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Photoperiod manipulation in flowers and ornamentals for perpetual flowering

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Abstract
Horticulture plays a key role in increasing the agricultural GDP by its high valued crops. Floriculture is one such allied sector of Horticulture which involves high valued, export oriented commercial flower crops and ornamental plants, playing as a major contributing sector to Horticulture. Due to uprising urbanization of the society worldwide, especially in India, demand for flower and ornamental crops is increasing. In order to fulfill the raising demands year-round and off-season production of these crops is necessary. So, exploitation of new techniques is needed to increase the production and productivity. Photoperiod manipulation is one of the effective techniques to produce offseason flowers and to do flower forcing in case of photosensitive crops like long day plants and short-day plants. Photoperiodism is a physiological process, which is correlated with the day length of the particular season and responsible for the developmental activities in the plants. Photoperiodic flowering in plants is regulated by photoreceptors including the red/far-red light-receptor phytochromes and the blue light-receptor cryptochromes, which can be altered by artificial lighting and shading by using different light sources and blackout cloths, respectively. Photoperiod regulation is also used intensively in potted ornamental plants like poinsettia, petunia etc. to reduce the plant height and shape of the plants to maintain the consumer appeal. Date of harvesting or flowering can be effectively scheduled by exploiting the daylength. In this paper reviews on photoperiod regulation techniques, different light sources and phytochrome manipulation are discussed.

Keywords: Photoperiod, photoreceptors, phytochrome, Far- red light, supplemental light, (LED) Light emitting diode, critical day length, night interruption

Introduction
Flowers have immense importance in India for offering in religious worship, also for the purpose of decorating the places, particularly when there are various festivals. In the Indian culture the flowers have great importance and significance. Indian flowers are exported only in the small quantity to world market. Traditional technologies are still followed by the farmers and they grow the flowers seasonally which will create the glut in market and prone to price drop, while the same produce will fetch very high price during offseason (Shelke, 2014) [59]. Since commercial floriculture and ornamental plants sector is highly economical, money spinning and export oriented, immense attention is needed for improvement of modern technology, innovative cultural operations which will boost the production and quality of the crops. Now, the Hi-tech flower industry is preferable for off-season production through crop regulation.

One such technique in hi-tech floriculture industry is photoperiod regulation of flowers and ornamental plants. Many potted flowering plants, bedding plants, cut flowers, and herbaceous perennials flowers show good response to photoperiod. By understanding the photosensitivity of the different plants, we can manipulate the vegetative and reproductive phase duration of those plants and can get economical produce year-round.

Photoperiodism
The photoperiodism can be defined as "response of plants to different duration and timing of the light and dark periods with respect to the flowering process". Photoperiodism is the developmental response of the plants to the relative lengths of light and dark periods. Day length measurement is found to be achieved through the integration of endogenous circadian rhythms with external light signals (Pittendrigh and Minis, 1964) [49].

Flowering is a correlative interaction exists between the leaf which receives the day light and the apex which actually develops in to a bud and then change into the flower. These photoperiodic reactions can also be produced when the natural day is lengthened by a very weak artificial light. Light quantity and the intensity will not affect much, but light duration is the important factor in lengthening the light period (Poesch, 1931) [50]. Henrard and Neuray (1965) [20] reported that, in two varieties of cyclamen, vegetative growth was affected more by day length than by light intensity.

Classification of plants according to different photoperiod requirement (Ha, 2014) [17]:

1. Short day plants or long night plants which flower in response to dark period that exceeds a minimum critical length,
2. Long day plants which flower in response to day lengths exceeding a certain minimum critical value.
3. There is still a small group of plants existing which is known to be non-responsive to variations in day length and they are called "day-neutral or indeterminate plants".

Table 1: Classification of plants based on different photoperiod

Class	Example
Obligate short-day plants	African marigold, Mina vine (*Mina /ipomoea lobata*).
Facultative short-day plants	Cosmos, Globe Amaranth (Gomphrena), Moonflower (*Ipomea*), Morning Glory, Signet marigold (*Tagetes tenuifolia*), Zinnia, Creeping Zinnia (*Sanvitalia*), Celosia.
Obligate long day plants	*Centaurea*, China aster, Fuchsia, Gazania, Lavatera, Lobelia, Monkey flower (*Mimulus*), Petunia, Strawflower, Sweet pea (*Lathyrus*), Primrose (*Oenothera*).
Facultative long day plants	Ageratum, Calendula, Dianthus, Linaria, Pansy (Viola), Petunia (Grandiflora types), Salvia, Snapdragon, Statice, Sunflower, African Daisy (*Dimorphotheca).*
Day neutral plants	Amaranthus, Cleome, Cobia, Stock, Verbascum, Wax begonia (*Begonia x semperflorens*), Balsam (*Impatiens balsamina*), French marigold (*Tagetes patula*).

Flowering in the photo-sensitive plants is an inductive process, that is, plants given with photoperiodic treatment promotes flowering and continue to produce flowers even though they are returned to a photoperiodic region that would not lead to flowering. Islam *et al*. (2005) [27] reported that *Eustoma grandiflorum* is photosensitive flower crop which will produce early visible flower buds and enhanced flower bud initiation under quantitative long day condition, but it requires short day length for its ideal vegetative growth.

Interestingly, within the short and long-day plant groups, the plants are categorized according to facultative (quantitative) and obligatory (qualitative) responses. The species with quantitative response will flower under any photoperiod; nonetheless, under the described photoperiod flowering is promoted. In contrast, the plants with qualitative response will not flower until they obtain the desired photoperiod (Ha, 2014) [17].

Some species possess a facultative response to photoperiod. For example, time to first visible inflorescence bud of *Rosa floribunda* was 31.4 ± 2.1 days under long day (16hrs photoperiod) compared to 73.0 ± 2.5 days under short day (8hrs day-length) (Bunker, 1995) [6] and *Chrysanthemum morifolium* and Geraldton wax-flower (*Chamelaucium uncinatum*) are quantitative short-day plants with flowering promoted in short day condition (Sharman *et al.*, 1989) [58].

Impact of photoperiod mechanism on growth and flowering

Flowering response to photoperiod is due to photoreceptors present in the plants (Lin, 2000) [36]. Light is absorbed by plant photoreceptors including phytochromes, cryptochromes and phytotropins (Muneer *et al*., 2014) [41]. Plants respond to photoperiod according to the quality of the light and interaction of phytochromes and cryptochromes (Mockler *et al*., 2003) [39]. Plants absorb various wavelength of light but, blue and red represent the majority of wavelengths absorbed by chlorophylls and contribute much more to photosynthesis (Pinho *et al*., 2012) [48]. Phytochrome is a blue green pigment which absorbs R(red) and FR(far-red) light, responsible for correlation of the plants and light. (Hughes, 2013) [24].

Light converts phytochromes into photo-reversible forms under *in vivo condition*: Pr(Phytochrome red) absorbing R(red) light, with an absorption peak at 650–670 nm and Pfr (Phytochrome far-red) absorbing FR (far-red), with an absorption peak at 705–740 nm. Pr absorbs R light and is converted to its active form Pfr; on the contrary, Pfr absorbs FR light and is converted to its inactive form Pr (Butler *et al.*, 1959; Paradiso and Proietti, 2021) [7, 46]. Runkle and Heins,2006 reported that low Pfr/ Pr+FR promotes stem elongation and flowering in long day plants (LDPs) which can be supported by report of Downs and Thomas(1982), when artificial lighting contains far red light(FR), particularly at the end of the photoperiod flowering was most rapid in many long day plants.

Along with providing artificial lighting, day light integration (DLI) plays important role in quality and yield. Oh *et al*. in 2010 revealed that during propagation of several herbaceous ornamentals, transplant quality and subsequent flowering can be increased effectively by increasing DLI.

Red: Far red (R:FR) ratio of light is important for controlling plant growth by creating direct impact on the phytochrome system, in turn regulating the gibberellic acid synthesis. The phytochrome photo-stationary state can be calculated for each light spectrum as described by Sager *et al.* (1988) [55]. Stem elongation is inversely proportional to P_{fr}: P_{total} (Morgan and Smith 1979) [40]. This is taken as an advantage to reduce the plant height in many ornamentals, bedding and potted plants.

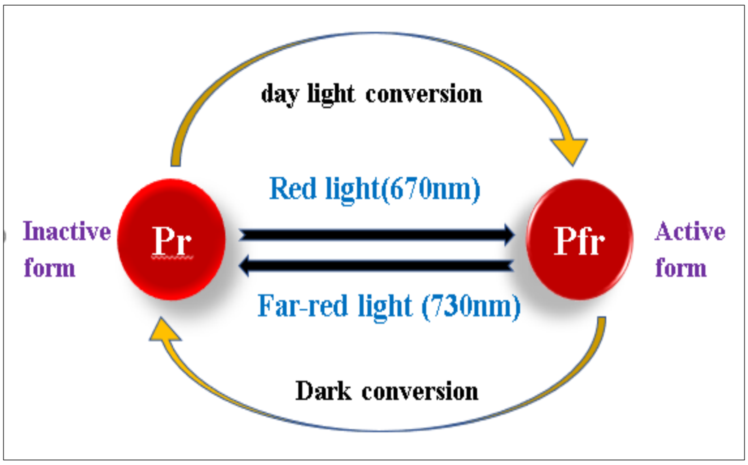

Fig 1: Interconversion of phytochrome red and far-red during day and night

Clifford *et al.* (2004) [9] demonstrated that filters reducing FR light are almost as affective as two treatments with CCC (cycocel) in controlling the height of Poinsettia and also suggested the movable screens, which was applied only in the morning and afternoon, when the R:FR ratio of the natural light is at its lowest range.

Photoperiodic lighting with R and FR proportion creating an intermediate PPE-photosynthetic photo efficacy (0.63–0.80) has been proved to be more effective to promote flowering in some long day species (*Antirrhinum majus, Fuchsia×hybrida, Petunia×hybrida, Rudbeckia hirta*) compared to a R and FR lighting creating a high PPE (above 0.80) (Craig and Runkle 2016) [11].

The flowering of chrysanthemum, dahlia (*Dahlia hortensis*) and marigold (*Tagetes erecta*) was delayed by 42, 11, and 10 to 20 days when grown under 4hrs night interruption (NI) provided by

light emitting diodes (LEDs) with an R:FR >0.66 at a photon flux density of 1.3 to 1.6 mmol·m^{-2}·s^{-1} compared with short day control (Craig and Runkle, 2013) [10].

Jeong *et al.* (2014) [30] studied the flowering responses and stem elongation of cut chrysanthemum to supplementary blue lighting under different photoperiods. Results indicate that supplemental monochromatic blue lighting for 4 hrs after 11 hrs of mixed RB (red and blue) light promotes internode extension and stem length (91.8cm) and it is highest in plants grown under 11 hrs of mixed RB light and then 13 hrs of B Light.

Table 2: Photoperiod requirement of some ornamentals and flowers

Plants	Critical day length(hrs)
Short day plants	
Chrysanthemum	10
Poinsettia	10
Celosia	10
Cosmos	11
Ipomoea lobata	9
African marigold	11
Long day plants	
Rudbeckia	13
Pansy	14
Petunia	13
Carnation	13
Dahlia	12

*Short day plants will initiate flowers when the day lengths are *shorter* than their critical day length.

* Long day plants will initiate flowers when the day lengths are *longer* than their critical day length.

Techniques to Manipulate Photoperiodism in Plants

Natural photoperiods can be altered to create long days or short days artificially.

Photoperiod regulation techniques to create short day

Use of black tarpaulin suspended on an iron frame from 5 PM until 7 AM for creation of short days in scheduling of short-day flowers is generally practiced. Short days are desirable for long day plants also, in order to delay or prevent flowering in them. Dense black polythene sheeting (150 gauge thick) is the most suitable material for complete black outs. Light levels should be <0.5-foot candles in a blackout condition (Sharma *et al*.,2019) [57].

While studying the photoperiod required for flowering of *Miltoniopsis* orchids (potted showy orchid), Lopez and Runkle (2006) [37] reported that it will flower completely (>90%), when plants are exposed to short days for 4 or 8 weeks before 8 weeks of vernalization.

Janakiram *et al.* (2004) [29] conducted an experiment on production of cut flower chrysanthemum cv. Ravikiran under low-cost polyhouse. The results found that 10 hrs dark and 14 hrs light period resulted the maximum plant height (77.73 cm), stem girth (0.62 cm), leaf area (102.03 m^2), earliest flower initiation (124.67 days) and earliness to reach 50 per cent flowering (137.33 days) followed by 11 hrs dark and 13 hrs light period.

Palai *et al.*(2018) [45] reported that in chrysanthemum, treatment involving 16 hrs of short day recorded higher plant height (63.63 cm), maximum number of flowers per spray (5.33). Whereas, maximum number of side shoots per plant (11.00) and number of flowers per plant (42.33) were recorded in treatment provided with 14 hrs dark and 10 hrs daylight

Short-day treatment applied from 5.00 PM to 9.00 AM induced the doubling of flower yield interns of cut stems and increase the length and diameter of cut flowers as compared to control (Sipho and Paul, 2010) [60].

Photoperiod regulation techniques to create long day

During natural short-day conditions, long days can be created by three different methods;

1. by giving supplemental lighting immediately after the sunset, known as day-extension,
2. by providing artificial lighting during the midnight, known as night-interruption and
3. Providing lighting from 2 am until sunrise, also called as pre- dawn lighting.

To create a long day for a range of different species, night interruption lighting should be delivered during the middle of the night for a continuous 4hrs. The increased number of flowers with increased night interruption, duration might be attributed to the more vegetative growth coupled with stimulated branching and high carbohydrate synthesis with enhanced mobilization of assimilates by young sink tissues of growing lateral shoots (Verma *et al*., 2011) [65]. But some long day plants will not respond to night breaks and did not bear flower under short day condition.

The artificial long days of 2 hrs extended light immediately after sunset, resulted in the highest number of flowers per plant and flower yield in chrysanthemum (Velmurugan and Vadivel, 2008) [64].

Baloch *et al*. (2011) [2] revealed that flowering time was hastened up to 25 (Pot Marigold cv. Resina and Oriental Poppy cv. Burning Heart), 24 (Annual Phlox cv. Astoria Magenta and Flax cv. Scarlet Flax) and 22 days (Cornflower cv. Florence Blue) under LD environment (17 hrs/day) and photoperiod (qualitative long day) is essential for flowering.

Kalanchoe species flowered, when grown under photoperiods ranging from 9-12 hrs and the flowering percentage of plants decreased in all the species as the photoperiod increased from 12 hrs to 14 hrs. When the plants grown under a 15 hrs photoperiod no flowering occurred (Curry and Ervin, 2010) [12].

Long days are also provided by end of day treatment with light. Applying End-of-day (EOD) treatments with red light is one of the methods, where a low input of light can have a great influence on plant elongation (Bergstrand, 2017) [3, 4].

Islam *et al*. (2014) [28] reported that, in poinsettia, EOD-R (end of day- red) light treatment, inhibits stem extension growth through affecting the metabolism of hormones; *i.e.*, correlated with 29(%) and 21(%) lower levels of GA and IAA, respectively.

Night interruption is one of the best methods of providing long day condition. Leaf expansion and stem elongation occurred at a faster rate in plants which were grown in short days with irregular light breaks during the night period as compared to plants grown in a consecutive long light condition (Katrine and Carl, 2011) [31].

Oh *et al*. (2013) [42] and Runkle *et al.* (2012) [54] reported that in long day plants like campanula (*Campanula carpatica*) ‘Pearl Deep Blue’, coreopsis (*Coreopsis grandiflora*) ‘Early Sunrise’, cyclamen (*Cyclamen persicum*) ‘Metis Red’, and rudbeckia (*Rudbeckia hirta*) ‘Becky Cinnamon Bicolor’, night interruption of 4-hrs along with short day of 9-hrs is as effective as a 6-hrs of day extension in promoting flowering.

Night interruption can be used to delay the flowering in many short-day crops and to schedule the flowering at desirable time. Flowering was effectively inhibited when the required long night phase was interrupted by a short period of exposure to red light (night break) in chrysanthemum (Yohei *et al.*,2012) [70].

In chrysanthemum, while supplementing the light during short day condition, regular night breaks increase the leaf expansion and stem extension at faster rate there by promotes the photosynthetic area of the plant and also saves the energy (Kjaer and Ottosen, 2011) [32]. *Kalanchoe blossfeldiana* flowering can be inhibited most effectively when the night interruption provided between 5-7 hours after the onset of darkness (Harder and Bode 1943) [18].

Mattson and Erwin (2005) [38] reported that artificial LDs are provided to maintain short day plants in a vegetative state (without flower initiation) for production of vegetative stem cuttings in commercial scale production.

Growth retardation of ornamental plants by photoperiod manipulation

The elongation of ornamental pot and bedding plants in greenhouses needs to be restricted in order to improve plant appearance by promoting compact growth, high density of flowers. By regulating the photoperiod one can effectively retard the growth and it can substitute the effect of chemical growth retardants, which are harmful to humans and ecosystem. However, short photoperiods delay development, as most bedding plants are long day plants.

Walters *et al.* (2019) [68] investigated the response of foliage annuals to different photoperiod and its effect on their growth and flowering. The results show that night interruption with 14 hrs of photoperiod is effective in inhibiting the flowering in foliage plants. Stem elongation of plants increased as photoperiod increased from 9 to 12 hrs using LEDs providing R: W: FR (red, white, far red) radiation.

Bergstrand *et al*. (2017) [3, 4] revealed the effect of lighting combined with short photoperiods as a way to control growth in green house grown ornamentals. Results shows that growth control using short photoperiods is more effective in *Argyranthemum* and *pelargonium* with plant height of 144mm and 234mm respectively, where as in case of *Tagetes* and *Calibrachoa* chemical growth control and short photoperiod treatment are equally effective.

Schussler and Bergstrand (2012) [56] reported that strong reduction in shoot elongation was obtained in bedding plants such as *Calibrachoa, Scaevola* and Petunia, when the two-week period of short photoperiod (6 or 8 hrs) was applied in the middle or at the end of crop growing period. El-Sheibany *et al.* (2007) [15], reported that short days and plant growth retardants reduced, stem length in chrysanthemum.

In poinsettia, 80%B + 20%R LED light reduced the plant height and the area of leaves and bracts and the leaf chlorophyll content compared to HPS (5% B), even though with no influence on flowering time and postproduction duration, in both growth chamber and greenhouse (Islam *et al*. 2012) [26].

Annual species crops like *Antirrhinum, Catharanthus, Celosia, Impatiens, Pelargonium, Petunia, Tagetes, Salvia and Viola* were grown under 16 hrs of photoperiod along with supplemental light using HPS and LED at different blue and red-light proportions. Results revealed that plant height was lower in the seedlings which were grown under LED, while the quality of the seedlings are superior or similar in case of LED compared to the HPS (Randall and Lopez, 2014) [51]

In *Dieffenbachia* and *Ficus* grown in greenhouse, supplemental B(blue) plus R(red) LEDs increased the plant height, but no noticeable effect on sugar, chlorophyll and carotenoid content was observed (Heo *et al*. 2010) [22].

Role of light sources in photoperiod regulation

Different light sources are being used in photoperiod regulation, such as incandescent (INC), CFL (compact fluorescent light), Halogen bulb, metal halide and LED(light emitting diode) bulbs. All these sources have their own pros and cons. INC lamps are easy to install, they emit light that is rich in R and especially FR and are inexpensive. But they are energy inefficient; they consume more energy and convert only 10% of it into visible light (Thimijan and Heins, 1983) [62]. Now a days, ideal and economical source of supplemental light is LED's. Although the HPS(high pressure sodium) lamps are the current industry standard, LEDs have emerged as an effective supplemental light source with regard to irradiance and efficacy (Wallace and Both, 2016) [67].

LEDs of different spectrum can be combined at the desired intensity to modulate the different plant functions, providing a useful tool to control plant growth and photomorphogenesis (Darko *et al.* 2014). Accordingly, they can be used for several purposes, such as the control of size in potted ornamentals, the scheduling of flowering in commercial cut flower crops, the strengthening of mechanisms of abiotic stress tolerance and the improvement of chemical composition of plant food (Huche-Thelier *et al*. 2015) [23].

Heo *et al*.(2003) [21] reported that in *Cyclamen persicum*, manipulation of light quality and photoperiod using blue and red LEDs(10hrs of photoperiod) improves the flower induction and enhances the blooming period up to 40 days, which was only 20 days in case of fluorescent light.

Ibibofori *et al*. (2019) [25] reported that LEDs are equally effective as halogen lamps in regulation of growth and flowering, but energy consumption is more in halogen lamps with similar light intensity. Plants grown under LEDs were superior in quality comparatively and there was a synergistic effect between the LEDs and GA_3 in growth regulation in potted ornamentals.

When high pressure sodium lamps are used to increase the photoperiod, it can effectively improve the vegetative growth of the chrysanthemum by increasing the plant height, number of leaves, internodal length and leaf area significantly (Kumar and Singh, 2017) [34].

The artificial light sources which are used for plant growth must balance quality, intensity and photoperiod successfully (Goto, 2003) [16]. Kohyama *et al.*, 2014 reported that Incandescent lamps and R + FR light-emitting diodes are effective at controlling flowering of LDPs since they create an estimated PPE of 0.6–0.7.

Blanchard and Runkle (2009) [5] reported that when NI is delivered at >2.4 μ mol m^{-2} s^{-1} using cyclic HPS lamp, flower induction can be delayed effectively and flowering can be prevented in chrysanthemum.

Light quality also affects the phytohormone content in many flowering plants. Ubukawa *et al.*, 2004 reported that light quality had impact on the active gibberellic acid (GA) content in petunia and GA content was lower under High pressure sodium (HPS) lamps compared to Metal halide (MH) lamps.

Flowering of campanula (*Campanula carpatica*) 'Deep Blue Clips' and coreopsis 'Early Sunrise' shows the same results under a 9-hrs day with a 6- h day extension or 4-hrs night interruption provided by using incandescent lamps, compact fluorescent or both (Padhye and Runkle, 2011) [44]

Thao *et al*. (2018) [61] conducted the experiment on effects of different supplemental lighting sources on chrysanthemum growth and flower quality in open-field conditions. The results revealed that LED supplemental lighting at night stimulated the growth in the early stage compared to compact florescent and incandescent lighting. The plants grown under LEDs was bloomed earlier yet got higher quality in term of plant height (24.50cm), stem diameter (3.98mm), flower sizes as well as leaf and flower numbers (22.22).

Park *et al*. (2016) [47] investigated the responses of Petunia growth and flowering to various artificial light sources. Results revealed that plants grown under HPS (high pressure sodium lamp) and MH (metal halide lamp) had 12 open flowers. Maximum plant height (53.2cm) and plant width (32.4cm) recorded in plants grown under fluorescent bulb + halogen lamp. Light sources with low R:FR (red: far-red) ratios promote flowering and stem elongation in petunia.

In tulip crop, days to sprouting and flowering reduced by white, blue, red light treatments especially at blue light (9.9 and 10.7%, respectively) with high yield, compared to dark conditions (Amiri *et al*., 2018) [1]. They also reported that as light can alter morphological, biochemical and the flowering traits of plant, it is suggested to use the changing of light qualities instead of using hormone for various purposes such as cut flowers or pot plants.

Table 3: Research outcome of flower crop regulation

Crop	Research outcome	Reference
Carnation	Extended photoperiod of >14hrs results in rapid growth and bud initiation.	White, 1960 [69].
Carnation (var. white sim)	Extended photoperiod results in earlier flower initiation.	Harris and Ashford, 1966 [19].
Fuchsia hybrida.	EOD*-treatments with red light reduced internode length	Vince-Prue, 1977 [66]
Rudbeckia fulgida 'Goldsturm'	For vegetative growth it requires ≤13hrs and for flowering it requires ≥14hrs of photoperiod.	Runkle *et al.*, 1999 [52].
Poinsettia	Filters reducing FR* are almost as affective as two treatments with CCC* in controlling the height.	Clifford *et al.*, 2004 [9].
Miltoniopsis orchids	When plants are exposed to short days for 4 weeks will flower >90%.	Lopez and Runkle,2006 [37].
Oncidium	B, R and FR LEDs results in maximum morphological and biochemical development.	Chung *et al.*, 2010 [8].
Paphiopedilum	B LED light results in compact plant with more flowers.	Lee *et al*., 2011 [35].
Calibrachoa, Scaevola and Petunia	Strong reduction in shoot elongation by providing 6 or 8 hrs of short photoperiod.	Schussler and Bergstrand, 2012 [56].
Chrysanthemum	NI with R light inhibited the flowering effectively.	Yohei *et al*.,2012 [70].
Chrysanthemum, Dahlia and *Tagetes erecta.*	Flowering was delayed by 4hrs of NI* with LED.	Craig and Runkle, 2013 [10].
Poinsettia	EOD-R treatment, inhibits stem extension effectively.	Islam *et al*.,2014 [28].
Antirrhinum majus, Fuchsia×hybrida, Petunia×hybrida, Rudbeckia hirta	Photoperiod with intermediate PPE* has been proved to be more effective to promote flowering in some LD* species.	Craig and Runkle, 2016 [11].
Petunia	Light sources with low R:FR (red: far-red) ratios promote flowering and stem elongation.	Park *et al*., 2016 [47].
Tulip	W: R: Blight treatments results in high yield, compared to dark	Amiri *et al*., 2018 [1].

	conditions.	
Chrysanthemum	LEDs are best lighting sources for open field cultivation compared to CFL* bulbs.	Thao *et al.*, 2018 [61].
Irisin, Alternanthera, Strobilanthus,	NI* with 14 hours of photoperiod (R: W:FR) is effective in inhibiting the flowering.	Walters *et al.*, 2019 [68].

N*- Night interruption, EOD*-End of day treatment, LD*-Long day, SD*-Short day, FR*- Far-red, R*-red, W*-White, B*-blue, CCC*-Cycocel, PPE*-photosynthetic photo efficacy, CFL*- Compact fluorescent light.

Conclusion

Now days, growing of flowers and ornamental plants are dollar earning sector. By using the proper techniques in cultivation one can achieve the target of high yield and export-oriented quality with year-round production, which is possible by manipulating the photoperiod and regulating flowering time as per the requirement and price in the market. It is one of the reliable methods, if growers prepare the proper schedule of light and dark.

period requirement of the plants with good knowledge about photosensitivity of specific crop.

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