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| RESEARCH ARTICLE

Factors Influencing Non-Uniform Flowering in Chrysanthemums and Insights toward Sustainable Management: A Review

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| ABSTRACT
Chrysanthemum (Chrysanthemum morifolium) is an ornament crop that is widely grown in the world. Though of economic and aesthetic significance, uniform flowering continues to be a significant challenge with commercial cultivation regimes. The development of flower in chrysanthemum is controlled by a complex of photoperiodic, nutritional, environmental and genetic factors. Being a short-day plant, it needs continuous dark phases to trigger floral initiation that is mediated by phytochrome signal pathways and the main genes such as flowering locus T (FT), constans (CO), and suppressor overexpression constans 1 (SOC1). Night lighting may cause the disruption of these pathways and postponement flowering. Alteration of nutrient balance, especially high nitrogen, deficiency in phosphorus, potassium and micronutrients, shift the plant metabolism to vegetative growth at the cost of reproductive growth. Other environmental stress factors like heat, drought, salinity and pollution also reduce flowering through hormonal and oxidative impairments. The development of controlled-environment agriculture, precision cultivation, and genome editing offers promising methods of flowering stabilization. This review brings together existing information and the importance of integrative management approaches to sustainable production of chrysanthemums.

| KEYWORDS

Chrysanthemum, postponement flowering, oxidative impairments.

| ARTICLE INFORMATION

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1. Introduction

Chrysanthemum (*Chrysanthemum morifolium*) is a very popular crop in the world floriculture sector because of its versatility, variety of cultivars, and popularity (Zhang et al., 2021; Chen et al., 2023). Nevertheless, the abnormalities in flowering are often noted in both field and controlled systems of cultivation. Uneven bud growth, retarded initiation of floral, or total failure is often observed under unfavorable conditions by growers.

The induction of floral in chrysanthemum is a multi-factorial process. The interactions between the environmental cues, nutrient status and genetic regulation influence when and whether flowering is successful (Smith and Johnson, 2019; Biology, 2022). Such interactions are continuously changing and even minor variations in a factor can greatly change results. In current intensive farming, there are other challenges of urban light pollution, changing weather conditions and soil limitations, and combined solutions are necessary.

2. Photoperiodic Regulation and Light Management

Chrysanthemum is a qualitative short-day plant, which needs long continuous dark periods to induce floral (Higuchi et al., 2012). Photoperiod perception is mediated by phytochromes, which controls the expression of *FT*, *CO* and *SOC1* genes (Oda et al., 2020; Sun et al., 2023).

Controlled lighting systems that use LEDs and blackout curtains have proven highly effective in controlling flowering and enabling the production throughout the year (Hwang et al., 2020; SharathKumar et al., 2021). A combination of spectral manipulation and photoperiod regulation gives greater predictable flowering.

3. Nutrient Dynamics and Soil Health

Effective nutrient control is essential in the initiation and growth of flora. Nitrogen promotes vegetation and retards blossoming (Dorajeerao et al., 2012). Phosphorus and potassium help to transfer energy and develop buds and flowers, and improve their quality and resistance to stress, respectively (Su et al., 2021; Zhang et al., 2018).

Boron, zinc, and iron are micronutrients that are required to participate in the pollen viability, hormone synthesis, and photosynthesis (Gao et al., 2023; Jamil et al., 2022). The nutrient availability is further determined by soil characteristics, such as pH (6.06.5), the amount of organic matter, and microbial activity (Sarkar et al., 2024). It is suggested to use organic amendments, biochar, and inoculants composed of microbes to improve the soil fertility and stable flowering (Sarkar et al., 2024; Zhang et al., 2018).

4. Environmental Stressors

Abiotic stress conditions have a great impact on flowering. An extreme high temperature (>30 o C) inhibits *FT* expression and promotes oxidative stress, and low temperature influences hormonal balance and flowering (Huang et al., 2026; Nakano et al., 2013). Water deficit slows down the rate of photosynthesis and postpones bud development, but waterlogging may cause root damage by hypoxia (Huang et al., 2026; Zhao et al., 2018).

Heavy metal and salinity pollution alters the ability to take up nutrients and diminishes flowering performance (Li et al., 2026; Wang et al., 2017). Other negative effects of air pollution, such as exposure to ozone, have adverse effects on physiological performance and reproductive success.

5. Cultivation Practices and Biotic Factors

Flowering is directly affected by the agronomic practice that includes planting density and pruning. The density leads to a small size of the flowers and number of buds as a result of competition over light and nutrients (Joshi et al., 2021). The untimely pruning will eliminate active meristems, and flowering will be delayed (Dorajeerao & Mokashi, 2012).

Flowering may also be compromised by pest pressure due to the damaging tissues or virus transmission by aphids, thrips, and other insects (Bethke et al., 2020; He et al., 2020). A combination of biological control, selective pesticides, and cultural control (integrated pest management, IPM) is necessary to have a sustainable ornamental production (van Lenteren, 2019).

6. Genetic and Hormonal Regulation

The process of flowering is regulated with the help of a complex of genes, among which there are *FT*, *CO*, and *SOC1* (Moon et al., 2005; Quiroz et al., 2021). Flowering further is modulated by hormones: gibberellins tend to slow flowering, cytokinins tend to induce bud development, and abscisic acid tend to delay flowering under stress conditions (Domagalska et al., 2010; Quiroz et al., 2021).

The latest research on CRISPR-Cas9 offers encouraging methods on how to alter flowering time and stress traits in ornamental crops like chrysanthemum to create day-neutral or stress-tolerant plants (Kishi-Kaboshi et al., 2017).

7. Climate Change and Future Perspectives

Global warming also brings new variability in flowering with temperature variations, changed precipitation, and increased stress on the environment (Cleland et al., 2007). Light pollution and soil degradation are the consequences of urbanization, and they also have an impact on the physiology of plants (Bennie et al., 2016).

The opportunities to reduce the impact of these effects and ensure stable flowering include advanced solutions (vertical farming, smart greenhouses, and real-time environmental monitoring) (Harbinson, 2024; Waseem, 2026).

8. Conclusion

Chrysanthemum flowering failure is a complex process caused by interplay of photoperiod, nutrition, stress in the environment, and genetics. To handle this problem, an integrative concept that involves the optimization of cultivation methods, stress-reduction techniques, and new technological solutions like genome editing and precision agriculture is necessary. The strategies can be used to guarantee stable and high-quality flowering and sustainable production of ornamentals in unstable environmental conditions.

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References

[1] Bennie, J., Davies, T. W., Cruse, D., & Gaston, K. J. (2016). Ecological effects of artificial light at night on wild plants. *Journal of Ecology*, 104(3), 611-620. https://doi.org/10.1111/1365-2745.12551
[2] Bethke, J. A., Cloyd, R. A., & Lopez, V. (2020). Integrated pest management for chrysanthemums in greenhouse production. *Journal of Integrated Pest Management, 11*(1), 18. https://doi.org/10.1093/jipm/pmaa015
[3] Beyond the genetic pathways (n.d), flowering regulation complexity in Arabidopsis thaliana. *International Journal of Molecular Sciences*, 22(11), 5716. https://doi.org/10.3390/ijms22115716
[4] Cheng, H., Yu, Y., Zhai, Y., Wang, L., Wang, L., Chen, S., Chen, F., & Jiang, J. (2023). An ethylene-responsive transcription factor and a B-box protein coordinate vegetative growth and photoperiodic flowering in chrysanthemum. Plant, Cell & Environment, 46(2), 440–450. https://doi.org/10.1111/pce.14488☐
[5] Cleland, E. E., Chuine, I., Menzel, A., Mooney, H. A., & Schwartz, M. D. (2007). Shifting plant phenology in response to global change. Trends in Ecology & Evolution, 22(7), 357-365. https://doi.org/10.1016/j.tree.2007.04.003
[6] Domagalska, M. A., Sarnowska, E., Nagy, F., & Davis, S. J. (2010). Genetic analyses of interactions among gibberellin, abscisic acid, and brassinosteroids in the control of flowering time in Arabidopsis thaliana. PLoS ONE, 5(11), e14012. https://doi.org/10.1371/journal.pone.001401
[7] Dorajeerao, A. V. D., & Mokashi, A. N. (2012). Effect of pinching on growth and yield of garland chrysanthemum (Chrysanthemum coronarium L.). *Karnataka Journal of Agricultural Sciences, 25*(2), 239-242.
[8] Harbinson, J. (2024). Food for thought: Perspectives on the current state of Vertical Farming. Current Research in Biotechnology, 8, 100185. https://doi.org/10.1016/j.crbiot.2024.100185
[9] He, Z., Gao, M., Zhao, S., Zheng, Y., & Chen, J. (2020). The damage and distribution of Frankliniella occidentalis (Thysanoptera: Thripidae) on different chrysanthemum cultivars. HortScience, 55(9), 1435-1440. https://doi.org/10.21273/HORTSCI15115-20
[10] Higuchi, Y., Narumi, T., Oda, A., Nakano, Y., Sumitomo, K., & Hisamatsu, T. (2012). Evaluation of FLOWERING LOCUS T-like genes in the photoperiodic flowering regulation of chrysanthemum. *Journal of the Japanese Society for Horticultural Science, 81*(4), 361-367. https://doi.org/10.2503/jjshs1.81.361
[11] Huang, Y. (2026). Functional characterization of chrysanthemum transcription factor CmbHLH112 in flowering and drought response. Horticulturae, 12(3), 383. https://doi.org/10.3390/horticulturae12030383
[12] Hwang, H., Shin, J. H., & An, S. (2020). Night-break lighting using specific LED light spectra regulates flowering time and quality in commercial chrysanthemum production. Scientia Horticulturae, 272, 109572. https://doi.org/10.1016/j.scienta.2020.109572

[13] Jamil, M., Anwar, S., & Baseer, A. (2022). Influence of foliar application of zinc and boron on vegetative, reproductive, and photosynthetic traits of chrysanthemum cultivars. *Journal of Plant Nutrition, 45*(14), 2115-2128. https://doi.org/10.1080/01904167.2022.2046077

[14] Joshi, S., Joshi, M., & Shrestha, S. (2021). Effect of plant density on growth, flowering, and yield of chrysanthemum (Chrysanthemum morifolium L.). *Journal of Agriculture and Natural Resources, 4*(2), 112-121. https://doi.org/10.3126/janr.v4i2.33664

[15] Kishi-Kaboshi, M., Aida, R., & resentment, K. (2017). Generation of gene-edited Chrysanthemum morifolium using multi-copy transgenes as targets and markers. Plant and Cell Physiology, 58(2), 216–226. https://doi.org/10.1093/pcp/pcw222

[16] Li, P. (2026). Chrysanthemum CmDOF2 positively regulates salt tolerance in transgenic Arabidopsis thaliana. Plants, 15(6), 936. https://doi.org/10.3390/plants15060936

[17] Moon, J., Lee, H., Kim, M., & Lee, I. (2005). Analysis of flowering pathway integrators in Arabidopsis. Plant and Cell Physiology, 46(2), 292–299. https://doi.org/10.1093/pcp/pci024

[18] Nakano, Y., Higuchi, Y., Sumitomo, K., & Hisamatsu, T. (2013). Flowering retardation by high temperature in chrysanthemums: involvement of FLOWERING LOCUS T-like 3 gene repression. *Journal of Experimental Botany, 64*(4), 909-920. https://doi.org/10.1093/jxb/ers370

[19] Oda, A., Gotoh, E., & Hisamatsu, T. (2020). Phytochrome-mediated regulation of photoperiodic flowering via transcriptional control of FTL3 in Chrysanthemum morifolium. Frontiers in Plant Science, 11, 568310. https://doi.org/10.3389/fpls.2020.568310

[20] Quiroz, S., Yustis, J. C., Chávez-Hernández, E. C., Martínez, T., Sanchez, M. d. l. P., Garay-Arroyo, A., Álvarez-Buylla, E. R., & García-Ponce, B. (2021).

[21] Sarkar, A., Rakshit, R., & Das, A. (2024). Biochar and microbial inoculants synergistically improve soil health, nutrient dynamics, and flowering performance of Chrysanthemum morifolium. Soil Use and Management, 40(2), e13002. https://doi.org/10.1111/sum.13002

[22] SharathKumar, M., Heuvelink, E., & Marcelis, L. F. (2021). Vertical farming: Moving from static to dynamic LED light scenarios to optimize growth and flowering of short-day ornamental crops. Frontiers in Plant Science, 12, 743454. https://doi.org/10.3389/fpls.2021.743454

[23] Su, J., Jiang, J., & Chen, S. (2021). Phosphorus utilization and transcriptomic responses to phosphate starvation in Chrysanthemum morifolium. Horticulture Research, 8(1), 114. https://doi.org/10.1038/s41438-021-00549-3

[24] Sun, J., Wang, H., & Chen, F. (2023). Molecular components of the photoperiodic flowering pathway in Chrysanthemum morifolium: Interaction of CO and SOC1 homologs. Plant Science, 328, 111589. https://doi.org/10.1016/j.plantsci.2022.111589

[25] van Lenteren, J. C. (2019). Commercial biological control of pests in greenhouse ornamental crops: Successes and future challenges. Insects, 10(12), 431. https://doi.org/10.3390/insects10120431

[26] Wang, K., Wu, Y. H., Tian, X. Q., Bai, Z. Y., Liang, Q. Y., Liu, Q. L., Pan, Y. Z., Zhang, L., & Jiang, B. B. (2017). Overexpression of DgWRKY4 enhances salt tolerance in chrysanthemum seedlings. Frontiers in Plant Science, 8, 1592. https://doi.org/10.3389/fpls.2017.01592

[27] Waseem, M. (2026). Transforming Agriculture with Cyber-Physical Systems: An Insight into Future Smart Farming. Preprints, 2026061181. https://doi.org/10.20944/preprints202606.1181.v1

[28] Zhang, K., Liu, Z., & Chen, F. (2018). Potassium nutrition improves the growth, flowering quality, and stress tolerance of greenhouse chrysanthemums via organic and microbial soil amendments. *Frontiers in Plant Science, 9,* 1242. https://doi.org/10.3389/fpls.2018.01242

[29] Zhao, N., Li, C., Yan, Y., Cao, W., Song, A., Wang, H., Chen, S., Jiang, J., & Chen, F. (2018). Comparative transcriptome analysis of waterlogging-sensitive and waterlogging-tolerant Chrysanthemum morifolium cultivars under waterlogging stress and reoxygenation conditions. *International Journal of Molecular Sciences, 19*(5), 1455. https://doi.org/10.3390/ijms19051455