 hour days. Take care to not let temperatures under the cloth get too hot or 'heat delay' can occur. Heat delay refers to high night temperature inhibition of flowering. This can occur when night temperatures exceed 72-74oF with some species such as Gomphrena. For this reason, some growers choose to pull cloth later in the day and remove the cloth later in the morning to reduce potential heat buildup under the cloth.

## Application:

Below I listed some common issues or case studies in bedding plant production and some ways you might use this new photoperiod information to solve those problems!

## Case Studies:

We want dill to keep producing leaves and not go to seed.

Solution: Grow under short day conditions – it is an OLDP (see definitions below).

Why do celosia flower early in the seed tray sometimes?

Solution: When celosia germinate early in spring when daylength is short (before March 21), we may be inadvertently causing early flowering – provide long days to keep seedlings vegetative longer – celosia is a FSDP.

How do you get cosmos to flower early?

Solution: Cosmos is a FSDP – provide short days – pull black cloth to get earlier flowering.

How do you get early flowering of Dianthus for April sales?

Solution: Light dianthus early to provide long days during March – it is a FLDP.

How do you get gazania, Love-In-The-Mist, lobelia, statice, Monkey Flower and 'Indian Summer' Rudbeckia to flower early?

Solution: Light early to provide long days since these crops are all OLDP.

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