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PHOTOPERIODISM, AN IMPORTANT ELEMENT FOR THE GROWTH AND FLOWERING OF *CHRYSANTHEMUM*S

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Abstract

The durations of the light phase and that of the dark phase (photoperiod) varies with the season, so their succession as well as their development time influences the plant response. Therefore, physiological parameters such as: height of main stems, number of leaves after planting, leaf area (cm^2), time to flowering, flowering time and the number of flowers, and diameter of buds and flowers (mm), may be studied in order to optimize the cut flower production for chrysanthemums grown in protected areas. Depending on the necessary environmental conditions, the floral induction and flowering of Chrysanthemum morifolium may be adjusted using camouflage (artificially shortening the length of the day by covering the plants). The purpose of this paper is to review the evolution of research on the behaviour of chrysanthemum plants exposed to a certain photoperiod.

Key words: *Chrysanthemum morifolium, photoperiod, photoperiodism, growth, flowering.*

INTRODUCTION

Chrysanthemums (*Chrysanthemum indicum* L. and *Chrysanthemum morifolium* Ramat.) are among the oldest, most spectacular, and most important ornamental herbaceous plants. They belong to the family Asteraceae (Compositae), genus *Chrysanthemum*. At first, chrysanthemums flowers were small, with a golden-yellow color, similar to wild plants in nature, which are found today in China and Japan (Dowrick, 1953). They have evolved over time following successive selections, using various techniques, reaching today the great diversity in terms of inflorescence shape, flower color and plant vigor.

Some experts point to the genetic resources of modern chrysanthemums as East Asia (Fukai, 2003; Zhao et al., 2009), others say chrysanthemums are native to the northern hemisphere, both Asia and Northeast Europe (Jeong et al., 2012; Singh & Chettri, 2013; Wang et al., 2019).

Today, over 30,000 chrysanthemum varieties are known globally, with about 3,000 varieties grown in China alone (Dong et al., 2020). Over 15,000 varieties are listed in Japan alone, and in the UK, accordingly to the National Society of Chrysanthemums, over 6000 varieties are listed (Datta, 2013).

Due to the existing relationships between environmental factors and the growth and development of chrysanthemum plants, the researchers paid special attention to the duration of the light and dark period during their vegetation period. Over time, these aspects have been researched through various approaches, namely: the behavior of plants at different latitudes; by studying species at a certain latitude but in different seasons; by prolonging the daylight with artificial light and by dimming the light for a certain period of time during the day. Thus, in 1920, in the writings of Garner and Allard, it is stated that, after 1918, when the darkroom was first used during experiments, the term "length of day" appeared, which referred to the length lighting of the period for every 24 hours. The terms "long day" (exposure to light for more than 12 hours) and "short day" (exposure to light for 12 hours or less) also appeared. Therefore, the relationship between the length of the day and the time of flowering acquires a great significance in crop yields. Subsequent studies classified chrysanthemums, as being short-day plants (SD), which respond to the decrease in

the day length by their transition from the stage of vegetative growth to the stage of reproduction (Thomas & Vince-Prue, 1997; Oda et al., 2017; Yang et al., 2018). Their flowering can be obtained with the help of the photoperiod, being a plant sensitive to this factor (Șelaru, 1995).
The duration of the light phase and the dark phase (photoperiod) varies depending on the season, so that their succession, as well as their development time, influences the plant's response. Therefore, physiological parameters, such as: height of main stems, number of leaves after planting, leaf area (cm^2), time to flowering, flowering time and number of flowers and diameter of buds and flowers (mm), can be studied to optimize the production of cut flowers for chrysanthemums grown in protected areas.

MATERIALS AND METHODS

In order to describe the evolution of the research on the behavior of chrysanthemum plants exposed to a certain photoperiod, the documentation on this subject was revised. Data and information were collected from the field of scientific research and these data were grouped so that they could lead to a deeper interpretation in this field.

PHOTOPERIODICITY

The etymology of the word "photoperiodism" derives from the Greek words "light" and "duration" and can be defined as day-long responses that allow living organisms to adapt to seasonal changes in their environment (Thomas & Vince-Prue, 1997; Thomas, 2017).
The duration of light (photoperiod), rather than the intensity of light, influences the earlier flowering of chrysanthemums. And low light intensity affects plant vigor (Laurie & Poesch, 1932).
The American researchers Wightman Garner and Henry Allard (1920) had a special contribution in the field, conducting the first experiments on the behavior of plants in the photoperiod. They found that plants bloomed in response to changing day lengths and made it clear for the first time that flowering in plants could be accelerated by either short days (SD) or long days (LD). They also introduced the terms "photoperiod" and "photoperiodism" (photoperiod response capacity), as well as the classification of plants into groups, according to their reaction to the photoperiod. In their writings, "photoperiod" is indicated for the favorable length of day for each organism, and "photoperiodism" is suggested for the organism's response to the relative length of day and night (Garner & Allard, 1920). Nowadays, photoperiodism can be defined as the response of plants through growth, development or metabolism, depending on the day light duration (Delian, 2019), and chrysanthemum, being a plant that responds to the photoperiod (period of exposure to light during 24 hours) is called photoperiodic sensitive. The light phase or photoperiod is also called the lumen period, and the dark phase is known as the nictiperiod (Burzo et al., 1999; Bădulescu, 2009; Burzo, 2016). In 1997, researchers Thomas and Vince-Prue grouped plants into three broad categories, according to their photoperiod flowering responses, namely: short-day plants (SDP); long day plants (LDP) and neutral plants. Chrysanthemums (*Chrysanthemum indicum* L. and *Chrysanthemum morifolium* Ramat.) belonging to the first category.
After the discovery of photoperiodism, various methods were found to control the flowering of chrysanthemums based on the photoperiod (Laurie 1930; Laurie & Poesch, 1932; Poesch, 1936).
Laurie and Poesch (1930-1932) experimented and demonstrated that the natural length of the day can be changed in the greenhouse protected space. They used this technique of covering chrysanthemum plants with black satin cloth (opaque), so they obtained a shorter photoperiod than the natural one. Thus, chrysanthemums bloomed 22 to 56 days earlier, with the same floral diameter, with slightly lower stem height, but in compliance with marketing standards. Until the 1930s and 1950s, photoperiodism was not applied in the commercial floriculture industry (Erwin, 2006). After that, the technique was taken widely used to increase the flowering season of photoperiod-sensitive plants.
Adams and colleagues (2001) argued that it is advisable to use photoperiod sensitivity, which

allows the acceleration of flowering, thus reducing lighting costs, but at the same time preserving the quality of plants. The easiest way to provide short days is to pull an opaque reflective cloth over the plants at the end of the day and remove it in the morning (Erwin et al., 2002). However, after 1950, to meet the demand for chrysanthemums throughout the year, growers adjusted the flowering time using artificial lighting and interruptions or night break (NB) (Fukai, 2014; Higuchi, 2018). In general, as light sources, for artificial lighting in the cultivation of plants in greenhouses, in addition to incandescent lamps, are also used: fluorescent lamps, metal halides and sodium at high pressure (Jeong et al., 2012).

One effect observed in the production of chrysanthemum flowers by treating them with short artificial days, was the lighter color of these flowers compared to those induced by the natural photoperiod. Following shading, the development of chrysanthemums was significantly influenced, especially by the sudden decrease of anthocyanins in the petals of rays from calatidium (Hong et al., 2015). The color of the flowers is an important feature that influences the commercial value of chrysanthemum varieties (Ohmiya, 2018). Thus, transcriptome analyzes of the molecular mechanism of chrysanthemum flowers color change in short-day photoperiods were performed. The results showed that the anthocyanin synthesis is strictly regulated by the photoperiod, which can be useful in the molecular growth of chrysanthemums (Dong et al., 2020).

THE ROLE OF THE CIRCADIAN CLOCK

The sensitivity of the chrysanthemum to light changes throughout the day is regulated by the circadian clock. It measures the length of the day and influences some basic plant activities, such as growing and reproducing. Circadian rhythms in plants have led to the discovery of an internal biological clock consisting of a molecular oscillator and an input path that allows the clock to be reset according to external indicators, such as the photoperiod. So, the clock allows an estimate of the time that synchronizes the process of flower initiation with the photoperiod (Micallef, 2011).

Imaizumi and Kay (2006) say that in short-day plants, the clock-regulated factor functions as a flowering suppressant. They also claim that the photoperiodic flowering path can be separated into two functional areas: a circadian clock and a regulated circadian mechanism for measuring the length of the day.

The German biologist Erwin Bünning made a great contribution by proposing in 1936 "the daily endogenous rhythm as the basis of the photoperiodic reaction", also called the "Bünning hypothesis", which later became the "external coincidence model". Thus, plants can track the length of the day, the photoperiod, with the help of an endogenous timer. This clock is synchronized with physiological and molecular processes up to the day-night cycle, allowing plants to anticipate future conditions (Green et al., 2002; Dodd et al., 2005; Johansson & Staiger, 2014).

PHOTORECEPTORS

Light signals are received by plants through a wide range of photoreceptors, including phytochromes and cryptochromes, which absorb light at specific wavelengths (Lin, 2000).

The main photoreceptors that regulate photoperiodic flowering in many plants are phytochromes (Song et al., 2015).

The light reception, as well as the inductive photoperiod duration are determined at the leaves level by means of phytochromes (Burzo et al., 2000; Bădulescu, 2009; Burzo, 2016). The photoperiod duration is received at the level of leaves with a medium maturity. They react best under the influence of the photoperiod compared to senescent leaves (Bădulescu, 2009).

Photochromes are best known in two forms: “stable” or “inactive” form (storage), which absorbs red light radiation (r - 660 nm); and the “unstable” or “active” form that absorbs distant red light radiation (fr - 730 nm) (Delian, 2019).

Flowering of *Chrysanthemum morifolium* Ramat. is inhibited when the required long night phase is interrupted by a short period of exposure to red light (night break; NB). But to obtain the reverse effect of this inhibition, the plants are subsequently exposed to distant red light (FR), thus involving phytochromes in the flowering response (Higuchi et al., 2012).

FLORAL INDUCTION AND FLORIGEN

Flowering is an important phenomenon found in flowering plants and not only in them. It can be influenced by several factors, but especially by the photoperiod (Garner & Allard, 1920; Chailakhyan, 1968; Pearson et al., 1993; Mattson & Erwin, 2005; Song et al., 2015; Thomas, 2017; Higuchi, 2018; Torabi et al., 2020).

The oldest concept of the physiological nature of flowering plants dates back to 1880 and was published by the German botanist Julius von Sachs, who claimed that a specific organ-forming substance was involved in the formation of each plant organ. His hypothesis referred both to plant formation and especially to flower-forming substances.

Mikhail Kh. Chailakhyan, following numerous photoperiodic experiments, including chrysanthemums, proposed in 1936 the existence of a universal plant hormone that he called "florigen". He claimed that it is produced by the leaves and it is involved in flowering. He also found in his experiments (1968) that plant species, regardless of the nature of their photoperiodic reaction, contain more sugars and starch in long day conditions and more nitrogenous compounds and proteins in short day conditions. He observed that the nitrogen deficiency in the chrysanthemum culture substrate inhibits its flowering, while in other long-day species (barley, oats, mustard) it stimulates it. Chailakhyan also demonstrated that floral induction can be transmitted from an induced plant to an uninduced plant by grafting. Zeevaart (1958) states in his paper that grafting is used more recently in transmitting the inducing stimulus of flowering from a flowering plant (donor) to one that does not bloom (recipient), but according to the literature, this is possible only if the receiver is defoliated. Chrysanthemum flowering can be grouped into two phases: induction of flower initiation and development of flower buds to anthesis, both processes being promoted for short days. But the initiation of chrysanthemum flowers on long days is inevitable, depending on the variety and the aging process in the apical meristems (Cockshull, 1976).

Floral induction can be defined as a process that forms, under the influence of inductive factors, a complex biochemical messenger, who can lead to a change in the expression of flowering genes (Bădulescu, 2009). It can be classified as a transition phase, according to which the plant passes from vegetative to reproductive growth, being able to produce flowers (Delian, 2019).

Floral induction of plants can be influenced by several external inductive factors, such as: photoperiodism (duration of the photoperiod), thermoperiodism (high temperatures), vernalization (low positive temperatures), as well as some internal factors, such as: hormones, autonomous cycle, nutrition (Dobrescu et al., 2018). Depending on the species, a single factor or several factors that act simultaneously can induce the flowering of plants (Bădulescu, 2009; Burzo et al., 1999).

Florigen is a hypothetical signal produced in the leaves that induces floral initiation at the top of the shoots (Zeevaart, 2008), but it can last for several days or even weeks. The change in the leaf can be seen as an "induction", while the peak response (initiation of flowering) can be called "evocation".

In the case of chrysanthemums, the floral induction is conditioned by the short days necessary for the transition from the vegetative to the reproductive cycle.

These short days must be consecutive, and their number varies according to the species and variety. In the case of standard chrysanthemum, it needs 21-28 consecutive short days for floral induction, while twig type chrysanthemum needs more time, namely 42 consecutive short days (Toma, 2013).

In chrysanthemum there are two types of buds, namely: crown buds and terminal buds. "Wreath buds" are those flower buds which, when they appear, differ in being surrounded by leaves, while the terminal buds are flower buds which are surrounded by other flower buds. In the case of shaded chrysanthemums, only terminal buds appear (Laurie and Poesch, 1932).

Plant growth, being an irreversible change over time, produces changes in size, shape and number (Hunt, 2003). For example,

chrysanthemums do not bloom unless they have a minimum number of leaves reached.
The duration of the photoperiod is fixed by the photosensitive pigments (phytochromes, cryptochromes), and they pass from the inactive phase to the active phase. The circadian biological clock helps determine the number of inducible photoperiods. In nictiperiodic plants, floral induction can be canceled if a short day is followed by a long day. However, if a plant has gone through the number of inductive photoperiods, it will flourish even if it is not subsequently exposed to the inductive photoperiod (Burzo, 2016).

RESULTS AND DISCUSSIONS

Depending on the necessary environmental conditions (in our case, the photoperiod), floral induction and chrysanthemum flowering can be adjusted using both camouflage (artificially shortening the length of day covering the plants) and artificial lighting with night break (NB).

APPLICATIONS OF PHOTOPERIODISM

Chrysanthemum being a sensitive plant throughout the day, allows the selection of varieties and facilitates their maintenance in a vegetative state or bringing them in the reproductive period (at flowering), by the grower in accordance with market requirements.

CONCLUSIONS

The aim of this paper is to review the evolution of research on the behavior of chrysanthemum plants exposed to a certain photoperiod. Successive stages of development can be seen in the progress of models that have been adapted in the production of chrysanthemum cut flowers. Looking ahead, research into the contribution of photoperiodism to regulating chrysanthemum flowering remains open.

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REFERENCES

Adams, S. R., Pearson, S., & Hadley, P. (2001). Improving quantitative flowering models through a better understanding of the phases of photoperiod sensitivity. *Journal of Experimental Botany, 52*(357), 655–662, https://doi.org/10.1093/jexbot/52.357.655.

Bădulescu, L. (2009). Botanică și fiziologia plantelor. *Editura Elisavaros*, București, pag 167–199.

Borthwick, H.A., & Cathey, H.M. (1962). Role of Phytochrome in Control of Flowering of Chrysanthemum. *Botanical Gazette, 123*(3), 155–162. DOI:10.1086/336143.

Bunning, E. (1936). Die endogene Tagesrhythmik als Grundlage der photoperiodischen Reaktion. Berichte der Deutschen Botanischen, Gessellschaft 54, 590–607, https://doi.org/10.1111/j.1438-8677.1937.tb01941.x.

Burzo, I., Toma, S., Crăciun, C-tin., Voican, V., Dobrescu, A. și Delian, E. (1999). Fiziologia plantelor de cultură. Vol.I, Întreprinderea *Editorial Poligrafică Știința*, Chișinău, pag.384-395.

Burzo I., 2016. *Fiziologia procesului de înflorire. Editura Elisavaros,* București, pag. 14, 25-29, 83–115.

Chailakhyan, M. Kh. (1937). Hormonal theory of plant development. Bull. Acad. Sci. U.R.S.S., pp.198, https://www.cabdirect.org/cabdirect/abstract/19390300007.

Chailakhyan, M. Kh. (1968). Internal Factors of Plant Flowering, Annual Review of Plant Physiology, pag. 1–37, https://www.annualreviews.org/doi/pdf/10.1146/annurev.pp.19.060168.000245.

Cockshull, K.E. (1976). Flower and Leaf Initiation by *Chrysanthemum morifolium* Ramat. in Long Days. *Journal of Horticultural Science, 51*(4), 441–450, https://doi.org/10.1080/00221589.1976.11514712.

Delian E. (2019). Fiziologia plantelor. Vol. II, Editura Ex Terra Aurum, București, ISBN 978-606-8817-83-5, pag. 203–216.

Dobrescu, A., Burzo, I., Bădulescu, L. & Badea M. (2018). Fiziologia plantelor de cultură. Editura Ex Terra Aurum, București, ISBN 978-606-8974-00-2, pag. 191 – 198, 209 – 220, 246 – 249.

Datta, S. K. (2013). *Chrysanthemum morifolium* Ramat. – a unique genetic material for breeding. *Sci. Culture. 79*(7-8). 307–313, https://www.researchgate.net/publication/321005423_Chrysanthemum_morifolium_Ramat-A_Unique_Genetic_Material_for_Breeding#fullTextFileContent.

Dong, W., Li M., Li Z., Li S., Zhu, Y., Hongxu, Wang, Z. (2020). Transcriptome analysis of the molecular mechanism of Chrysanthemum flower color change under short-day photoperiods. *Plant Physiology and Biochemistry*, 146, 315–328, https://doi.org/10.1016/j.plaphy.2019.11.027.

Dowrick, G.J. (1953). The chromosomes of Chrysanthemum II: Garden varieties. *Heredity 7*, 59-72, https://doi.org/10.1038/hdy.1953.5.

Erwin, J. (2006). Factors Affecting Flowering in Ornamental Plants. *Flower Breeding and Genetics*, 7–48, DOI: 10.1007/978-1-4020-4428-1_1.

Erwin, J., Warner, R., & Mattson, N. (2002) How Does Daylength Affect Flowering of Spring Annuals? UM / MNLA Minnesota Commercial Flower Growers Bulletin, 50+ Years of Service, Dept. of Horticultural Science, University of Minnesota, 6-10, https://www.academia.edu/22253903/How_Does_Daylength_Affect_Flowering_of_Spring_Annuals.

Fukai, S. (2014). Flowering Physiology of Chrysanthemum. *Acta Horticulturae, (1025*), 135–142. DOI: 10.17660/ActaHortic.2014.1025.20.

Fukai, S. (2003). Dendranthema Species as Chrysanthemum Genetic Resources. *Acta Horticulture (620)*, 223–230, DOI: 10.17660/ActaHortic.2003.620.26.

Garner, W. & Allard, H. (1920). Effect of the relative length of day and night and other factors of the environment on growth and reproduction in plants. *Journal of Agricultural Research* 11, Vol. XVIII, 553-606, https://naldc.nal.usda.gov/download/IND43966282/PDF.

Green, RM, Tingay, S, Wang, Z-Y, Tobin, EM. (2002). Circadian rhythms confer a higher level of fitness to Arabidopsis plants. *Plant Physiology 129*, 576–584.

Higuchi, Y. (2018). Florigen and anti-florigen: flowering regulation in horticultural crops. *Breeding Science, 68*(1), 109–118, https://doi.org/10.1270/jsbbs.17084.

Higuchi, Y., Sumitomo, K., Oda, A., Shimizu, H., & Hisamatsu, T. (2012). Day light quality affects the night-break response in the short-day plant chrysanthemum, suggesting differential phytochrome-mediated regulation of flowering. *Journal of Plant Physiology, 169*(18), 1789–1796, https://doi.org/10.1016/j.jplph.2012.07.003.

Hong, Y., Tang, X., Huang, H., Zhang, Y., & Dai, S. (2015). Transcriptomic analyses reveal species-specific light-induced anthocyanin biosynthesis in chrysanthemum. *BMC Genomics*, *16*(1).

Hunt, R. (2003). Growth and development / Growth Analysis, Individual Plants, *Encyclopedia of Applied Plant Sciences,* 579-588, https://doi.org/10.1016/B0-12-227050-9/00028-4.

Imaizumi, T. & Kay, S.A. (2006). Photoperiodic control of flowering: not only by coincidence. *Trends in Plant Science, 11*(11), 550–558, https://doi.org/10.1016/j.tplants.2006.09.004

Jeong, S. W., Park, S., Jin, J. S., Seo, O. N., Kim, G.-S., Kim, Y.-H., … Shin, S. C. (2012). Influences of Four Different Light-Emitting Diode Lights on Flowering and Polyphenol Variations in the Leaves of Chrysanthemum (*Chrysanthemum morifolium*). *Journal of Agricultural and Food Chemistry*, *60*(39), 9793–9800, https://doi.org/10.1021/jf302272x.

Johansson, M., & Staiger, D. (2014). Time to flower: interplay between photoperiod and the circadian clock. *Journal of Experimental Botany, 66*(3), 719–730., https://doi.org/10.1093/jxb/eru441.

Laurie, A. & Poesch, G.H. (1932). Photoperiodism - The Value of Supplementary Illumination and Reduction of Light on Flowering Plants in the Greenhouse, Agricultural Experiment Station, Buletin 512, Wooster, Ohio, 18–37,

Laurie, A. (1930) Photoperiodism—practical application to greenhouse culture. *Proc. Am. Soc. Hortic. Sci*. 27: 319–322, https://scholar.google.com/scholar_lookup?journal=Proc.+Am.+Soc.+Hortic.+Sci.&title=Photoperiodism%E2%80%94practical+application+to+greenhouse+culture&volume=27&publication_year=1930&pages=319-322&.

Lin, C. (2000). Photoreceptors and Regulation of Flowering Time. *Plant Physiology, 123*(1), 39–50, doi: 10.1104/pp.123.1.39.

Mattson, N.S., & Erwin, J.E. (2005). The impact of photoperiod and irradiance on flowering of several herbaceous ornamentals. Scientia Horticulturae, 104(3), 275–292. doi:10.1016/j.scienta.2004.08.018

Micallef, B. J. (2011). Circadian Clocks/Photoperiodism and Crop Quality. *Comprehensive Biotechnology (Third Edition) Volume 4*, 237-252, https://doi.org/10.1016/B978-0-444-64046-8.00260-3

Oda, A., Higuchi, Y. & Hisamatsu, T. (2017). Photoperiod-insensitive floral transition in chrysanthemum induced by constitutive expression of chimeric repressor CsLHY-SRDX. *Plant Science, 259*, 86–93, https://doi.org/10.1016/j.plantsci.2017.03.007.

Ohmiya A. (2018). Molecular mechanisms underlying the diverse array of petal colors in chrysanthemum flowers. *Breeding Science, 68*(1), 119–127, https://doi.org/10.1270/jsbbs.17075.

Pearson, S., Hadley, P., & Wheldon, A. E. (1993). A reanalysis of the effects of temperature and irradiance on time to flowering in chrysanthemum (*Dendranthema grandiflora*). *Journal of Horticultural Science, 68(*1), 89–97, https://doi.org/10.1080/00221589.1993.11516332.

Singh, P. & Chettri, R. (2013). A new propagation method for rapid multiplication of Chrysanthemum under in Vivo conditions. *International Journal of Conservation Science, Vol. 4*, Issue 1, 95-100, ISSN: 2067–533X.

Song, Y.H., Shim, J.S., Kinmonth-Schultz, H.A., & Imaizumi, T. (2015). Photoperiodic Flowering: Time Measurement Mechanisms in Leaves. *Annual Review of Plant Biology, 66*(1), 441–464, https://doi.org/10.1146/annurev-arplant-043014-115555.

Șelaru, E. (1995). Culturi de seră pentru flori tăiate. Floricultura 1, Editura Ceres, București, 1995, pag. 135-159.

Thomas, B. (2017). Photoperiodism. *Encyclopedia of Applied Plant Sciences,* 448–454, https://doi.org/10.1016/B978-0-12-394807-6.00107-6

Thomas, B. & Vince-Prue, D. (1997). Photoperiodism in Plants. *Academic Press*, Second edition, London. 56, 88–90, https://books.google.ro/books?id=Gwk76aFc8qsC&printsec=frontcover&hl=ro#v=onepage&q=chrysanthemum&f=false.

Toma, F. (2013). Floricultură. U.S.A.M.V. București, pag. 37–40.
Torabi, B., Adibnya, M., Rahimi, A., & Azari, A. (2020). Modeling flowering response to temperature and photoperiod in safflower. *Industrial Crops and Products*, *151*, 112474, https://doi.org/10.1016/j.indcrop.2020.112474.
Zeevaart, J. A. (2008). Leaf-produced floral signals. Current Opinion in Plant Biology, 11(5), 541–547.
Zeevaart J.A.D. (1958). Flower formation as studied by grafting. *Publicația Nr. 178 al Laboratorului de creștere a plantelor horticole*, Colegiul Agricol, Wageningen, Nederland, 58 (3), 1-88, file:///D:/Doctorat/Doctorat%2012.09.2020/Articole/Zeevaart,%201958.pdf.
Zhao, H. E., Liu, Z. H., Hu, X., Yin, J. L., Li, W., Rao, G. Y., … Chen, J. Y. (2009). Chrysanthemum genetic resources and related genera of Chrysanthemum collected in China. *Genetic Resources and Crop Evolution, 56*(7), 937–946, DOI 10.1007/s10722-009-9412-8.
Wang, Y., Xu, Z., Wen, X., Li, M., Pang, S., Huang, Y., & Ni, Y. (2019). The formation and bioactivities of green substances in *Chrysanthemum morifolium* tea. *Food Chemistry, Vol. 286*, 268–274, https://doi.org/10.1016/j.foodchem.2019.02.026.
Yang, L., Wen, X., Fu, J., & Dai, S. (2018). ClCRY2 facilitates floral transition in *Chrysanthemum lavandulifolium* by affecting the transcription of circadian clock-related genes under short-day photoperiods. *Horticulture Research, 5*(1). doi:10.1038/s41438-018-0063-9.

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MISCELLANEOUS

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