Plant Archives Vol. 25, Supplement 2, 2025 pp. 2704-2710 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-2.344

SYNCHRONIZING BLOOMING WITH MARKET DEMAND: CROP REGULATION IN COMMERCIAL FLOWER CROPS

B. Bhargavi*, M. Raja Naik, N. Vinod Kumar, T. Sumathi, P.T. Srinivas and P. Jassica Keren
Department of Floriculture and Landscaping, College of Horticulture, Anantharajupeta,
Dr. Y.S.R. Horticultural University, Andhra Pradesh-516105, India
*Corresponding author E-mail: bhargavibhumi@gmail.com
(Date of Receiving : 30-04-2025; Date of Acceptance : 03-07-2025)

ABSTRACT

Flower forcing also known as crop regulation, is a planned and impactful horticultural practice aimed at altering the phenology of ornamental plants to meet specific market demands, climatic conditions and production goals. This approach is particularly vital in commercial floriculture, where the timely availability, uniformity, and quality of flowers are crucial for profitability. The process involves the controlled adjustment of environmental, cultural, and chemical factors to either induce or delay flowering. Common methods include pruning, pinching, altering irrigation schedules, nutrient management, photoperiod control, and the use of plant growth regulators (PGRs). Additionally, temperature manipulation is also employed to synchronize flowering and improve bloom quality. The natural peak flowering time of a plant often does not align with the period of highest market demand. Therefore, the flowering sequence is adjusted to avoid excessive production during in season and to encourage a more continuous, steady supply of flowers throughout the year. This practice benefits both producers and consumers by ensuring a consistent availability of quality flowers**.** Its implementation enables growers to meet consumer demands year-round, making it indispensable for competitive flower production systems.

Keywords **:** Flower forcing, crop regulation, year-round production, photoperiod, vernalization, plant growth regulators.

Introduction

Flowers have been an integral part of human beings, growing flowers has been a traditional and non-commercial activity in the past. However, after the globalization of the Indian market, the trading of floriculture products boosted leaps and bounds and has become a commercially viable industry (Sinha and Sharma, 2022). Flowers and flowering plants have been associated with mankind since time immemorial, as they have been used for religious offerings and other social ceremonies. Besides their aesthetic and religious value, flowers are also important for their economic use. However, with globalization and the rise of a free market economy, flower cultivation has developed into a full-fledged industry. Today, cut flowers and potted plants are among the most commercially grown and exported ornamental plants (Nazki and Wani, 2018; Rao and Sushma, 2016). As a result, traditional farming has become more commercially viable and cost-effective than many conventional practices. This has transformed traditional farming into more profitable and cost-effective ventures compared to conventional farming.

The global floriculture industry has experienced significant growth in recent years, driven by increasing demand for ornamental plants, flowers, and foliage worldwide. In 2024, the market was valued at approximately USD 63.87 billion and is projected to reach USD 90 billion by 2029, growing at a compound annual growth rate (CAGR) of 7.33%. The leading commercial cut flowers producers are Netherland, USA, Columbia, Kenya, Zimbabwe, Japan, and Israel. Colombia, Germany, Italy, Ecuador, and Kenya are major exporters next to Netherlands which contribute to a 43.8% share in international exports in 2018 (Anumala and Kumar, 2021). The United States holds the leading position in global cut rose imports, with a reported import value of approximately $799 million in 2023, highlighting its dominant share in the international market. Other key importers include the Netherlands, Germany, the United Kingdom, and France. While exact percentage shares may vary across sources, available data clearly indicates the U.S. as the top importer in this category (Observatory of Economic Complexity (OEC), 2023).

The significant global demand for flowers underscores the importance of regulating and synchronizing flower production. To bridge the gap of in season surplus and off season market demand, flower forcing techniques are employed to manipulate the flowering time, ensuring consistent and timely supply regardless of seasonal limitations (Song and Shim, 2015). The objective of this review is to provide an overview of current knowledge on crop regulation techniques in floricultural crops, with a particular focus on how these processes can be strategically manipulated for the growers benefit. This article aims to consolidate and present updated insights into flower regulation influenced by environmental factors such as ambient temperature, light, and photoperiod, chemical factors including the use of plant growth regulators and other agrochemicals, physical and cultural practices such as pruning, pinching, thinning and planting time, as well as genetic regulation. Understanding these regulatory mechanisms is crucial for optimizing production schedules and improving the economic viability of commercial floriculture.

Objectives of Crop Regulation in Floriculture Crops

1. **Synchronizing Flowering with Market Demand:** One of the primary objectives of crop regulation in floriculture is to align the flowering period of crops with market demand. Floriculture markets, both domestic and international, are heavily influenced by seasonal events such as festivals like Diwali, Christmas and holidays such as Valentine's Day, Mother’s Day *etc*. By controlling the flowering schedule, growers can schedule the harvest to coincide with these high-demand periods, thereby maximizing the returns.
2. **Achieving Year-Round Flower Production**: Consistent flower production is a critical objective in commercial floriculture. Crop regulation techniques enable growers to extend or shift the natural blooming period of flowers, facilitating year-round production. This is particularly beneficial in flower crops like chrysanthemum, gerbera, and rose, which are in high demand throughout the year (Chandel *et al*., 2023). Continuous production ensures a stable income for growers and reliable supply for markets, exporters, and retail chains.
3. **Enhancing Flower Quality and Uniformity**: Regulating the flowering process also contributes to improved flower quality and uniformity. Environmental and chemical interventions can be used to enhance desirable traits such as flower size, color intensity, stem length, and overall freshness. Uniform flowering leads to synchronized harvesting, which simplifies post-harvest handling and grading. High-quality blooms with consistent appearance command better prices in both domestic and international markets.
4. **Increasing Economic Returns**: Through strategic manipulation of flowering, growers can achieve better price realization by supplying the market at times of scarcity. This targeted production approach allows for premium pricing and reduces the risk of selling at lower rates during glut periods.
5. **Reducing Pest and Disease Pressure**: By altering the flowering period, growers can also avoid times of the year when pests and diseases are most prevalent. This not only reduces the need for chemical interventions but also minimizes crop losses and improves overall plant health. A well-regulated crop is often more resilient and easier to manage, contributing to sustainable floriculture practices.
6. **Supporting Export-Oriented Production**: In the context of international floriculture trade, crop regulation plays a pivotal role. Export markets demand strict adherence to delivery timelines and quality standards. By using flower forcing and regulatory techniques, producers can cater to these market demands effectively. Timely production also ensures compliance with shipping schedules and reduces post-harvest losses, which are crucial in maintaining the competitiveness of floriculture exports.
7. **Facilitating Breeding and Hybridization Programs**: Regulating the flowering period is equally important in research and breeding programs. Controlled flowering helps synchronize the bloom of different genotypes, making planned hybridization and seed collection more efficient. This accelerates the development of new flower varieties with improved traits, which in turn

benefits the industry through innovation and diversification.

Physiology of flowering

Prior to flowering the plant in response to its environment (particularly temperature and day length) the leaves or meristems that detect the environmental change, must reach a condition called 'ripeness to respond' (Higuchi, 2018). It has been hypothesized that, after reaching to ripeness-to-respond stage and with exposure to proper stimuli, a plant able produce floral primordium through the formation of hypothetical substances. These hypothetical substances, if stimulated by proper temperature known as 'vernalin' and 'florigen', if stimulated by proper photoperiod. This floral primordium will ultimately develop into flower (Chomchalow, 2004).

Table 1: Flowering seasons of important flowers

S. No	Crop	Normal season of flowering	Off-season
1.	*Jasminum sambac Jasminum grandiflorum Jasminum auriculatum*	February - June, June - September May - September	July- January October - May October - April
2.	*Rosa centifolia*	March - October	November- February
3.	Tuberose	February - October	November - January
4.	Chrysanthemum	September - February	March-August
5.	Carnation	February - April	June - August
6.	Marigold	January - April	May - July
7.	Gerbera	May - July	April - June
8.	Anthurium	All year round but in cycles of 2- 3 months on and 2-3 months off	-
9.	Gladiolus	October - March	-

Factors influencing on flowering

Flowering in ornamental plants is regulated by a combination of environmental, physiological and genetic factors, all of which play a critical role in determining the timing, intensity, and quality of blooms.

A) Environmental factors

1) **Photoperiod:** Photoperiod, or the length of daylight, is one of the key environmental triggers, with plants being categorized as short-day, long-day, or day-neutral based on their response (Song *et al.*, 2018).

Short Day Plants (SDP):

These plants require a relatively short-day light. period (usually 8-10 hours) and a continuous dark period of about 14-16 hours for subsequent flowering. These plants are also known as long night-plants. In short day plants the dark period is critical and must be continuous. If this dark period is interrupted even with a brief exposure of red light.

Long day plants (LDP)

These plants require a longer day light period (usually 14-16 hours) in a 24 hours cycle for subsequent flowering. Also called as short night plants. In long day plants the light period is critical. The prolongation of the light period stimulates flowering in long day plants.

Day neutral plant (DNP):

Without critical day length, they can flower in any day length of 24 hr cycle, if other conditions are congenial.

Table 2: Classification of plants based on different photoperiod

Class	Examples
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*).

2) **Temperature:** Temperature also greatly influences flowering, as some species require exposure to low temperatures (vernalization) to initiate flowering, while excessive heat may delay or inhibit it (Chandel *et al.*, 2023). Recent studies have demonstrated that heat-induced delay of flowering is mainly due to inhibition of capitulum development (Nakano *et al.* 2013).

3) **Classification based on Temperature in chrysanthemum**

Thermo-positive: low temperature between 10-27℃ inhibit or delay bud initiation which occur more consistently at 16℃. High temperature over 27℃ accelerates bud initiation but delay flowering. Ex: Cameo

Thermo-negative: Bud initiation occurs at low to high temperature (10-27℃) but high temperature delays development of buds. Ex: Defiance

Thermo-zero: Flowering occurs at any temperature between 10-27℃, more consistently ay 17℃-night temperature. Ex: Shasta

3) **Light intensity and quality:** The phytochrome system a light-sensing molecular switch composed of two interconvertible forms, Pr (inactive, absorbs ~660 nm red light) and Pfr (active, absorbs ~730nm far-red light) regulates flowering by monitoring the red-to-far-red (R:FR) ratio in the environment: high R:FR shifts the balance toward Pfr and typically promotes flowering in long-day plants, whereas low R:FR (as under canopy shade) increases Pr, often delaying flowering and triggering shade-avoidance traits, a brief pulse of far-red light at the end of the day can shift phytochrome to Pr, simulating longer nights and thus accelerating flowering in some species.

4) **Nutrition:** The nutritional status of the plant, particularly the balance of nitrogen, phosphorus, and potassium, also affects flowering. High nitrogen levels encourage vegetative growth and may suppress flower formation, while phosphorus and potassium are essential for floral induction and development.

B) **Plant growth regulators (PGRs):** The application of plant growth regulators (PGRs) such as gibberellins, cytokinins and ethylene can be used to manipulate flowering, either promoting or inhibiting it based on the species and desired effect (Farman *et al.*, 2019).

C) **Cultural practices** like pruning, pinching, mulching, adjusting planting dates, and optimizing spacing can significantly influence flowering behaviour by altering plant growth dynamics.

D) **Genetic factors** govern the innate flowering tendencies of each species or cultivar, including their flowering frequency, duration of the juvenile phase, and responsiveness to external cues. A comprehensive understanding of these factors is essential for effective crop regulation and for ensuring consistent, high-quality flower production in commercial floriculture systems.

Methods of flower forcing

A. **Adjusting Factors Affecting Flowering**

a) **Temperature**: prolonged chilling treatment (most effective temperature 1-7°C) required to promote or accelerate flowering is known as **Vernalization**. Vernalization does not cause immediate flowering but enables the plant to respond to later flowering cues. This treatment activates *florigen,* a hormone that promotes flowering. In ornamental crops like lilies, vernalization ensures uniform and timely blooms. It is widely used to synchronize flowering with market demand.

b) **Photoperiod:**

1. **Photoperiod regulation techniques to create short day (Artificial Short day):**
   - SD can be artificially created in a greenhouse by the use of opaque material (Black cloth/blackout).
   - Under natural long day, black cloth can be pulled at a specified time in the afternoon to cut short natural daylength (Dhiman *et al.*, 2018).
   - Automatic curtain system can also be installed.
   - There can be retracted in the morning, to expose plants to light when desired.
   - Synthetic fabrics with reflective outer surfaces are desirable because they reflect light and simultaneously minimise heat build-up.
   - Otherwise heat build-up as in case of black cloth can delay flowering which is referred to as heat delay as reported in Poinsettia and Chrysanthemum.

2. **Photoperiod regulation techniques to create long day (Artificial Long day):**
   During natural short-day conditions, long days can be created by three different methods

i. **Day-extension:**
   DE lighting is the practice of delivering light to extend the length of the natural day.
   For example, if the natural day length is 9 hours and we desire a 14-hour photoperiod, we would operate the lights beginning at sunset for about 5 ½ hours.

ii. **Night-interruption:**
   NI lighting is the practice of providing low-intensity light to plants during the middle of the night. NI lighting is typically delivered during the middle of night (such as from 10 p.m. to 2 a.m.), because plants are most sensitive to light at this time**.**

iii. Providing lighting from 2 am until sunrise, also called as pre- dawn lighting.

Table 3: Photoperiod requirement of some ornamentals and flowers

Plants	Critical day length (hrs)
Short day plants	
Chrysanthemum	10
Poinsettia	10
Celosia	10
Cosmos	11
Ipomea 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.

B. Chemical Flower Forcing

Four types of chemicals affect flowering, namely fertilizers, plant hormones, ethylene, and other chemicals.

i. **Fertilizers:** Certain fertilizers affect the C/N ratio of the plant, which in turn affects flowering. The broader C/N ratio, i.e., higher C, will induce flowering, while the narrower C/N ratio, i.e., lower C, will keep the plant in the vegetative phase. Adjusting fertilizer dosage can be used to retard or stimulate flowering.

   Retarding flowering: This can be done by providing fertilizers having high amounts of N to the plant. Watering should also be provided so that N will be readily absorbed by the plant.
   Stimulating flowering: This can be done by giving fertilizers having low amounts of N and reducing watering. Other chemicals that help to fix N to a bound form can also stimulate flowering.

ii. **Plant Hormones:** Two main types of plant hormones affect flowering, namely:

Gibberellins: At least 50 gibberellins have been discovered in fungi and plants. All could properly be called gibberellic acids, or GA. Gibberellins have the unique ability among plant hormones to stimulate extensive growth of intact plants. It has been demonstrated that gibberellins can substitute for the long-day requirement in some species, and has an interaction with light (Chomchalow, 2004). They also overcome the need some species have for an inductive cold period to flower (vernalization). It appears that the formation of flowers caused either by long days or by cold periods might normally depend upon the build-up of endogenous gibberellins during these periods because the gibberellin content on some affected plants increases following these treatments. The formation of normal flowers has been achieved through the direct application of bioactive gibberellins to abnormal plants lacking viable pollen. Gibberellins, a class of growth-regulating hormones naturally produced by plants, are also present in seeds where they play a key role in breaking seed dormancy (Zhang *et al*., 2006).

Growth retardants: These are a group of synthetic chemicals that inhibit stem elongation and cause overall stunting. They do so in part because they inhibit gibberellin synthesis. These include Phosphon D, Amo1618, CCC or Cycocel, and Ancymidol. Growth retardants (e.g., CCC) promote the initiation of floral primordium by reducing endogenous GA levels or antagonizing its inhibitory effect on floral initiation.

Ethylene: Ethylene has been popularly known to induce flowering in the pineapple. A sprinkle of acetylene, a precursor of ethylene, on top of the pineapple plant, is quite effective in inducing the pineapple plant to flower. An ethylene-releasing substance, called ethephon or ethereal, is commercially available. The induction of flowering in the mangoes and the bromeliads by ethylene is unusual because the gas inhibits flowering in most other species.

iii. **Other Chemicals:** Several other chemicals are used to induce flowering, especially of fruit trees. These include the potassium chlorate and its related compound sodium chlorate, potassium nitrate, thiourea, paclobutrazol (commercially known as cultar), etc. which, when applied as a soil drench or leaf spray results in the flowering of many fruit trees.

C. Mechanical Flower Forcing

a) Pruning: Pruning helps to broaden the C/N ratio, thus stimulating flowering. This can be seen in the case of bougainvillea, jasmine, rose in which flowering takes place soon after pruning, with the application of proper fertilizers and watering. Other flowers, such as roses, also need pruning for flowering induction.

b) Leaf Trimming: n some plants like certain jasmine varieties younger leaves produce flowering inhibitors (such as abscisic acid or other shade-related hormones) that can suppress the flower-inducing signal. Removing part of a leaf or pruning off select leaves reduces the local source of these inhibitory compounds, rebalancing hormone levels (e.g., decreasing ABA, altering auxin/ethylene concentrations) and effectively lifting the suppression on floral development, thereby enabling or accelerating flowering.

c) Ringing: Ringing helps to broaden the C/N ration, thus stimulating flowering. This is obvious in the case of fruit trees in which ringing induces flowering and fruiting.

d) Low-temperature Storage: Many plants are promoted to flower by low temperature storage. This can be done by exposing the plants, usually the bulbs or corms to low temperature for a period of time before they are taken out for planting.

e) Breaking Dormancy: Seeds and buds of some plants are in dormant stage, i.e. no growth at all, for a period of time. Breaking dormancy can be done by exposure to low temperature, or treatment with chemicals and gibberellins. The latter, i.e. gibberellins, are more commonly used in association with flowering. Applied gibberellins break dormancy of many cold-requiring seeds and induce flowering of many cold-requiring plants (Keerthishankar and Nivya, 2022).

Conclusion

Flower forcing is a vital technique in modern floriculture that enables growers to manipulate the natural flowering cycle to meet market demands and ensure year-round production. By carefully regulating environmental, physical, and chemical factors, flowering can be either advanced or delayed to achieve uniformity, quality, and timely availability of blooms. This practice not only enhances the commercial value of ornamental crops but also supports better planning, resource use, and profitability for growers. As consumer demand for flowers continues to rise, the strategic use of flower forcing will remain an essential tool in sustainable and efficient flower production.

References

Adnan, Y., Atif, R., Salman, A., Muhammad, A., Usman, T., Fariha, J., Muhammad, N and Mansoor, H. (2013). Effect of different pruning dates on growth and flowering of *Rosa centifolia*. Pak. *J. Agri. Sci*, **50**(4): 605-609.

Anumala, N.V. and Kumar, R. (2021). Floriculture sector in India: current status and export potential. *J. Hortic. Sci. Biotechnol,* **96**:673–680.

Baskaran, V. and Abirami, K. (2017) Effect of pinching on yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda under Andaman conditions. *Agricultural Science Digest-A Research Journal*, **37**(2): 148-150.

Chandel, A., Thakur, M., Singh, G., Dogra, R., Bajad, A., Soni, V. and Bhargava, B. (2023). Flower regulation in floriculture: an agronomic concept and commercial use. *Journal of Plant Growth Regulation*, **42**(4): 2136-2161.

Chomchalow, N. (2004). Flower forcing for cut flower production with special reference to Thailand. *AU JT*, **7**(3), 137-144.

Dhiman, S.R., Gupta, Y.C., Thakur, P., Kashyap, B., Sharma, M and Sharma, K. (2018). Effect of different black-out materials on off-season flower production of chrysanthemum (*Dendranthema grandiflora*). *Indian J. Agric. Sci*, **88**(4): 601–605.

Farman, S., Mushtaq, A. and Azeem, M.W. (2019). Plant growth regulators (PGRs) and their applications. *Int. J. Chem. Biochem. Sci*, **15**: 94-103.

Higuchi, Y. (2018). Florigen and anti-florigen: flowering regulation in horticultural crops. *Breeding science*, **68**(1): 109-118.

Keerthishankar, K. and Nivya, K.R. (2022). Flower forcing: a novel approach to enhance farmer's income. *Recent Innovative Approaches in Agricultural Science*, 85.

Muhammad, A., Shoaib, R., Adnan, Y., Atif, R., Usman, T. and Rashid, W. (2012). Different strategies to create earliness and enhance quality of tuberose (*Polianthes tuberosa* L.) cv. Single. *Asian. J. Pharm. Biol.* Res, 2231-2218.

Nakano,Y., Higuchi, Y., Sumitomo, K. and Hisamatsu, T. (2013). Flowering retardation by high temperature in chrysanthemums: involvement of FLOWERING LOCUS T-like 3 gene expression. *J. Exp. Bot*, **64**: 909–920.

Nazki, I.T. and Wani, M.A. (2018). *In vitro* propagation of ornamentals for maximising livelihood security. In: Lichtfouse E (ed) Sustainable agriculture reviews. *Springer, Cham.* https://doi.org/10. 1007/978-3-319-75190-0_9

Rao, D. and Sushma, K. (2016). Standardization of techniques for continuous growth and production in *Jasminum sambac* under agro climatic conditions of Telangana state, India. *Agric. Sci. Digest*, **36**(4): 267-271.

Sinha, D. and Sharma, R. (2022). Impact of national horticulture mission on the growth of Indian floriculture industry. *Int. J. Acc. Fin. Bus*, **1**(2): 1-10.

Song, Y. H., Kubota, A., Kwon, M. S., Covington, M. F., Lee, N., Taagen, E.R. (2018). Molecular basis of flowering under natural long-day conditions in arabidopsis. *Nat. Plants* **4**, 824–835. doi: 10.1038/s41477-018-0253-3.

Song, Y.H. and Shim, J.S. (2015). Photoperiodic flowering: time measurement mechanisms in leaves. *Annu. Rev. Plant. Biol,* **66**: 441–464.

Sujatha, A. S., Sujatha, K. and Venugopalan, R. (2009). Influence of pruning time on enhancing the yield and quality of *Jasminum sambac* flowers during off-season. *Indian J. Agric. Sci*, **79** (11): 857-860.

Zhang, W., Bi, J., Ning, T., Liu, X. and He. M. (2006). Effects of temperature, light and other treatments on seed germination of *Leymus chinensis*. *Canadian Journal of Plant Science*, **86**(1): 143-148.