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Effect of photoperiod on flowering in ornamental annuals

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Abstract
Photoperiodism is a response to the seasonal variation of day length and changes in day length above or below the critical level affects the blooming of flower (Irwin, 1982) [4]. Flowering is the end result of physiological processes, biochemical sequences, and gene action, with the whole system responding by the influence of photoperiod. Many flowering plants have a photoreceptor protein, such as phytochrome or cryptochrome, to sense seasonal changes in day length, which act as signals to flower. Photoperiodic response to flower induction, initiation and development of many plant species are synchronized temporarily during the year with night length. The emergence of flower being extends by using artificial light, black cloth, black polythene sheets. Photoperiod manipulation through the use of black cloth or night interruption lighting may be for controlling flowering. reported by Biondo and Noland (2006) [1].Short day induction, it took 4 days to reach the growing point hypertrophy stage, 8 days to finish involucres primordial differentiation, 12 days to finish floret primordial differentiation, crown formation in the chrysanthemum cultivars 'Jingyun' (Jiang *et al*., 2010) [5]. *Primula malacoides* Franch. 'Primula Lilac' was grown at 160C or 200C in combination with short day (SD, 8 hours) or long day (LD, 16 hours). Time to flower (first horizontal petals) at 160C increased from 56 to 64 days as so increased from 1 week to continuous conditions in SD, while LD decreased time to flower from 64 to56 days. Time to flower at 200C varied from 73 to 87 days with additional SD exposure resulting in flower and LD in faster flowering (Karlsson and Werner, 2002) [6]. The flowering was hastened up to 16, 15, 10, 11, 14, and 29 days for Zinnia, Sunflower, French Marigold, African Marigold, Cockscomb, Cosmos under SD environment respectively reported by (Baloch *et al*., 2010) [2]. Delayed or no flowering of obligate long day plant/facultative long day plant can be alleviated by delivery of long day conditions when ambient short day conditions are prevalent (Mattson and Ervin (2005) [7]. Photoperiod increased from 9 h to13 h, the total flower numbers decreased from 45 flowers to 13 flowers *Kalanchoe uniflora* (a short day plant). All species of *Kalanchoe* flowered when grown under photoperiods under ranging from 9-12 h and percentage of flowering plants decreased for all species as the photoperiod increased from 12 h to 14 h. No flowering occurred on plants grown under a 15 h photoperiod (Curry and Ervin, 2010) [3].Flowers can also be grown under non-inductive environment during juvenile phase to improve their quality for marketing viewpoint. Off-season flower will produce by use of photoperiod and light intensity that provide a year-round production of flowers, which will eventually increase the income of ornamental growers.

Keywords: photoperiod, influence photoreceptor, florigen, phytochrome.

Introduction

Photoperiodism: The phenomenon of photoperiodism was first discovered by Garner and Allard (1920). Relative length of day and night is called photoperiod. Flower requires a certain day length. Plants can be classified into three categories on the basis of photoperiod:

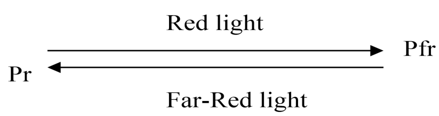
Short day plant, long day plant, day neutral plant Photoperiod is very important phenomena which are described by Garner and Allard 1920. When they got the tobacco plant grown in long day it remains vegetative and non-reproductive, because tobacco plant is a short day plant.

Short Day Plant (SDP)-These plants require a relatively short day light period (8-10 hours) and a continuous dark period of about 14-16 hours for subsequent flowering.

Classification of Short Day Plants:

Short Day Obligate Plants – Photoperiodic plants absolutely require a long night before flowering. Example – *Chrysanthemum, Poinsettia* Short Day Facultative Plants – Photoperiodic plants are more likely to flower under the appropriate light conditions, but will eventually flower regardless of night length. Example – Hamp (*Cannabis*), *Cosmos, Zinnia*.

Long Day Plant-These plants require a longer day light period (usually 14-16 hours) in a 24 hours cycle for subsequent flowering.
Long Day Obligate Plants – These plants absolutely require a short night before flowering. Example – Carnation, Bellflower (Campanula)
Long Day Facultative Plants – These plants are more likely to flower under the appropriate light conditions, but will eventually flower regardless of day length. Example – *Collinsia heterophylla, Phacelia tanacetifolia.*
Day Neutral Plant (DNP)-These plants flower in all photoperiods ranging from 6 to 24 hours continuous exposures. Example – Sunflower, Rose.
Phytochrome-Phytochrome, a blue protein pigment with a molecular mass of about 250 Kda (Kilo Daltons).In dark – grown or etiolated plants, phytochrome is present in a red light – absorbing form, referred to as Pr because it is synthesized in this form. Pr, which to the human eye is blue, is converted by red light to a far-red light absorbing form called Pft, which is blue green. Pfr, in turn, can be converted back to Pr by far-red light, known as photo reversibility; this conversion/ reconversion property is the most distinctive property of phytochrome.



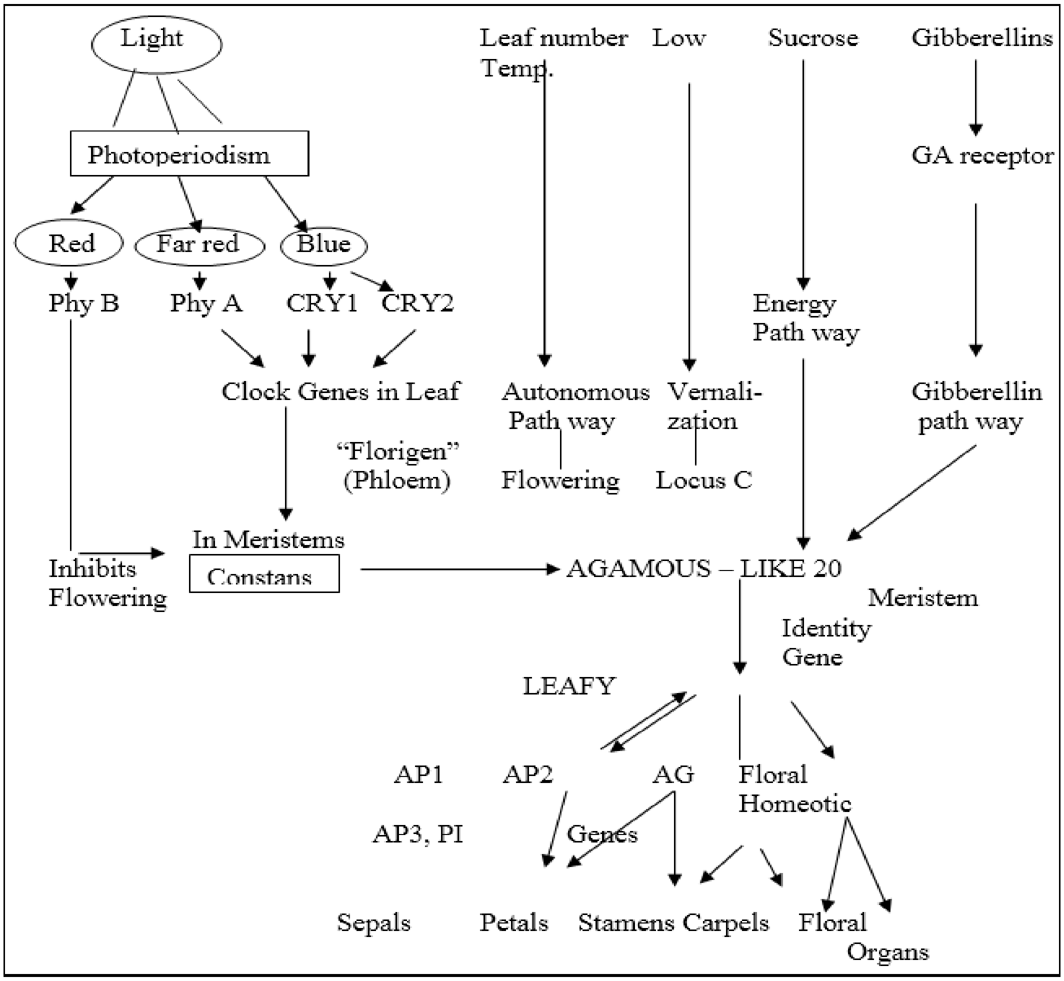
When Pr molecules are exposed to red light, most of them absorb it and are converted to pfr, but some of the Pfr also absorbs the red light and is converted back to Pr because both Pr and Pfr absorb red light. Thus the proportion of phytochrome in the Pfr form after saturating irradiation by red light is only about 85%. Similarly the very small amount of far-red light absorbed by Pr makes it impossible to convert Pfr entirely to Pr by broad spectrum far-red light. Instead, equilibrium of 97% Pr and 3% Pfr is achieved. This equilibrium is termed the "Photostationary State".
Phytochromes on the basis of gene are two types: Phytochromes A Phytochromes B, Effects of Phytochromes A & B on Flowering, Phytochrome is encoded by members of a multigene family and it is possible that the effect of red and far-red light are mediated by different types of Phytochrome (A and B). In LDPs such as Arabidopsis, Pea (*Pisum sativum*) and sorghum (*Sorghum bicolor*), Phytochrome B (Phy B) appears to be an inhibitor of flowering, since mutations in the gene Phy B that eliminate or reduce the amount of Phy B protein cause more rapid flowering. The proportion of flowering by far-red light may result from a decrease in the amount of the Pfr form of Phy B, which would have the same effect on the Phy B. Pfr levels as the mutations that reduce the total amount of Phy B. Red-light interruptions of a dark-period prevent flowering in SDPs, therefore, the Pfr form of Phy B may be an inhibitor of flowering in SDPs as well. In LDPs Arabidopsis and Pea, mutation in the PHYA gene interfere with the promotion of flowering by long days thus the Pfr form of Phy A may promote flowering in LDPs. The effect of Phy A mutation is quite strong in pea (the mutants plants are essentially unable to respond to inductive photoperiods), where are the Phy A mutation in Arabidopsis has only a slight effect on the ability to respond inductive photoperiods. The species difference in the effect of Phy A mutations is probably due to the fact that pea relies entirely on Phy A to sense inductive photoperiods, whereas Arabidopsis also uses a blue light photo receptor for this purpose.

Florigen-A mobile molecule that is synthesized in leaves in response to a favourable photoperiod and it migrates through the vascular system to the apical meristem to promote floral initiation.
Grafting studies have provided evidence for a transmissible flora stimulus: The production in photo periodically induced leaves of a biochemical signal that is transported to a distant target tissue (the short apex) where it stimulates a response (flowering) satisfies an important criterion for a hormonal effect. In the 1930s, Mikhail Chailakhyan, working in Russia, postulated the existence of a universal flowering hormone, which named "Florigen". The evidence in support of florigen comes mainly from early grafting experiments in which non-induced receptor plants were stimulated to flower by being grafted on to a leaf or shoot from photoperiodically induced donor plants. For example, in the SDPs *Perilla crispa*, a member of the mint family, grafting a leaf from a plant grown under inductive short days on to a plant grown under non inductive long days causes the latter to flower.

Transmissible Factors Regulate Flowering

Donor plants maintained under flower inducing conditions	**Photoperiod type a, b**	**Vegetative receptor plant induced to flower**	**Photoperiod type a, b**
Helianthus annus	DNP in LD	*H. tuberosus*	SDP in LD
Petunia hybrida	LDP in LD	*Hyoscyamus niger*	LDP in LD

The transition to flowering involves multiple factors and pathways – The photoperiodic pathways involves Phytochromes and Cryptochromes. The interaction of these photoreceptors with a circadian clock initiates a pathway that eventually results in the expression of the gene, CONSTANS (CO), which encodes a zinc-finger transcription factor that promote flowering. CO acts through other genes to increase the expression of the floral meristem identity gene LEAKY (LFY).
All four pathways coverage by increasing the expression of the key floral meristem identity gene AGAMOUS 4KE (AGLl 20). The role of AGL20, A MADS box – containing transcription factor, is to integrate the signals coming from all four pathways into a unitary output. Obviously the strongest output signal occurs when all four pathways are activated.
Once turned on by AGL20, LTY activates the floral homoerotic genes – AP□TALA1 (AP1), AP□TALA3 (AP3), PISTILLATA (PI) and AGA MOUS (AG) that are required for floral organ development. AP□TALA2 (AP2) is expressed in both vegetative and floral meristems and is therefore not affected by LFY. However, as AP2, exerts a negative effect on AG expression.
Blue Light Receptors
The Blue Light photoreceptor is involved in sensing inductive photoperiods in Arabidopsis that mutations in one of the cryptocrome genes, CRY2, caused a delay in flowering and an inability to perceive inductive photoperiods.
In some long day plants, such as Arabidopsis, blue light can promote flowering, Cry1 and Cry2 are two Arabidopsis genes involved in blue light dependent inhibition of stem elongation, cotyledon expansion, anthocyanin synthesis, the control of flowering, and the setting of circadian rhythms. It has been proposed that CRY1 and CRY2 are apo-proteins of flavin-containing pigment proteins that mediate blue-light photo reception.



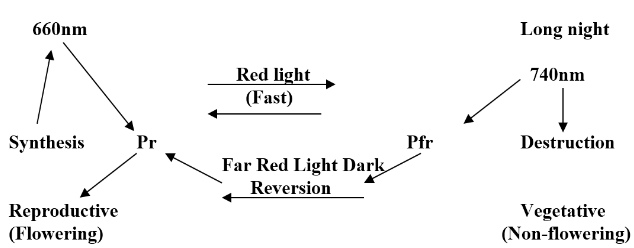
The Cry1 and Cry2 gene products have sequence similarity to photolyase but no photolyase activity. The Cry1 protein and to lesser extent Cry2 accumulates in the nucleus and might be involved in gene expression. The Cry1 protein also regulates anion channel activity at the plasma membrane.

In many long – day plants blue light is more effective than red light.

Cry2 mutants will flower much later during long days but not in short days.

Cry2 has a role in photoperiodic regulation of flowering time in long days.

Phytochrome



Short-Day Plants Need Low Pfr

Phytochromes are two types on the basis of the red and far-red light spectrum. The Pfr absorbs the light 740nm in the day time, it conversion the energy to Pr in the right conditions by slow process and to activate Pr to induce for florigen. As well as the Pr absorbs red light (660 nm), it converse the energy very fast in the day for the activation of Pfr. The short day plants need low Pfr.

The Control of Flowering

Change in day length

↓

Photoperiod mechanism in the leaves

"Florigen" Hormone

↓

Flower Buds

↓

Flowering

Flowering in ornamental plants depend on the seasonal variation. The change in day length promote the phytochromes in leaves to induction for induce flowering in meristematic region by florigen hormone. The florigen is a hormone which is work by induction by photochrome. After induction of florigen the flower buds induced and flowering will occurs in the plant.

Global Photoperiodic Differences

Photoperiod is remaining same in their past situation. The light period in 21st June will remain 12 hours day and 12 hours night in equal or 24 hours night in South Pole and 24 hours day in North Pole, but the light period in 20-21 March and 22-23 September will remain 12 hours day and 12 hours night is equal in all the three equator, North and South Poles. So the long day plants can be flowering after 20-21 March and before 21st June and in short day period will grows vegetative. In the case of short day plant can be produce flowering after 21st

June. The long day plant will grow mostly in 30o – 45o north and south latitude in their season.
Concept of Light Radiation: A process of emitting energy in the form of electromagnetic waves or particles (photons). It ranges from cosmic rays, gamma rays, x-rays, UV light, visible light, to infra-red and radio waves.
Light: That portion of radiation perceived or the light-restricted portion of spectrum.
Irradiation: A process by which a surface is illuminated or irradiated (i.e. irradiation of flower buds with x-ray to induce mutation).
Light on Flowering Mechanism
Hormone- Leaves perceive stimuli produce hormone to induce flowering elsewhere hormone translocated to meristems genes for floral features switched on genes for vegetative features switched off.
Latitude and Season-Seasonal patterns affect plant distribution
Short day plants found nearer equator/temperate regions
Long day plants in more extreme latitudes
Significance-All numbers of a species flower at the same time. Allows cross-pollination to occur helps increase variation and natural selection.
Black cloth for darkness and artificial bulb for extend light
The production of flowers in short day plants induce earlier by use of black cloth for short day. In Chrysanthemum and Poinsettia we should be use black cloth or clack polythene for early induction of flower.
Artificial light should be given for long day flowering plants because it need long day for initiation of flower. So the use of incandescent (yellow – orange light limiting) bulb or fluorescent (Mercury) bulbs.

Photoperiodic Regulation of Flowering
Short-day plants flower when the day length less is less than a critical period in 24-h cycle. In short day plants (Chrysanthemum) requires the critical day length is 12-14 hours, if the length of the day increased this critical period, it will not produce flower. Short-day (long-night) plants flower when night length exceeds a critical dark period. In interruption of the dark by brief light treatment it will prevents the flowering in short day plants.
Long-day plants flower when the day length exceeds certain duration in 24-h cycle. In long-day plants (Carnation) required the critical day length 16-17 hours, if the light is less than this or night length increased it will not initiate flower.
Long day (short-night) plants flower if the night length is shorter than a critical period. In long-day plants the night break of dark by light for short period induces flowering.
Effects of the Duration of the Dark period on Flowering
In SDP when darkness is more than critical period will initiate flower and long day plants remain vegetative. If the light period will increase the SDP remain vegetative and LDP plants induce flowering. In SDP night break in middle of the night by short period remain vegetative but LDP initiate early flowering if it will give some short of dark period in day.
Example: Short day flowering plants – *Chrysanthemum, Kalanchoe, Poinsettias*, Morning glory (*Pharbitis*), Cocklebur (*Xanthium*)
Example of long day flowering plants – *Hibiscus, Fuchsia, Arabidapsis*.

Light for Florigen Activation
In the day time both PFR and PR build up to absorb the for-red (730 nm) and Red (660 nm) respectively. The PR conversion the energy (photon) to PFR in day time and PFR store them and in night conversion to PR. So the reverse reaction continuously in the phytochrome. The PFR is activated florigen and induce flowering. PR also conversion into PFR for inducing flowering.
Differences between acclimatized and non-acclimatized plants to artificial light
Acclimatized plants will be medium to dark green leaves but non-acclimated plants remain yellowish to light green leaves.
In acclimated plants have large leaves, flat leaves and thin leaves and widely spaced because the photosynthesis will occur more in plants. In non-acclimated plants have small leaves partially folded leaves, thick leaves, leaves crowded together because the chlorophyll content less in plants.

How the gating model may work in short days?
The model will work in biotechnological tools for genetic change in phytochrome. The red light absorb by phytochrome B, C, D, E and blue light absorb by phytochrome and cryptochrome, by use of biotechnological tools we eliminate phy B content from gene sequence and more promotion of cryptochrome 2, 1 and phytochrome A.

How the gating model may work in long days?
The long day plants will not produe flower if the content of cryptochrome 2 and phytochrome B, C, E, E. The red light absorb by phy B, C, D, E and inhibits the flowring. The blue and red light and far-red absorbed by photochrome and cryptochrome.
The elimination of Cry 2 gene and phytochrome B gene which inhibits the initiation of flowering.

Chrysanthemum have two critical photoperiod
The experiment conducted by Bhattacharji in 2008. The cultivar White Wonder requires 16 hours/day for flower initiation and 13 hours, 45 minute/day for flower development after 6 weeks. The show cultivar requires 11 hours/day for flower initiation and 10 hr/day for flower development after 15 weeks. In this experiment they took five varieties and got their flower initiation and flower development under number of weeks and critical day length.
Effect of photoperiod of the percentage population flowering (% flowering) and total flower number in *Kalanchae glaucescens, K. manginii and K. uniflora.*
The experiment done by Curry and Erwin in 2010. In this work they took three species of *kalanchoe* and given photoperiod in hours. The *Kalanchoe glaucesceus* would produced 100% flowering in 9, 10, 11, 12 hours respectively but after 13, 14 hours decreased 91, 9%. In *K. manginii* and *K. uniflora* gave 100% flowering in 9, 10, 11, 12 hours

Effect of photoperiod of the percentage population flowering (% flowering) and total flower number in *Kalanchoe glaucescens, K. manginii,* and *K. uniflora*

Parameter/Species	Photoperiod(h)					
	9	10	11	12	13	
Percent population flowering						
K. glaucescens	100	100	100	100	91	9
K. manginii	100	1oo	1oo	1oo	0	0
K. uniflora	1oo	1oo	100	1oo	25	0
Total flower number						
K. glaucescens	317	318	300	275	250	307
K. manginii	79	81	68	89	--	--
K. uniflora	45	36	29	32	12	--

respectively but in 13, 14 hours it would not produced flowering in *K. manginii* and 13 hours it would produced 15% flower, 14 hours no flower. The total number of flower maximum in *K. glaucescens* in 318 after 10 hours treatment and 250 in 13 hours treatment. The *K. uniflora* would gave 45 flowers in 9 hours and 12 flowe3r in 13 hours.

Effect of the number of weeks of short day (SD) treatment on the percentage population flowering (% flowering) and total flower number in *K. glaucescens, K. mangini* and *K. uniflora.* The experiment was conducted by Christopher and Erwin in 2010. They gave number of weeks of short days in *kalanchoe glaucescens, K. manginii* and *K. uniflora.*

The 100 per cent of flowering would constantly produced in *K. glaucescens* 1, 2, 3, 4, 5, 6, 7, 8 weeks light respectively but without week it would not gave flower. In *K. manginii* would not produced flower in 0 and 1 weeks but would increased 86% in 2 weeks and constantly increased 100% in 3-8 weeks. *K. uniflora* would not produced flower in 0, 1, 2 weeks and after 3, 4, 5, 6, 7, 8 weeks increased as 10, 53, 86, 100% respectively. The total number of flower maximum in *K. glaucescens* 130 in 5 weeks and 58 in *K. manginii* after 7 weeks short days and minimum 30 in *K. uniflora.*

The effect of photoperiod at equal light integral, achieved by the use of day extension, supplementary lighting-The experiment have done by Langton and co-workers in 2002. In this they took species of Geranium and Petunia and photoperiod, leaf area, greenness, dry weight. Geranium have maximum leaf area, greenness, dry weight 15.8cm2, 29.6 (SPAD-502), 0.036 g respectively.

Days to first flower for *Aquilegia flabalata* Cameo series and experimental *Aquilegia X hybrida* (Expt.) cultivars at five cooling durations and long or short-day photoperiod

Cultivar	Weeks of cooling at 4 ^{0}C									
	0	4	8	12		0	4	8	12	
	Long Days					Short days				
	DAYS					Days				
Cameo Blue and White	39	17	8	8	L***^{y}	37	15	12	11	L***
Cameo Blush	46	26	11	10	L***	46	22	19	10	L***
Cameo Pink and White	50	17	10	8	L***	44	14	16	16	L***
Cameo Rose and White	40	19	13	13	L***	38	23	18	13	L***
Expt. Blue and White	54	25	16	14	L***	46	29	24	15	L***
Expt. Red and White	47	33	21	22	L***	44	31	27	8	L***
Expt. Rose and White	51	31	30	16	L***	55	34	26	17	L***
Expt. White	39	26	18	18	L***	38	31	20	16	L***
^{y}L- linear response at the 0.001 (***) level Garner and Armitage, 1998										

Petunia also have maximum leaf area, greenness, dry weight 9.8 cm2, 39.0 (SPAD-502), 0.023 g, respectively.

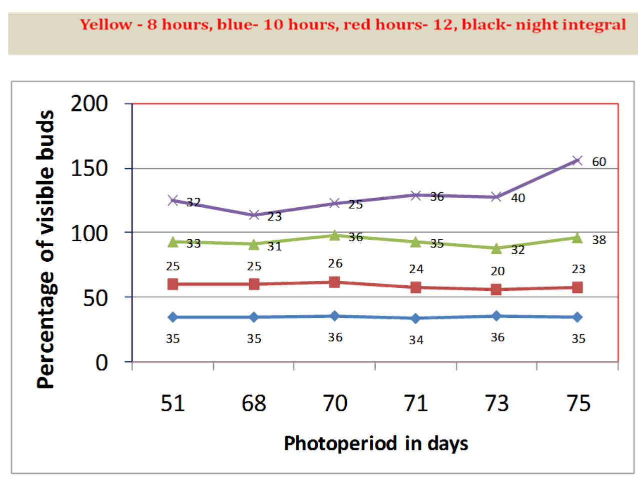
Day to first flower for *Aquilegia flabalata, Cameohap* series and experimental Aquilegia x Hybrida (Expt.) cultivars at five cooling durations and longer short-day photoperiod. The experiment conducted by Garner and Armitage in 1998. They have took cultivar of *Aquilegia flabalata* under number of weeds of cooling at 4oC in long days and short days conditions. The Cameo Blue and White would produce first flower in 2 weeks of cooling at 4oC and after 8 days in long days, as well Cameo Pink and White also produced after 8 days which is minimum days. The experiment Blue and White and Exp. Rose and White would gave maximum days in longs days as 54 and 51 for first flower initiation, respectively. The Cameo Blash and Exp. Red and White would took minimum day 10 and 8 for first flower initiation.

Effect of different photoperiod in floral initiation and development in Tuberose

The experiment has done by Peichang and co-workers in 1998. They have took parameters seedling height and mean length of the plants at harvest for effective in photoperiod to promotion of flower initiation and development. The Tuberose at seedlings height 0.5 cm and mean length at harvest 4.3 cm would emerge flower (5) in long days and no flower in short days. As well as seedlings height and mean length of the plants at harvest produced flower in LD and SD as 6-30 cm, 17.5cm, 10 and 8, also in 31-50 cm, 42.8 cm, 8 and 9. But flowers development of 5 and 4 in seedlings height (31-50 cm) and harvested stage length 42.8 cm in LD and SD conditions.

Percentage of *Strobilanthes dyrinus* plants showing visible buds under each photoperiod in the greenhouse experiment. The experiment conducted by Scoggins and co-workers in 2003. They have taken photoperiod in days for *Strobilanthes* visible buds.

Percentage of *Strobilanthes dyrianus* plants showing visible buds under each photoperiod in the greenhouse experiment Scoggins *et al.*, 2003



The *Strobilanthes* flower would produced maximum 60% visible buds with night integral (given short light in mid night) after 75 days and minimum 20-25% in 10 hours photoperiod after 51-75 days. The 8 hours and 12 hours produced 31-38% visible buds after 51-75 days.

Effect of four colour shade-nets on inflorescence diameter in *Trachelium.*

The experiments has done by Ovadia and co-workers in 2009. They have taken yellow, red, black and blue type of coloured shade nets. The maximum inflorescence diameter found in black shade-nets was 12 cm, and minimum 8.3 cm in blue colours shade nets.

Effect of photoperiod on the flower diameter (cm) of sunflower

This work have done by Hayata and Yukiko in 2009. They have taken four cultivar of sunflower under LD, SD and ID.The Big Smile, Sun-rich orange, valentine gave flower diameter as 9.3, 13.5, 9.4 cm in LD at emergence of seedling stage and LD in flower bud emergence. The Taiyo gave flower diameter 11.4 cm in SD – SD for emergence at seedling stage and SD in flower bud emergence.

Short days required for each stage of inflorescence differential in Chrysanthemum

The work have done by Jiang and co-workers in 2002. They have taken short days and evaluate each stage of inflorescence differentiation in chrysanthemum.

(S1 a flat shoot apex with leaf primordial), growing point hypertrophy (S2 the shoot apex formed a hemispherical shape) initial involucres are primordial differentiation (S3 involucres primordial differentiated at the periphery of the dome), final involucres primordial differentiation (S4, the dome became flat and many involucres differentiation completed), initial floret primordial differentiation (S5, floret primordial differentiated at the periphery of the dome), final floret primordial differentiation (S6 more than 50% of dome was covered with floret primordial), initiate crown formation (S7, the petal primordial differentiated in the floret primordial at the base of dome), metaphase crown formation (S8, the floret primordial covered the dome and further development of each floret progressed a cropetally) and final crown formation (S9, the florets with closed petals filled the dome). It took 8 days to complete involucres primordial differentiation, 12 days to complete floret primordial differentiation and 10d to complete crown formation. In florescence differentiation began within 4 days of exposure to SD.

Different endogenous hormone levels during the inductive inflorescence differentiation process in Chrysenthemum. The work has done by Jian and co-workers in 2010. They have taken short day and long days and hormone levels during inflorescence differentiation.

After floral induction, the four endogenous hormone levels significantly changed. The level of FAA decreases in chrysanthemum buds just prior to the appearance of the floral meristem. The FPA content increased markedly after floral induction, with implies that a transient increase in cytokinin is associated with the early events of the floral transition. The IPA level reached its peak at the final stage of involucres primordial differentiation and remained high thereafter, a period characterized by rapid cell decision. Since cytokinins are primarily associated with the acceleration of cell division, it is reasonable to suppose that the observed high levels of cytokinins at these stages is required for the formation of the involucres, the floret primordial and the crown.

Endogenous ABA level during inflorescence differentiation was higher than that in vegetative growth control all throughout, indicating that endogenous ABA promote floral transition, while different stages need different ABA content during the inflorescence differentiation of chrysanthemum. The gradual decrease in endogenous GA3 from S1 to S4 in 'Jingyun' grown under induced conditions indicates that lower content of GA3 appears to be necessary for floral induction and floral initiation in chrysanthemum. Stages S6 to S9 during inflorescence differentiation are characterized by quick formation and growth of florets, especially the growth of petals and formation of stamens. Higher GA3 level during these stages may be responsible for accelerating the cell division and elongation of florets.

Effect of photoperiod on the flower diameter (cm) of sunflower

Day-length I^Z II^Y	Big smile	Sun-rich orange	Taiyo	Valentine
LD-LD	9.3	13.5	11.3	9.4
LD-SD	8.8	12.3	10.9	9.0
SD-LD	7.8	12.3	11.2	9.1
SD-SD	7.4	12.4	11.4	8.9
ID-ID	8.2	12.3	10.0	9.2

The experiment has done by Hayata and Yukiko in 2009. They have taken four cultivar under different photoperiod condition.The Big Smile and Sun-rich orange gave 69 and 87 number of flower bud differentiations in LD from germination to first bud emergence and also LD in flower bud differentiation to anthesis. The Taiyo and Valentine gave 73 and 97 number of flower bud differentiations in LD from germination to first bud differentiation to first but SD in flower bud differentiation to anthesis.

Conclusion

Photoperiod should be used for early and extended production of flower in off-season.

Photoperiod will be manipulated through the use of black cloth or right integral lighting.

Year round production of flower will increase income of ornamental growers.

The European countries more demand in winter but in India will more export of flower at that time. The flower will get better price.

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