Teaching Methods

New Methodology to Teach Floral Induction in Floriculture Potted Plant Production Classes

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Additional index words. education, floriculture, flower bud initiation, flower bud development, flowering, teaching methodology

Summary. The increasing number of crops being grown for the floriculture market has frustrated educators faced with limited classroom and laboratory time. Time constraints necessitate selection of crops to serve as examples of floral induction treatment(s) and provide an accurate scope of production requirements for all cultivated species. Since flowers are the primary reason for purchasing most floricultural products—with the notable exception of cut and potted foliage—the various treatments required for flower bud initiation and development were used to categorize potted plants. New and old crops (>70 species) are categorized for flower bud initiation and development requirements, including photoperiod (short, long day, day neutral; facultative/obligate responses), vernalization, temperature, autonomous, rest period, and dormancy. Crop-specific temperature, irradiance, and photoperiod interactions are noted, as well as temperature × photoperiod interactions. A course syllabus can be modified to ensure that at least one crop from each category is presented to serve as a model. It is recommended that the class focuses on example crop(s) from each floral induction category and then reviews other crops within each category for differences or similarities. This method allows coverage of floral induction categories without leaving information gaps in the students' understanding. This method was used with students in the Fall 1999, floriculture production class (Hort 4051) at the University of Minnesota, St. Paul.

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Students enrolled in floriculture production classes (potted plants, cut flowers, or bedding plants) are routinely taught production requirements with a crop-specific emphasis. Course syllabi commonly cover the major crops, with selective coverage of minor crops (Anderson, 1999; Fonteno, 1999; Haynes, 1999). Consequently, students spend a high percentage of their study time learning crop-specific temperature, photoperiod, propagation, flowering, and plant growth substance requirements, as well as disease/insect control strategies. Commonly used floriculture text or reference books are organized with this type of information delivery system (Ball, 1998; Dole and Wilkins, 1999; Larson, 1980). However, there are more floricultural crops on the market than can be covered in any production class. The domestication of new crops has recently become a major emphasis within the floriculture industry (Fletcher, 1994; Janick, 1999; Janick and Simon, 1993). While no publications have reported the number of new taxa being domesticated and introduced into the floriculture market each year, more than 100 new crop species have been introduced in the past decade (N. Anderson, unpublished data) and this rate is unlikely to decline (Reichard and Hamilton, 1997).

The influx of new crops, requiring additional classroom and laboratory time, necessitates dropping traditional crops to cover newer ones. Ultimately, students study a decreasing fraction of floricultural crops and learn the additional crops on their own or during employment. This dilemma necessitates considering a revision of current teaching methodology.

Since flowers are the primary reason for purchasing most floricultural products—with the notable exception of cut and potted foliage—the various treatments required for flower bud initiation and development were used to categorize potted plants. A similar method has been used with bedding plants (Armitage, 1994; Dole and Wilkins, 1999; Erwin, et al., 2000; Seeley, 1985, 1989), the largest sector of the floriculture market (USDA, 1999), and with other flowering plants (Bickford and Dunn, 1972; Hanan, 1998; Salisbury, 1982). To the best of our knowledge, no summary tables have been created for potted plants to complement crop production education. In potted plant production classes, educators and students rely on the extensive crop production information contained in the standard floriculture textbooks and this paper is not meant to replace this reference material (Anderson, 1999; Ball, 1998; Dole and Wilkins, 1999; Fonteno, 1999; Haynes, 1999; Larson, 1980). The purpose of this paper is to present reference tables on floral induction and delineate their potential use(s) in potted plant production classes.

Floral induction treatments as a template for education

Pedagogy in floriculture produc-

Table 1. Treatments to induce flower bud initiation (FBI) and development (FBD) in flowering potted plant crops. Additional abbreviations: day neutral (DN), facultative (F), long day (LD), obligate (O), short day (SD).

Scientific name	Common name	O/F
Photoperiodism		
SD plants		
Anigozanthos manglesii D.	cat's paw	F
Aster pilosus Willd.	aster	O
Begonia ×*hiemalis* Fotsch.	rieger begonia	O
Bougainvillea spectabilis Willd.	bougainvillea	F
Callistephus chinensis L.	china aster	O
Cattleya sp. Lindl.	cattleya orchid	O
Clerodendrum thomsoniae Balff.	bleeding heart vine	F
C. ×*speciosum* Dombr.	java glory bean	F
Dahlia variabilis Cav.	dahlia	F
Dendranthema ×*grandiflora* Tzvelv.	chrysanthemum	F/O
Euphorbia pulcherrima Willd. ex Klotzsch.	poinsettia	O
Helianthus annuus L.	sunflower	F
Kalanchoe blossfeldiana Poelln.	kalanchoe	O(FBI), F(FBD)
Rhododendron hybrids L.	Azalea	O
Schlumbergera truncata Morna.	Thanksgiving cacti	O
S. ×*buckleyi* Tjaden	christmas cacti	O
LD plants		
Anemone coronaria L.	anemone	O
Anigozanthos flavidus DC.	tall kangaroo paw	F
Aquilegia L. ×*hybrida*	columbine	F
Asclepias tuberosa L.	milkweed	O
Astilbe ×*arendsii* Arends.	false spirea	F
Begonia ×*tuberhybrida* Voss.	tuberous begonia	O
Calceolaria L. Herbeohybrida group	pocketbook plant	F
Calendula officinalis L.	pot marigold	O
Callistephus chinensis L.		F/FBI, F/FBD
Campanula fragilis Cyr.	bellflower	O
C. leucophylla Moretti	harebell	O
C. carpatica Jacq.	tussock bellflower	O
C. poscharskyana Degn	bellflower	O
Lilium L. asiatic and oriental hybrids	asiatic lily, oriental lily	F
LD–SD plants		
Aster dumosus L.	aster	O, LD–SD
A. ericoides L.	aster	O, LD–SD
A. novi-belgii L.	novi-begii aster	O, LD–SD
SD–LD plants		
Campanula medium L.	canterbury bells	O, SD-LD
Hatiora gaertneri Barthlott.	easter cacti	O—SD/LD

Notes[z]	Reference
	Motum and Goodwin, 1987a, 1987b Kadman-Zahavi and Tahel, 1986
Obligate when temperatures are >75 °F. Will flower at 54 °F with a 16-h photoperiod. For FBI, the critical photoperiod is 12–13 h for most cultivars, if temperature is >75 °F; 14 h if temperature is >65 °F.	Heide and Rünger, 1985; Sandved, 1968 Allard, 1935
Obligate requirement for FBD.	Cockshull, 1985
LD may delay or inhibit FBI, FBD.	Goh and Arditti, 1985
LD may delay FBD	Beck, 1975; Shillo and Engel, 1985
LD may delay FBD	Beck, 1975; Shillo and Engel, 1985
Flowering and tuberization are controlled by photoperiod and temperature.	Maatsch and Rünger, 1985
Most cultivars are F for FBI and O for FBD. DN cultivars do exist.	Anderson, 1991; Cathey and Borthwick, 1957
FBD requires a shorter photoperiod than FBI. Very sensitive to light pollution during FBD.	Ecke and Matkin, 1976 Schuster, 1985
FBI commences within two days. To increase flower number, 40 SD are used commercially; may be grown under LD thereafter.	Schwabe, 1985
A dormant flower bud appears after 12–16 weeks of SD.	Kiplinger, 1944; Petterson, 1972 Boyle, 1997a, 1997b
	Boyle, 1997a, 1997b
Tuber storage at 36–43 °F necessary for FBI. LD, high temperatures and moisture stress cause tuber dormancy.	Ben-Had et al., 1989; Kadman-Zahavi et al., 1984; Meynet, 1993; Ohkawa, 1987 Motum and Goodwin, 1987a, 1987b
The Songbird Series are F/LD plants that will undergo FBI without vernalization under certain photoperiods. After vernalization, LD and 60–64 °F hasten FBD for the McKana's Giant and Fairyland series. Leaf number, duration of vernalization (3–8 weeks at 40 °F), and series all interact. Higher leaf counts decrease the vernalization period.	Armitage, 1996; PanAmerican Seed Co., 1999; Shedron and Weiler, 1982; White, 1985; Zhang, et al., 1991
Requires photoperiods of ≥13 h for FBI and FBD.	Armitage, 1996
FBI/FBD under LD during later summer into early fall. Crowns harvested in the fall are non-dormant and can be forced immediately with reproductive meristems. No photoperiodic treatment is required for forcing, although LD are beneficial.	Pemberton and de Hertogh, 1994
Decreasing temperatures and SD have the following effects: leaf initiation and FBI/FBD cease, shoots senesce, and an abscission zone forms between the stem and tuber.	Heide and Rünger, 1985
Plants must have 4–5 leaf pairs before the commencement of LD.	Poesch, 1931; Post, 1937
The critical day length for FBI and FBD is 6.5 h.	Kamlesh and Kohli, 1981
Facultative for FBI; FBD is independent of temperature, but occurs more rapidly under SD.	Hughes and Cockshull, 1965; Lin and Watson, 1950
The critical daylength is 14 h when grown at 59–70 °F.	Heide, 1965; Madsen and Madsen, 1986; Zimmer, 1985a
The critical daylength is 14 h when grown at 59–70 °F.	Heide, 1965; Madsen and Madsen, 1986; Zimmer, 1985a
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The critical daylength is 14 h when grown at 59–70 °F.	Heide, 1965; Madsen and Madsen, 1986; Zimmer, 1985a
Four types of FBI/FBD: Type I—FBI during late summer, FBD by autumn (SD); Type II—FBI in late summer with FBD the following spring; III—FBI and FBD during the spring before emergence of the shoots; Type IV—FBI in spring after shoot emergence.	Baranova, 1972
A. dumosus, A. ericoides also require vernalization before the commencement of LD.	Schwabe, 1986
A. dumosus, A. ericoides also require vernalization before the commencement of LD.	Schwabe, 1986
A. dumosus, A. ericoides also require vernalization before the commencement of LD.	Schwabe, 1986
In most series, FBI occurs after vernalization and SD, followed by LD.	Wellensiek, 1985
FBI is enhanced by 47–55 °F during SD.	Boyle, 1990; Boyle, et al., 1988

Table 1. Continued.

Scientific name	Common name	O/F
DN plants		
Abutilon L. ×*hybridum* Hope	flowering maple	
Achimenes Dumort. hybrids	hot water plant	
Alstroemeria L. hybrids	lily of the incas, peruvian lily	
Anigozanthos rufus Labill	australian sword lily	
A. pulcherrimus Hook	kangaroo paw	
A. flavidus×*manglesii*	kangaroo paw	
Capsicum annuum L.	ornamental pepper	
Crossandra infundibuliformis Nees.	firecracker flower	
Cyclamen persicum Mill.	cyclamen	
Dianthus carthusianorum L.	miniature carnation	
Eustoma grandiflorum Shinn.	lisianthus	
Exacum affine Balf.	persian violet	
Gerbera jamesonii Bol. Ex Adlam.	transvaal daisy	
Helianthus annuus L.	sunflower	
Hibiscus rosa-sinensis L.	hibiscus, rose of china	
Hydrangea macrophylla Ser.	hydrangea	
Orchidaceae (except for *Cattleya*)	orchids	
Pelargonium L'Hérit. sp.	geranium	
Pentas lanceolata Deflers.	star-cluster	
Primula malacoides Franch.	fairy primrose	
Rosa L. hybrids	rose	
Saintpaulia ionantha Wendl.	african violet	
Sinningia speciosa Hiern.	gloxinia	
Solanum pseudocapsicum L.	jerusalem cherry	
Streptocarpus×*hybridus* Voss.	cape primrose	
S. nobilis Clarke	cape primrose	
Zantedeschia aethiopica Spreng.	calla lily	
Z. albomaculata Baill.	calla lily	
Z. elliotiana Engl.	calla lily	
Z. rehmannii Engl.	calla lily	
Vernalization		
Anemone coronaria	anemone	O
Aquilegia×*hybrida*	columbine	O
Aster dumosus L.	aster	O
A. ericoides L.	aster	O
A. novi-belgii L.	novi-belgii aster	O
Campanula medium L.	canterbury bells	O
Cymbidium Sw. sp.	cymbidium orchid	O
Dendrobium Sw. sp.	dendrobium orchid	O
Hatiora×*graeseri* (Werderon) Barthlott	cactus	F
Lilium hybrids (Asiatic, Oriental)	asiatic, oriental lilies	
Lilium longiflorum Thunb.	easter lily	O, with inner scales
Paphiopedilum Pfitz. sp.	lady's slipper orchid	O
Phalaenopsis Bl. sp.	moth orchid	O

Notes[z]	Reference
'Bella Mix'	PanAmerican Seed Co., 1999
Flowering occurs after the 3rd–4th leaf whorl develops regardless of photoperiod.	
Cultivar and irradiance have the greatest influence on flower number.	Zimmer and Junker, 1985; Vlhahos, 1990
Flowering controlled by rhizome temperatures; ≥6 weeks at 41–55°F. Devernalization occurs at higher temperatures.	Healy and Wilkins, 1981, 1982; Heins and Wilkins, 1979
	Motum and Goodwin, 1987a, 1987b
	Motum and Goodwin, 1987a, 1987b
	Motum and Goodwin, 1987a, 1987b
FBI/FBD occur faster at 12-h photoperiods.	Vince-Prue, 1975
Sometimes classified as a F/LD plant, as LD accelerates FBI, FBD.	Harthun, 1991
Plant remains vegetative until 10–13 leaves are formed. Flower buds occur in older leaf axils.	Widmer and Lyons, 1985
Low temperatures increase the number of flowering shoots and hasten FBI/FBD.	Moe, 1983
Dwarf pot types are DN.	PanAmerican Seed Co., 1999; Sakata Seed Co., 1998
	Williams et al., 1983
FBI and FBD are influenced by cultivar, temperature, and light intensity.	Lin and French, 1985; Erwin et al., 1991
Some cultivars.	Schuster, 1985
Flowering is autonomous, dependent on total light energy and shoot growth.	
See also Autonomous.	Wilkins, 1986
Cool temperatures and naturally shortening days cause FBI/FBD. It is imperative that a critical leaf mass be reached prior to FBI. If night temperatures are within 55–65 °F,	
FBI will occur under any photoperiod.	Wallerstein and Rünger, 1985
See also flower requirements for *Dendrobium, Phalaenopsis.*	Goh and Arditti, 1985
FBI/FBD is faster with greater irradiance.	Langton and Rünger, 1985
Will flower in 14–18 weeks when grown at 65–70 °F.	PanAmerican Seed Co., 1999
	Ruenger and Wehr, 1971
Most cultivated hybrids are recurrent flowering, DN plants although some are F/LD plants.	Moe, 1970; Zieslin and Moe, 1985
Total irradiance controls flowering, rather than photoperiod.	Hanchey, 1955
Light duration, intensity, and temperature control flowering by enhancing leaf initiation rates.	Strømme, 1985
Believed to be DN, although no research has been performed on the species. Need pollination to set fruit.	Aimone, 1985; Dole and Wilkins, 1999
Most *Streptocarpus* hybrids are DN, although *S. nobilis* should be considered a F/SD plant when grown at 77 °F.	Simmonds, 1982
All species are DN; FBI/FBD occurs in any environment conducive to vegetative growth.	Greene et al., 1932; Harrison, 1972
All species are DN; FBI/FBD occurs in any environment conducive to vegetative growth.	Greene et al., 1932; Harrison, 1972
All species are DN; FBI/FBD occurs in any environment conducive to vegetative growth.	Greene et al., 1932; Harrison, 1972
All species are DN; FBI/FBD occurs in any environment conducive to vegetative growth.	Greene et al., 1932; Harrison, 1972
Vernalization temperature and duration varies depending on location: France, 4–6 weeks at 36 °F; Japan, 4 weeks at 41 °F; Florida, 7 weeks at 43 °F.	Maia, 1973; Ohkawa, 1987; Radspinner and Sheehan, 1963
'McKana's Giant', 'Fairyland'	Armitage, 1996; Shedron and Weiler, 1982; White, 1985; Zhang, et al., 1991
LD-SD after vernalization.	Schwabe, 1986
LD-SD after vernalization.	Schwabe, 1986
LD-SD after vernalization.	Schwabe, 1986
FBI occurs after vernalization and SD, followed by LD.	Wellensiek, 1985
For uniform FBI, grow at 41–46 °F. Temperatures can be raised after flower buds are visible.	Goh and Arditti, 1985
Grow plants at 55–65 °F and LD for uniform FBI.	Goh and Arditti, 1985
A 4–6 week period of 47–53 °F is recommended for FBI. FBD is enhanced by warmer temperatures (65–68 °F) and LD.	Boyle, 1997b
All *Lilium* species respond to cold temperatures, resulting in stem elongation, FBI/FBD.	
See LD for the FBI/FBD types.	Dole and Wilkins, 1999
Asexually propagated cultivars require ≈1,000 h or 6 weeks at 35–45 °F. Controlled temperature forcing (rooting before cooling) produces the best plants.	Stuart, 1954
A 2–3 weeks treatment of 55 °F is required for FBI.	Goh and Arditti, 1985
A 2–5 week period of ≈59–68 °F (on average) is necessary for FBI. SD may stimulate FBD and spiking.	Goh and Arditti, 1985

Table 1. Continued.

Scientific name	Common name	O/F
Vernalization (continued)		
Pericallis ×hybrida R. Nordenstam	cineraria	F
Primula ×polyantha Mill.	polyantha primrose	O/F
P. vulgaris Huds.	primrose	O/F
Schizanthus ×wisetonensis Hort.	poor man's orchid	O
Warm temperatures for FBI		
Hyacinthus orientalis L.	hyacinth	O
Iris reticulata Bieb.	dwarf iris	F
Narcissus pseudonarcissus L.	daffodil	O
N. cyclamineus DC.	daffodil	O
N. tazetta L.	paperwhites	O
Tulipa gesneriana L.	tulip	O
Cooling for root/shoot formation after FBI/FBD (to G or gynoecium stage).		
Crocus vernus Hill.	crocus	O
Hyacinthus orientalis	hyacinth	O
Iris reticulata	dwarf iris	O
I. Danfordiae	iris	O
Narcissus pseudonarcissus	daffodil	O
N. cyclamineus	daffodil	O
Tulipa gesneriana	tulip	O
Cooling while dormant or to break dormancy		
Oxalis adenophylla Gillies	oxalis	O
O. pres-caprae L.	oxalis	O
O. tetraphylla Cav.	four-leaved clover	F
Platycodon grandiflorus A.DC.	balloon flower	O
Ranunculus asiaticus L.	ranunculus	O
Rhododendron hybrids	azalea	O
Zantedeschia albomaculata	calla lily	O
Z. elliotiana	calla lily	O
Z. rehmannii	calla lily	O
Autonomous		
Hibiscus rosa-sinensis	hibiscus	
Hippeastrum Herb. *×hybridum*	amaryllis	
Primula obconica Hance.	german primrose	
Rest period		
Caladium bicolor Vent.	caladium	F
Dormancy		
Astilbe ×arendsii Arends.	false spirea	
Begonia tuberhybrida	tuberous begonia	

[z]ºC = 5/9 (ºF – 32).

tion classes has been slow to change. With the influx of many minor crops, educators and students need to adopt new methodologies to educate and learn floral induction. New and traditional potted crops (>70 species) currently on the market were categorized for flower bud initiation and development requirements, including photoperiod, vernalization, temperature, autonomous, rest period, and dormancy (Table 1). Photoperiodic treatments were further subdivided into short and long day plants, long day–short day, short day–long day, as well as day neutral, and whether the species had a facultative or obligate requirement. Specific temperature, irradiance, and photoperiod interactions are noted with each crop. In addition, facultative and obligate photoperiod requirements and temperature effects are outlined for specific crops under long and short days (Table 2).

These summary tables were developed for students' use at the beginning and throughout the production class (Hort 4051, Floriculture Production and Management I—Potted Plants, University of Minnesota). Within the first 2 weeks of class lecture, students work in small groups to familiarize themselves with the basic categories of floral induction and terminology. These terms include photoperiod, short day plants, long day plants, day neutral plants, facultative and obligate responses, vernalization, dormancy, warm and cool temperature treatments, rest period, and au-

Notes[z]	Reference
A 5–6 week period of 50–55 °F for FBI/FBD is recommended.	Post, 1942
6 weeks at 45–50 °F is traditional, although not all cultivars require a cold treatment.	Armitage and Billingsley, 1983; Karlsson, 1996
6 weeks at 45–50 °F is traditional, although not all cultivars require a cold treatment.	Armitage and Billingsley, 1983; Karlsson, 1996
Grow at 50 °F for FBI and FBD.	PanAmerican Seed Co., 1999
FBI commences at an optimal temperature of 78 °F, although a range of 68–82 °F is acceptable.	Dole and Wilkins, 1999
Temperatures of >86 °F is optimal for FBI. Cooler temperatures of >68 °F stop leaf initiation and start FBI.	De Hertogh, 1996b
FBI/FBD begins before harvest and continues thereafter.	De Hertogh, 1996c
FBI/FBD begins before harvest and continues thereafter.	De Hertogh, 1996c
FBI/FBD begins before harvest and continues thereafter.	De Hertogh, 1996c
Advanced FBD to the gynoecium or G stage should be completed prior to commencing rooting and cooling.	De Hertogh, 1996d
A period of 13–20 weeks at 48 °F is required, depending on the cultivar. FBI occurs in the spring after flowering.	De Hertogh, et al., 1990
Cool for ≥10 weeks at 48 °F, i.e. rooting room B temperatures.	De Hertogh, 1996a
A treatment of 48–59 °F is necessary for leaf and flower elongation after potting.	De Hertogh, 1996b
A treatment of 48–59 °F is necessary for leaf and flower elongation after potting.	De Hertogh, 1996b
Necessary for continued FBD and rapid emergence.	De Hertogh, 1996c
Necessary for continued FBD and rapid emergence.	De Hertogh, 1996c
Precooling at 48 °F is necessary for early forcing schedules.	De Hertogh, 1996d
Requires a moist storage at 41 °F for 10 weeks while dormant.	Armitage et al., 1996
Requires a moist storage at 41 °F for 10 weeks while dormant.	Armitage et al., 1996
Storage in dry conditions at 33–40 °F while dormant is recommended.	Dole and Wilkins, 1999
If dormant, a 6-week treatment at 40 °F is necessary to break dormancy.	Armitage, 1989
A 4–5 week treatment of 39–41 °F is required.	Elber, 1970
A 4–6 week period at 35–40 °F in complete darkness or 40–50 °F, if light is required.	Womack, et al., 1995
Tubers may be stored at 46 °F and 70%–80% relative humidity for up to 6 months.	De Hertogh, 1996
Tubers may be stored at 46 °F and 70%–80% relative humidity for up to 6 months.	De Hertogh, 1996
Tubers may be stored at 46 °F and 70%–80% relative humidity for up to 6 months.	De Hertogh, 1996
See also the listing for DN.	Wilkins, 1986
FBI/FBD are autonomous after potting and watering, following a dry-down period.	Rees, 1985
This species does not require a cold period or photoperiodic treatments for flowering.	Karlsson, 1997
Leaf production is faster when the tubers have a rest period.	Poole and Conover, 1977
If freshly harvested crowns are stored for ≥1 week at 41 °F, dormancy will occur.	
Otherwise, the crowns are not dormant when forced immediately.	Pemberton and De Hertogh, 1994
SD and decreasing temperature causes leaf and shoot senescence; FBI/FBD cease.	Haegeman, 1993; Heide and Ruenger, 1985

tonomous responses. A class discussion follows to elaborate on the definitions and clarify their importance in potted plant production. As the course progresses, students refer back to the tables to clarify the species-specific needs of the crop, as well as the similarities each crop shares with others in the same floral induction category.

Additional class discussion

An existing production course syllabus can be organized to ensure that at least one example crop from each floral induction category is presented in lecture. Production classes can retain focus on the major potted crops, while strategically including selected minor crops. At the end of each crop presentation, the class reviews other crops within the same floral induction category noticing differences or similarities. This method allows for coverage of major potted crops, as well as specifically chosen minor species, providing the students with an overall framework or template to classify floricultural crops.

Teaching notes

This method of educating potted plant production students was used in Hort 4051 during the Fall 1999 semester. Twenty junior and senior students were enrolled, with emphases in either floriculture or nursery management.

The floral induction categorization enabled students to selectively

Table 2. Effect of long and short day photoperiods on flower bud initiation (FBI) and development (FBD) of various flowering potted crops.

Scientific name	Common name	Series
Achimenes hybrids	hot water plant	
Alstroemeria ×hybrida	lily of the incas, peruvian lily	Jazze, Princess Lily
Anemone coronaria	anemone	
Anigozanthos flavidus	kangaroo paw	
A. manglesii	cat's paw	
A. pulcherrimus, A. rufus, *A. flavidus ×mangelsii*	kangaroo paw, australian sword lily	
Aquilegia ×hybrida	columbine	
Asclepias tuberosa	milkweed	
Aster dumosus, *A. ericoides*, *A. novi-belgii*	aster, novi-belgii aster	
A. pilosus	aster	
Astilbe ×arendsii	false spirea	
Begonia ×hiemalis	rieger begonia	
B. tuberhybrida	tuberous begonia	
Bougainvillea spectabilis	bougainvillea	
Calceolaria Herbeohybrida Group	pocketbook plant	
Calendula officinalis	pot marigold	
Callistephus chinensis	china aster	dwarf cultivars
Campanula carpatica, C. fragilis, *C. isophylla, C. poscharskyana*	bellflower	
C. medium	canterbury bells	
Capsicum annuum	ornamental pepper	
Cattleya hybrids	cattleya orchid	
Clerodendrum thomsoniae, *C. ×speciosum*	bleeding heart vine, java glory bean	
Crossandra infundibuliformis	firecracker flower	
Dahlia variabilis	dahlia	Figaro (seed), vegetative types
Dendranthema ×grandiflora	chrysanthemum	
Dianthus carthusianorum	miniature carnation	
Euphorbia pulcherrima	poinsettia	
Gerbera jamesonii	transvaal daisy	
Hatiora gaertneri	easter cacti	
Helianthus annuus	sunflower	dwarf pot types
Hydrangea macrophylla	hydrangea	
Kalanchoe blossfeldiana	kalanchoe	
Primula malacoides	fairy primrose	
Rhododendron hybrids	azalea	florist type azaleas
Schlumbergera ×buckleyii	christmas cacti	
S. truncata	thanksgiving cacti	

[z]ºC = 5/9 (ºF–32).

study potted crops and correlate production treatment(s) to other species in the same category. Students discovered trends within categories that were not apparent without the use of the summary tables. Additionally, different species within a genus were found to require similar [thanksgiving cacti (*Schlumbergera truncata*) versus christmas cacti (*S. ×buckleyi*)] (Table 1) or different [cat's paw (*Anigozanthos manglesi*) versus tall kangaroo paw (*A. flavidus*) or australian sword lily (*A. rufus.*), kangaroo paw (*A. pulcherrimus* or *A. flavidus ×manglesii*)] floral induction treatments. Series and cultivars within a species could be easily identified with similar or differing trends, e.g., columbine (*Aquilegia ×hybrida*) 'McKana's Giant' and 'Fairyland' versus the Songbird series.

Use of these tables in the classroom and laboratory did not replace intensive coverage of treatments for floral bud initiation and development in example crops. Rather, they served as conceptual guidelines to focus students' attention on the physiological responses and environmental manipulations necessary to achieve flowering for a production schedule. As more vegetative and seed-propagated flowering potted plant species are domesticated and introduced into the marketplace, the need for using conceptual tools such as these will increase.

Long days[z]	Short days[z]	References
Increases plant height, flower no., accelerates FBI/FBD	Delays FBI, FBD	Zimmer and Junker, 1985; Vlhahos, 1990
Earlier FBI, FBD with day continuation or night interruption lighting	Delays FBI, FBD	PanAmerican Seed Co., 1999
Cultivar dependent for speed of FBI/FBD, flower quality and quantity. May enhance onset of dormancy.	Inhibits FBI/FBD	Radspinner and Sheehan, 1963; Ohkawa, 1987; Ben-Had et al., 1989
FBI, FBD	Slowed FBI, FBD	Motum and Goodwin, 1987a
Slowed FBI, FBD	FBI, FBD	Motum and Goodwin, 1987a
FBI, FBD	FBI, FBD	Motum and Goodwin, 1987a, 1987b
Accelerates flowering date	No effect	Armitage, 1996
FBI, FBD	Inhibits FBI, FBD	Armitage, 1996
Required for FBI	Required for FBD	Schwabe, 1986; Zimmer, 1987; Johansson, 1990
Required for FBI	Required for FBD	Schwabe, 1986; Zimmer, 1987; Johansson, 1990
No effect	Required for FBI/FBD	Kadman-Zahavi and Tahel, 1986
FBI, FBD; enhances greenhouse forcing	No effect	Pemberton and De Hertogh, 1994
FBI, FBD at <75F	FBI, FBD at >75F	Sandved, 1968, 1974
Leaf initiation, FBI (≥12 hrs)	No FBI, FBD	Heide and Rünger, 1985; Haegeman, 1993
Slows FBI, FBD; fewer buds formed	Accelerates FBI, FBD	Allard, 1935
Accelerates FBI, FBD when temps >59F	FBI, FBD with cold temperature (<50F)	Poesch, 1931; Post, 1937
FBI, FBD	Inhibitory for FBI, FBD if <5.5 hr	Kamlesh and Kohli, 1981
FBI	FBD; FBI only if temps. are 55–68F	Cockshull, 1985
FBI, FBD	Inhibits FBI, FBD	Heide, 1965; Zimmer, 1985a; Madsen and Madsen, 1986
FBD	FBI	Wellensiek, 1985
FBI, FBD; accelerated at 12 hr. photoperiods	FBI, FBD	Vince-Prue, 1975; PanAmerican Seed Co., 1999
Delays or inhibits FBI, FBD	FBI, FBD	Goh and Arditti, 1985
FBI; Inhibits FBD	FBI, FBD	Beck, 1975; Shillo and Engel, 1985
Accelerates FBI, FBD	FBI, FBD	Harthun, 1991; PanAmerican Seed Co., 1999
Slows FBI, FBD	Accelerates FBI, FBD	PanAmerican Seed Co., 1999
Delays FBI in facultative SD types; FBI/FBD in DN cultivars	FBI, FBD	Cathey and Borthwick, 1957; Anderson, 1991
Hastens FBI, FBD	Delays FBI, FBD	Moe, 1983
Inhibitory for FBI, FBD	FBI, FBD	Ecke and Matkin, 1976
Slowed FBD	Accelerated FBD	Lin and French, 1985
FBD at 65–70 °F; enhances flower uniformity	FBI enhanced by 47–55 °F	Boyle, 1990; Boyle, et al., 1988
Slowed FBI, FBD except for DN types	FBI, FBD	Post, 1949a; Schuster, 1985
Delayed FBI, FBD	FBI, FBD	Wallerstein and Ruenger, 1985
Inhibits FBI; FBD after SD treatment	Min 40 d SD required for FBI/FBD.	Nell et al., 1982; Schwabe, 1985
FBI occurs at 41–63 °F	Obligate SD at 60–76 °F; DN at 50–60 °F	Post, 1937, 1949b; Zimmer, 1985b
Inhibits FBI/FBD	FBI, FBD with 8 h SD	Kiplinger, 1944; Petterson, 1972
Inhibits FBI/FBD	FBI, FBD	Boyle, 1997a, 1997b
Inhibits FBI/FBD	FBI, FBD	Boyle, 1997a, 1997b

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