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INSIDE THIS ISSUE:

Day Length Effects on Bedding Plant Flowering I 1-5

Fundamentals of Flowering in Plants: Supplemental Lighting and Earliness of Flowering! 6-9

The Search for Wild Gaura, Part II 10-11

Trends in Garden Mums- Past, Present, and Future 11-14

Member Services: Garden Center Trays 15

Day Length Effects on Bedding Plant Flowering I

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Introduction:

In the last two articles we reviewed 1) that plants have an early stage (juvenile) when they are not capable of flowering and a later stage (mature) when they are capable of flowering, and 2) how light intensity or irradiance affects the length of the juvenile stage of many bedding plants. In the next two articles we will present research results on how day length affects flowering of different bedding plant species. The last article will focus on pulling all this information together to apply it in your greenhouse.

As I mentioned before, we started working on how day length or photoperiod affects bedding plant flowering after we received two telephone calls; one from Terry Smith in Bellingham, Washington asking how to induce petunias to flower earlier for early season sales promotions in the Pacific Northwest; and one call from Ron Wagner in Minneapolis, Minnesota asking how to delay flowering of pansies germinated and grown in the summer in Minnesota for sales in the Southern U.S. After some checking in the literature we realized how little work has been done on how day length affects flowering of many of the common bedding plants we grow. In fact the last major research effort was conducted during the late 1950's and early 1960's by John Seeley and H. Marc Cathey!

What we found, in short, was that day length affects flowering of many common bedding plants. In addition, we believe, we stopped growing many of the 'old fashioned' bedding plants such as 'Love-In-The-Mist' (Nigella) and lavatera because we could not get them to flower in spring (Nigella is a long-day plant). The information we are generating will allow growers to precisely schedule flowering of their bedding plant crops in the same way that chrysanthemums and other potted plants are scheduled year round. This will likely improve plant quality and allow growers to schedule plants to flower when they want to maximize profits. This and the next article will present results on a number species we have studied so far.

Flowering Responses To Photoperiod:

Plant flowering responses to day length, or photoperiod, can be divided into three distinct groups: **short-day, long-day,** and **day-neutral** flowering responses.

a) Short-day plants require a night length longer than a specific number of hours for flower induction to occur.
b) Long-day plants require a night length shorter than a specific number of hours for flower induction to occur.
c) Day-neutral plant flower induction is unaffected by day length.

Within the short and long-day photoperiodic groups, plants can have a **facultative** (quantitative) or

Continued on page 2

Continued from page 1

an **obligate** (qualitative) response.

a) Flowering of plants with a facultative response is hastened by the identified photoperiod.
b) In contrast, plants with an obligate response must have the identified photoperiod to flower.

Commercial potted plant growers have used photoperiod or day length manipulation to induce flowering of short-day plants year round for quite some time. For instance, *Dendranthemum grandiflora* Ramat. (chrysanthemum) flowering is induced by pulling a cloth over plants at the end of the day and pulling it back in the morning to provide a short-day environment during long-day periods of the year (late spring, summer and early fall). The understanding that mums are short-day plants allowed a year round potted mum industry to develop.

Although John Seeley (1989) classified a number of bedding plant species into photoperiodic response groups, manipulation of day length to affect flowering of bedding plants is rare in the industry. Perhaps the only common use of photoperiod manipulation in spring bedding plant production is the common practice of shading (pulling black cloth over) the obligate short-day plant *Tagetes erecta* L. (African marigold) seedlings when germinated after mid-March (in temperate regions) to insure flowering when days are naturally long (inhibitory to flowering). Similarly, we have seen some growers light fuchsia baskets prior to April 1 to induce earlier flowering; most fuchsia are long-day plants and naturally induce flowers after March 21 each year and flower at or around Mother's day. Earlier fuchsia flowering is beneficial for advanced baskets sales. Although there has been some manipulation of photoperiod to schedule flowering in bedding plants, the industry has not shown interest in the topic until recently as mass marketers have demanded greater emphasis on scheduling. In addition, increased price pressures have led growers to hasten flowering to reduce production costs. Lastly, a lack of application of photoperiod to manipulate flowering of spring annuals has, in part, been due to the lack of information showing how day length affects flowering of each of the current bedding plant species and cultivars.

Figure 1a and b. The effect of day length (8 hour (black clothed from 1600-0800 HR) and 18 hour (daylight plus supplemental lighting from 0800-0200 HR)) and increasing light intensities on *Celosia plumosa* 'Flamingo Feather Purple' (a) and *Cosmos bipinnatus* 'Sensation White' (b) flowering. Plants were grown with a 68°F day and 65°F night temperature under ambient daylight conditions with or without supplemental high-pressure sodium lighting (0, +25 *u*mol m^{-2} s^{-1} (approx. 125 footcandles), +50 *u*mol m^{-2} s^{-1} (approx. 250 footcandles). Note that cumulative molar levels are for the 18 hour photoperiod.

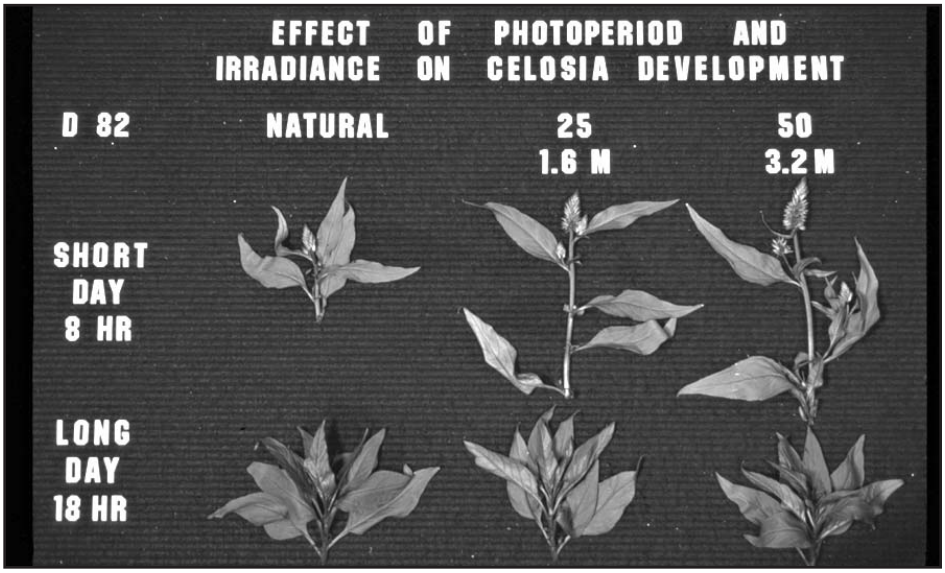

Figure 1a

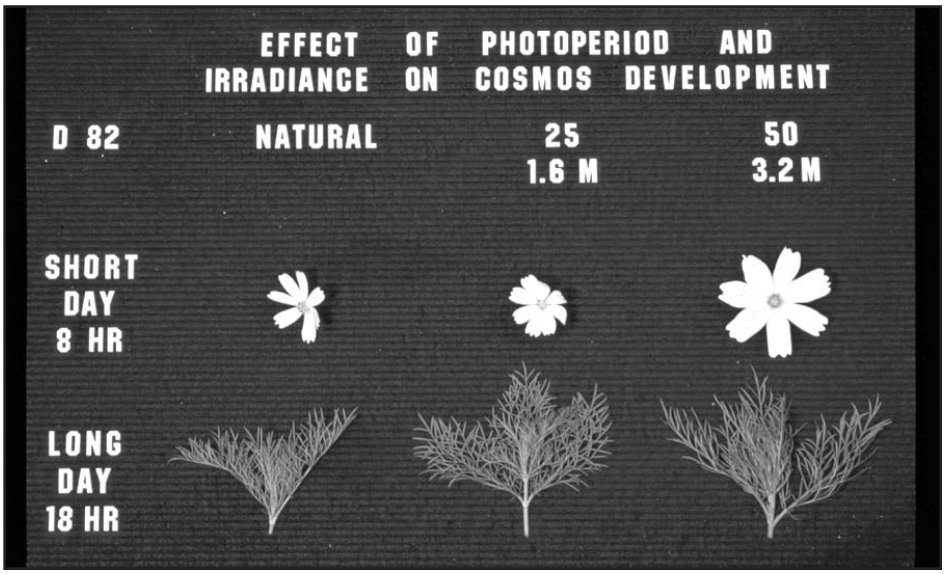

Figure 1b

Short-Day Plants:

As mentioned before, short-day plants flower when night length exceeds a certain number of hours. Chrysanthemums and poinsettias are

Continued on page 3

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examples of common short day potted plants because they induce flowers naturally as nights get longer after June 21 and into the fall. We found few short-day plants among common bedding plants grown (Table 1). Plumed Celosia (*Celosia plumosa*) is a facultative short day plant. In other words, plumed celosia will flower more quickly if grown under short days! I can't help but think that some of the very early undesirable flowering that is common in celosia seedlings in early spring is because young seedlings receive short days before March 21st and induce flowers too early. In contrast, we found that Mina Vine (*Mina lobata*) and Hyacinth Bean (*Dolichos lablab*) are obligate short day plants, i.e. the plants will not flower unless they receive short-days. This is why hyacinth bean vine and mina vine do not flower until September in Minnesota because seedlings germinate under long days and don't initiate flowers until fall. Similarly, Morning Glory *(Pharbitis nil,* facultative/obligate short day plant) will have delayed flowering if early seedling growth occurs under long days. It is very possible to have blooming Morning Glory, Hyacinth Bean vine and Mina vine plants for sale in April with the right short-day treatments!

Long-Day Plants:

Most bedding plants are long-day plants (Table 1). We found facultative and obligate long-day plants. Some of the facultative long-day plants we found include pansies (*Viola x wittrockiana*), Mexican Sunflower (*Tithonia rotundifolia* 'Sundance') and Blue Salvia (*Salvia farinacea* 'Strata'). Facultative long-day plants flower earlier when grown under long-day versus short-days conditions.

In contrast to facultative long-day plants, we also found many obligate long-day plants including Bachelor's Buttons (*Centaurea cyanus* 'Blue

Figure 2. The effect of day length (8 hour (black clothed from 1600-0800 HR) and 18 hour (daylight plus supplemental lighting from 0800-0200 HR)) and increasing light intensities on *Lavatera trimestris* (Lavatera) flowering. Plants were grown with a 68°F day and 65°F night temperature under ambient daylight conditions with or without supplemental high-pressure sodium lighting (0, +25 *u*mol m^{-2} s^{-1} (approx. 125 footcandles), +50 *u*mol m^{-2} s^{-1} (approx. 250 footcandles). Note that cumulative molar levels are for the 18 hour photoperiod.

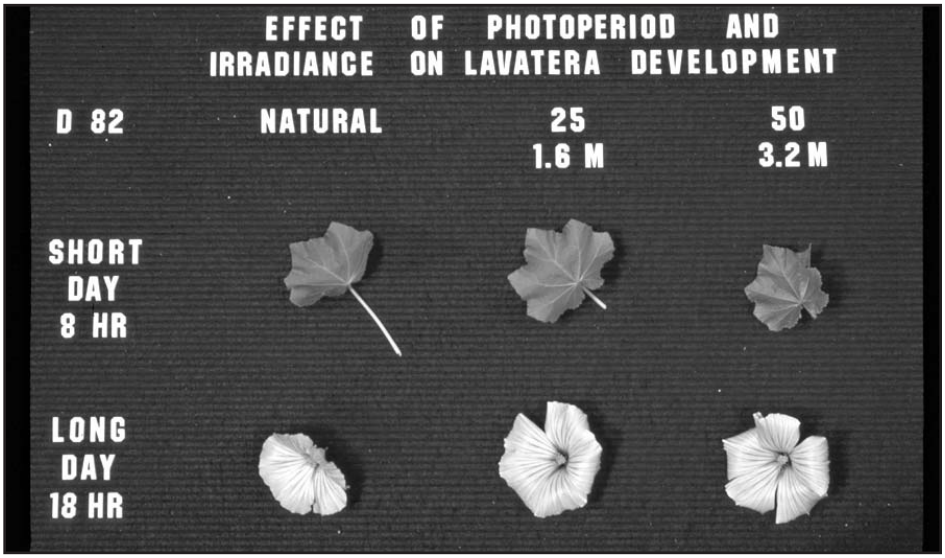

Table 1. Photoperiod and irradiance classifications of several bedding plant species.

Plant	Latin Name	Photoperiod Group
Amaranthus	*Amaranthus hybridus* 'Pygmy Torch'	Day neutral
Ammi	*Ammi majus*	Obligate Long Day
Celosia	*Celosia plumosa* 'Flamingo Feather Purple'	Obligate/Facultative Short Day
Cup and Saucer Vine	*Cobaea scandens* 'White'	Day Neutral
Cosmos	*Cosmos bipinnatus* 'Sensation White'	Facultative Short Day
Hyancynth Bean Vine	*Dolichos lablab*	Obligate Short Day
California Poppy	*Eschscholzia californica* 'Sundew'	Obligate Long Day
Foam and Eggs Flower	*Limnanthes douglasii*	Obligate Long Day
Statice	*Limonium sinuata* 'Heavenly Blue'	Facultative Long Day
Flax	*Linum perenne*	Obligate Long Day
Stock	*Matthiola longipetala* 'Starlight Scentsation'	Day Neutral
Oxypetalum	*Oxypetalum caerulea* 'Blue Star'	Day Neutral
Purple Wave Petunia	*Petunia x hybrida* 'Purple Wave'	Obligate Long Day
Dream's Red Petunia	*Petunia x hybrida* 'Dream's Red	Facultative Long Day
Blue Salvia	*Salvia farinacea* 'Strata'	Facultative Long Day
Silene	*Silene armeria* 'Elektra'	Obligate Long Day
Black Eyed Susan Vine	*Thunbergia alata*	Day Neutral
Mexican Sunflower	*Tithonia rotundifolia* 'Sundance'	Facultative Short Day
Pansy	*Viola x wittrockiana* 'Delta Pure White'	Facultative Long Day
Pansy	*V.* x *wittrockiana* 'Crystal Bowl Supreme Yell.	Facultative Long Day

Continued on page 4

Continued from page 3

Boy'), California Poppy (*Eschscholzia californica* 'Sundew'), and Purple Wave Petunia (*Petunia x hybrida* 'Purple Wave'). Obligate long-day plants only flower when grown under long days. Growers often have delayed flowering when growing obligate long-day plants under natural daylight as some of these plants such as Rudbeckia hirta 'Indian Summer' will only flower when day length is quite long, i.e. July.

Long days can be delivered by extending the day with lights or by interrupting the night with lights. For instance, many plug growers extend the day with high pressure sodium lamps – this will hasten flowering of long-day plants in most cases (depends on the length of the day extension). In contrast, a grower could interrupt the night with lighting from 10 pm to 2 am; this will stimulate flowering of all long-day plants once they are past the juvenile phase. How to choose between these two options is discussed later in this article.

Day-Neutral Plants

A number of bedding plants are day-neutral plants (Table 1). These species do not care if they are grown under short- or long-days with respect to flowering; they flowered under either photoperiod. For instance, Amaranthus (*Amaranthus hybridus* 'Pygmy Torch'), Stock (*Matthiola longipetala* 'Starlight Scentsation'), and Black Eyed Susan Vine (*Thunbergia alata*) are all day-neutral plants (Table 1). They will have the same number of leaves below the first flower regardless of what day length they are grown under. However, remember that some day-neutral flowering response plants have a 'facultative irradiance' response and will flower earlier as the total amount of light plants receive increases during the day. For instance, seed geraniums are day-neutral plants but we commonly light them to hasten flowering because they have a facultative irradiance response and will flower earlier as total daily light increases.

Figure 3. The effect of day length (8 hour (black clothed from 1600-0800 HR) and 18 hour (daylight plus supplemental lighting from 0800-0200 HR)) and increasing light intensities on Cleome hasslerana 'Queen Pink' flowering. Plants were grown with a 68°F day and 65°F night temperature under ambient daylight conditions with or without supplemental high-pressure sodium lighting (0, +25 *u*mol m^{-2} s^{-1} (approx. 125 footcandles), +50 *u*mol m^{-2} s^{-1} (approx. 250 footcandles). Note that cumulative molar levels are for the 18 hour photoperiod.

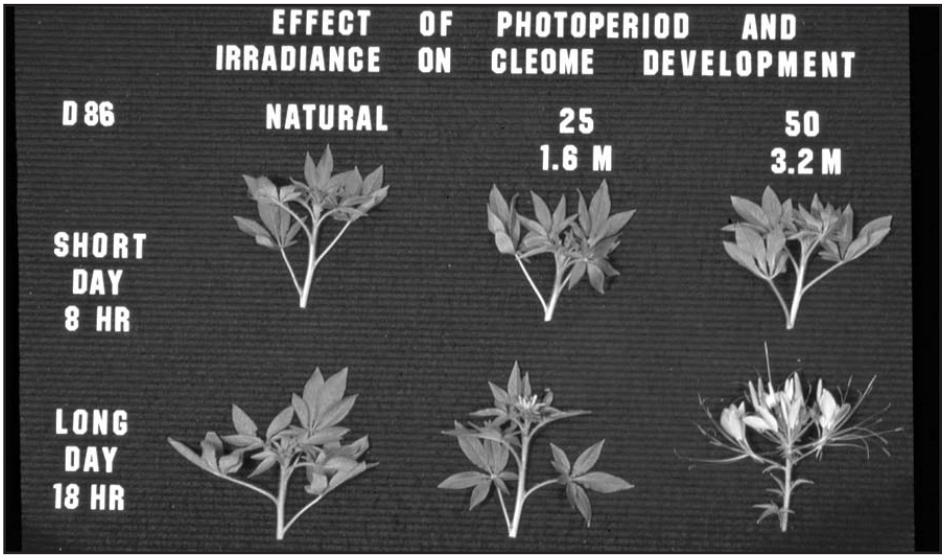

Table 2. Photoperiod treatment effects on day to flower when plants were grown with a 68°F day temperature and a 65°F night temperature under natural daylight conditions for Sta. Paul, Minnesota during March and April (approx. 13 moles of light per day). Short day treatment was natural days shortened to 8 hours by pulling a black cloth over plants. Long day treatments were natural days plus a 4 hour night interruption using incandescent lamps from 2200-0200 hr (10 pm to 2 am). Night interruption light intensity was 10 footcandles.

Plant		Short Day	Long Day
Amaranthus	Day Neutral	17 days	17 days
Ammi	Obligate Long Day	–	48 days
Cup and Saucer Vine	Day Neutral	100 days	92 days
Cosmos	Facultative Short Day	33 days	89 days
Hyancynth Bean Vine	Obligate Short Day	59 days	–
California Poppy	Obligate Long Day	–	70 days
Foam and Eggs Flower	Obligate Long Day	–	125 days
Statice	Facultative Long Day	89 days	58 days
Flax	Obligate Long Day	–	91 days
Stock	Day Neutral	91 days	63 days
Oxypetalum	Day Neutral	100 days	92 days
Petunia 'Dreams Red'	Facultative Long Day	57 days	41 days z
Petunia 'Purple Wave'	Obligate Long Day	–	74 days z
Blue Salvia	Facultative Long Day	125 days	98 days
Silene	Obligate Long Day	–	67 days
Black Eyed Susan Vine	Day Neutral	46 days	46 days
Mexican Sunflower	Facultative Short Day	59 days	69 days
Pansy	Facultative Long Day Plant	52 days	41 days z

Z grown at constant 68oF.

Continued on page 5

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So What Does This Mean For You?

The bottom line is that you can achieve the fastest flowering if you place seedlings in the appropriate day length environment after seedlings are mature (Table 2). For instance you can decrease days to flower from 89 to 33 days with cosmos by placing seedlings under short days compared to long days (Table 2) (cosmos is a facultative short day plant). You have to be very careful with when scheduling very early flowering because you many stimulate flowering on a seedling before it reaches a size to support large and numerous flowers. For instance, it is a common problem for growers to have asters (obligate long-day plant) that bloom too early when they are lighted in the plug tray. This reduces plant quality for the consumer. To improve finished aster plant quality, place young seedlings under short-day conditions to delay flowering for 2-3 weeks after germination and then place the seedlings under long day conditions to stimulate flowering. This will result in a much higher quality plant when plants flower and better garden performance for the consumer.

In contrast, if you want to delay flowering of celosia (facultative short-day plant), place them under long days for 2-3 weeks after germination! This will eliminate the problem with celosia flowering too early in the plug tray. Remember though that drought stress is also believed to induce premature celosia flowering.

In contrast, if you want blue salvia to flower earlier, place it under long day conditions since blue salvia is a facultative long-day plant; plants will flower in 98 days instead of 128 days when plants are grown under short days. You might also remember from the previous articles, that blue salvia is a facultative irradiance plant. In other words, adding supplemental lighting can hasten flowering still more! Therefore, give long-days using high pressure sodium lamps and provide either a night interruption or extend the day to 16 hours.

In the last article we will try to pull all this together and offer some different ways that you can use this information to program your crops in your greenhouse. In addition, some pre-finishing strategies will be presented for plug growers to potentially produce pre-finished seedling for different uses, i.e. finishing containers.

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