Ornamental Horticulture
ISSN 2447-536X | WWW.ORNAMENTALHORTICULTURE.COM.BR

SBFPO Sociedade Brasileira de Floricultura e Plantas Ornamentais

ARTICLE

Understanding the dynamics of vegetative and reproductive development in on-farm cut dahlia

Entendendo a dinâmica do desenvolvimento vegetativo e reprodutivo em dália de corte a campo

Moara Eliza Siqueira Fernandes[1,*], Charles Patrick de Oliveira de Freitas[1], Regina Tomiozzo[1], Marizane Lied Simon[1], Luana Gabriele Oliveira da Silva[1], Lilian Osmari Uhlmann[1], Alencar Júnior Zanon[1], Nereu Augusto Streck[1]

[1]Universidade Federal de Santa Maria, Santa Maria-RS, Brasil.

Abstract: The objective in this study was to determine the duration of the vegetative and the reproductive phases, as the relationship between total developmental cycle and developmental phases in on-farm cut dahlia cultivars. Ten on farm trials using two to eight cut dahlia cultivars during three years (2021 to 2023) at eight locations in the state of Rio Grande do Sul, Southern Brazil, were used. Tubers were planted in beds 1.0 m wide and 0.2 m high, at a 0.40 m x 0.40 m spacing and at a depth of 0.05 m. The date of crop emergence was considered when 50% of the plants had emerged. The main shoot of 10 plants per cultivar was tagged. The number of unfolded leaf pairs on tagged plants was counted until the last pair of unfolded leaves on the main shoot. The date that 50% of the tagged plants were at first visible floral bud on the main shoot and at the first flower on the main shoot with the first layer of petals fully open (harvest point) were collected by observing the tagged plants daily. It was observed that the vegetative phase varied from 14 to 58 days, while the reproductive phase varied from 11 to 48 days, depending on the cultivar and planting date. The duration of the total developmental cycle, from plant emergence to the first flower opening, which is considered the harvest point of the crop, is primarily determined by the duration of the vegetative phase, which, in turn, is related to the phyllochron or leaf appearance rate. These results have practical applications for farmers, consultants, and breeders, such as selecting cultivars for specific regions, optimizing planting dates, planning the harvest, and adjusting management practices.
Keywords: cut flowers, phenological variables, phenology, reproductive development, vegetative development.

Resumo: O objetivo deste estudo foi determinar a duração das fases vegetativa e reprodutiva, e a relação entre o ciclo de desenvolvimento total e as fases de desenvolvimento em cultivares de dálias de corte em condições de campo. Foram realizados dez ensaios em lavouras comerciais utilizando de dois a oito cultivares de dálias de corte durante três anos (2021 a 2023) em oito locais no estado do Rio Grande do Sul, sul do Brasil. Os tubérculos foram plantados em canteiros com 1,0 m de largura e 0,2 m de altura, com espaçamento de 0,40 m x 0,40 m e a uma profundidade de 0,05 m. A data de emergência da cultura foi considerada quando 50% das plantas haviam emergido. O broto principal de 10 plantas por cultivar foi marcado. O número de pares de folhas desdobradas nas plantas marcadas foi contado até o último par de folhas desdobradas no broto principal. A data em que 50% das plantas marcadas apresentavam o primeiro botão floral visível no broto principal e a primeira flor no broto principal com a primeira camada de pétalas totalmente aberta (ponto de colheita) foram coletadas observando as plantas marcadas diariamente. Observou-se que a fase vegetativa variou de 14 a 58 dias, enquanto a fase reprodutiva variou de 11 a 48 dias, dependendo da cultivar e data de plantio. A duração do ciclo de desenvolvimento total, desde a emergência da planta até a abertura da primeira flor, considerado ponto de colheita da cultura, é principalmente determinado pela duração da fase vegetativa que, por sua vez, tem relação com o filocrono ou velocidade de emissão de folhas. Estes resultados têm aplicações práticas para agricultores, consultores e melhoristas, como selecionar cultivares para regiões específicas, otimizar datas de plantio, planejamento da colheita e ajustar práticas de manejo.
Palavras-chave: desenvolvimento reprodutivo, desenvolvimento vegetativo, fenologia, flores de corte, variáveis fenológicas.

Introduction

Dahlia (*Dahlia spp.*), native to Mexico and belonging to the Asteraceae family, is widely appreciated as an ornamental plant due to its diversity of colors and shapes that resemble orchid, anemone, plate, cactus, pompom, among others. Although the native land of the Dahlia is Mexico, it is among the popular bulbous flowers found in most gardens around the world (Alkaç et al., 2022). Dahlia is an herbaceous, shrubby, perennial plant with a tuberous root system and an upright growth habit (National Dahlia Society, 2021). The versatility of Dahlia is evident in its adaptability to grow in the open field with temperatures up to 35 °C (Fernandes et al., 2023a), eliminating the need for greenhouses and making its cultivation with relatively low production cost (Uhlmann, 2022). Dahlia is one of the flowers species of the Flowers for All Project, a nationwide project that since 2018 brings cut flowers as a source of income for small landholder family farmers in Brazil (Uhlmann et al., 2019; Streck and Uhlmann, 2021). Also, it is a common annual garden plant that provides a variety of colors and interest to the landscape, being an important part of modern floriculture and landscaping industries (Schneck et al., 2021).

Plant growth and development are related but different processes that can occur simultaneously or not. While growth is related to an increase is size (i.e., height, area, or volume) of the different plant organs or canopy, development is related to events that include cell differentiation, organs initiation (organogenesis), organs appearance (morphogenesis) and extends to plant senescence (Streck et al., 2012; Hilty et al., 2021; Proietti et al., 2022). The developmental cycle of a plant (from planting to senescence) can be divided into vegetative and reproductive phases. This division is often based on morphological indicators that are easily identified by the naked eye in the field so that the vegetative phase starts at plant emergence from the soil surface and ends when the reproductive organ in visible, whereas the reproductive phase starts when the reproductive organ is visible and ends when plant senesces (McMaster, 2005; Streck et al., 2012). During the vegetative phase, the appearance of leaves takes place until the flag leaf appears and fully develops, so defining the final leaf number which represents the total number of primordia that differentiated into leaves on a stem. The appearance of new leaves also drives the dynamics of leaf area index that intercepts solar radiation for photosynthesis and is often represented by the phyllochron, defined as the time interval between the appearance of two successive leaves (Schuh et al., 2005; Streck et al., 2007).

Several studies have been conducted to understand the role of the vegetative and reproductive phases on the duration of the developmental cycle of different agricultural crops, including flowering plants. For instance, in rice (Streck et al., 2006), in wheat (Walter et al., 2009), in gladiolus (Streck et al., 2012), and in freesia (*Freesia x hybrida)* (Santilli et al., 2023) the duration of developmental cycle is driven by the duration of the vegetative phase, which in turn is defined by the final leaf number and/or by the rate that leaves appear (represented by the phyllochron). These basic studies are important from a practical viewpoint for a fine-tuning of management practices, for breeders to select cultivars that are better suited for specific regions, for optimizing planting date, and for

***Corresponding author**: moaraeliza@gmail.com | https://doi.org/10.1590/2447-536X.v30.e242754 | Editor: Raissa Rachel Salustriano da Silva-Matos, Universidade Federal do Maranhão, Brasil | Received: May 04, 2024 | Accepted: Aug 16, 2024 | Available online: Oct 25, 2024

planning harvesting schedules. Recently, the phyllochron and the final leaf number of cut dahlias were determined in Southern Brazil (Fernandes et al., 2023b) and, although several studies have been conducted on the post-harvest durability of Dahlia flowers in different countries, with a primary focus on prolonging vase life (Alkaç et al., 2020; Azuma et al., 2020; Shimizu-Yoto et al., 2020), no detailed studies aiming to understand the relationships between vegetative and reproductive development in field grown dahlias were found. The objective of this study was to determine the duration of the vegetative and reproductive phases, as well as the relationship between total developmental cycle and developmental phases in on-farm cut dahlia cultivars.

Materials and methods

Ten on-farm trials using two to eight cut dahlia cultivars during three years (2021 to 2023) at eight locations in the state of Rio Grande do Sul, Southern Brazil, were used (Table 1). The varying number of cultivars used at each location was because of the availability of tubers provided by the farmers.

Table 1. On-farm trials with cut dahlias in Rio Grande do Sul State, Brazil, used in the study.

Location	Cultivars	Planting date (dd/mm/yyyy)
Santa Maria (1) **Santa Maria (2)**	Rebecca´s World, Siberia, Promise, Dark Spirit, Pompom, Vera, Frantonio Rebecca´s World, Siberia, Promise, Dark Spirit, Pompom	25/02/2021 21/09/2021
Jaguari	Rebecca´s World, Siberia, Promise, Dark Spirit, Pompom, Vera, Frantonio	27/02/2021
Pelotas	Rebecca´s World, Siberia, Promise, Dark Spirit, Pompom, Vera, Frantonio	27/08/2021
Cachoeira do Sul	Rebecca´s World, Siberia, Promise, Dark Spirit, Pompom	14/10/2021
Novo Cabrais	Rebecca´s World, Siberia	18/11/2022
Lajeado	Rebecca´s World, Siberia	21/11/2022
Júlio de Castilhos (1) **Júlio de Castilhos (2)**	Rebecca’s World, Siberia Vicent Van, Marina, Carla	18/11/2022 01/05/2023
Alegrete	Rebecca´s World, Siberia, Promise, Dark Spirit, Pompom, Vera	06/02/2023

The climate in all the locations is Cfa according to the Köppen system, which corresponds to a humid subtropical climate with hot summers and no dry season (Kuinchtner and Buriol, 2001; Kottek et al., 2006). Soil sampling for chemical tests were performed at the Santa Maria and Cachoeira do Sul farms and indicated soil organic matter content of 2.1% and 3.3%, soil pH of 4.55 and 6.13, phosphorus (P) content of 88.3 mg dm^{-3} and 56.1 mg dm^{-3}, potassium (K) content of 206.5 mg dm^{-3} and 366.7 mg dm^{-3}, and calcium (Ca) + magnesium (Mg) content of 5.4 $cmol_c$ dm^{-3} and 11.1 $cmol_c$ dm^{-3}, respectively. No soil tests were taken at the other locations, but the areas had been previously used for flower and vegetable cultivation by farmers and therefore represented local farmers conditions. Tubers from a private company were used by the farmers and planted in beds with a width of 1.0 m and a height of 0.2 m, at a 0.40 m x 0.40 m spacing and at a depth of 0.05 m in all farms. Fertilization included pre-planting application of lime to achieve a pH of 6.0 and 50 g m^{-2} of NPK (5-20-20) and top dressing with 12 g m^{-2} of urea and 18 g m^{-2} of potassium chlorite at 35 days after planting and 12 g m^{-2} of urea and 18 g m^{-2} of potassium chloride at 65 days after the onset of harvesting as indicated by Brondum and Heins (1993) and Kumar et al. (2019). All farmers used irrigation to prevent water stress in their dahlia crops at all locations.

Daily minimum and maximum air temperatures were collected from automatic weather stations of the National Institute of Meteorology (INMET) as shown in the Table 2. The table shows the experimental locations alongside the geographic coordinates of the corresponding automatic weather stations, indicating the precise location of each station used to collect meteorological data for the experiments.

Table 2. Experimental locations and the geographic coordinates of their corresponding automatic weather stations.

Location of the experiment	Automatic weather stations geographic coordinates (indicating the precise location of each station)	
Santa Maria	Santa Maria (A803)	-29.72, -53.72
Novo Cabrais	Santa Maria (A803)	-29.72, -53.72
Pelotas	Pelotas (V0628)	-31.80, -52.51
Jaguari	São Vicente do Sul (A889)	-29.70, -54.69
Júlio de Castilhos	Cruz Alta (A853)	-28.60, -53.67
Lajeado	Teutonia (A882)	-29.26, -51.48
Cachoeira do Sul	Rio Pardo (A813)	-29.87, -52.38
Alegrete	Alegrete (V0600)	-29.79, -55.77

The number of emerged plants (shoot was first visible at the soil surface) was counted daily until reaching the final plant stand. The date of crop emergence was considered when 50% of the plants had emerged. After complete emergence, the main shoot of 10 plants per cultivar was tagged in each farm. The number of unfolded leaf pairs (NLP - a leaf was considered unfolded when the edges of the leaflets were no longer touching) on each tagged plant was counted once a week in Cachoeira do Sul, Lajeado, Júlio de Castilhos, Novo Cabrais, and Alegrete, and twice a week in Santa Maria, Jaguari, and Pelotas until the last pair of unfolded leaves, which is the final leaf pair number on the main shoot (FLPN). Furthermore, the date that 50% of the tagged plants were at first visible floral bud on the main shoot and at the first flower with the first layer of petals fully open on the main shoot (harvest point) were collected by observing the 10 tagged plants daily. The vegetative phase was assumed be to from emergence to the first visible floral bud on the main shoot, and the reproductive phase was assumed from the first visible floral bud on the main shoot to the first flower with the first layer of petals fully open on the main shoot.

Daily thermal time (TTd) from emergence to the first flower with the first layer of petals fully open was calculated according to Gilmore and Rogers (1958), and Arnold (1960):

$$TTd = (T_{mean} - Tb) \cdot 1 \text{ day, when } T_{mean} \text{ is between Tb and Topt} \quad (1)$$

$$TTd = \{(Topt - Tb) \cdot [TB - T_{mean})/(TB-Topt)]\}, \text{ when } Topt < T_{mean} < TB \quad (2)$$

$$TTd = 0, \text{ when } T_{mean} < Tb \text{ or } T_{mean} > TB \quad (3)$$

Where Tmean is the mean air temperature calculated as the average of the daily minimum and maximum air temperatures, and Tb, Topt, and TB are the lower base, optimum, and upper base cardinal temperatures for the unfolding of the leaf pairs (5.5 °C, 24.6 °C, and 34.9 °C, respectively), for the vegetative phase (2.4 °C, 22.4 °C, and 31.1 °C, respectively), and for the reproductive phase (5.2 °C, 24.2 °C, and 33.1 °C, respectively), as determined by Brondum and Heins (1993). The accumulated thermal time (TT, °C day) from emergence to the first visible floral bud (vegetative phase) and from the first visible floral bud to the first flower with the first layer of petals fully open (reproductive phase) was calculated as follows.

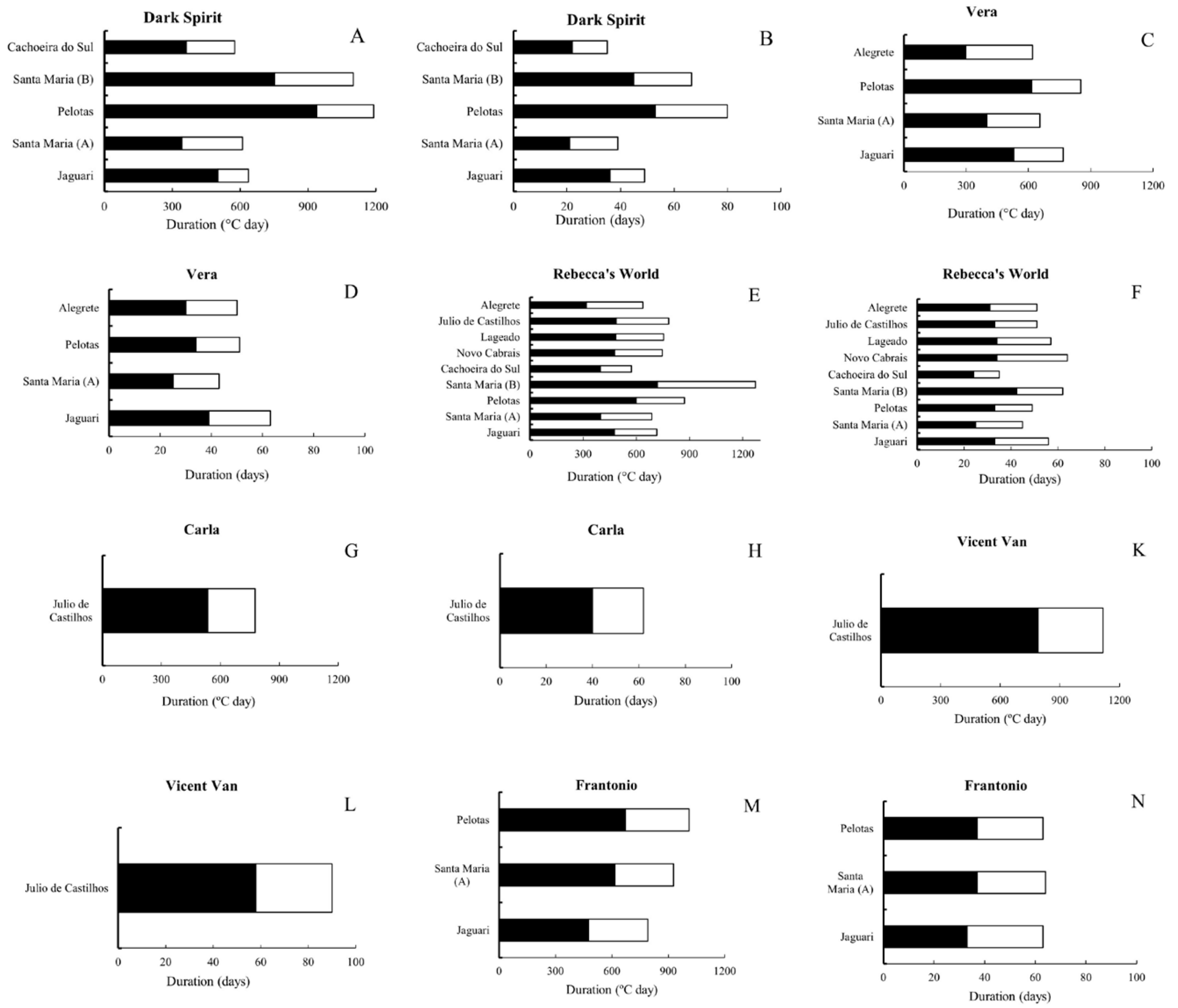
$$TT = \sum TTd \quad (4)$$

The phyllochron, with unit of °C day leaf pair^{-1}, was calculated as the slope of the linear regression between NLP against TT (Schuh et al., 2005; Streck et al., 2007; Koefender et al., 2008). The duration in thermal time of the developmental cycle was regressed against the duration in thermal time of the vegetative and the reproductive phases, and the duration in thermal time of the vegetative phase was regressed against the phyllochron and the FLPN (Streck et al., 2012).

Results and discussion

The 10 trials in eight locations used in this study (Table 1) exposed the eight cut dahlia cultivars to different environments. The minimum temperature varied from -0.4 to 15.4 °C whereas the maximum temperature varied from 31.6 to 40.8 °C. Dahlia cultivars had different durations of vegetative and reproductive phases so that some cultivars spent more time in the vegetative phase whereas others entered the reproductive phase earlier (Fig. 1). For each cultivar, sowing date and location also played an important role in affecting the duration of the vegetative and reproductive phases both in days and in °C day (Fig. 1).

The vegetative phase varied from 14 to 58 days and the reproductive phase varied from 11 to 48 days. The development rate of dahlia is highly influenced by air temperature (Brondum and Heins, 1993). Therefore, the duration of developmental phases in thermal time (with units of °C day) is biologically a more meaningful measure of time compared to calendar days or days after sowing (Steinmetz et al., 2017; Parent et al., 2019). The vegetative phase varied from 208.8 to 938.3 °C day and the reproductive phase varied from 134.7 to 554.7 °C day according to cultivar, location, and planting date (Fig. 1). The duration of the vegetative and reproductive phases has practical applications for dahlia farmers, researchers, and consultants such as to select cultivars that are better suited for specific regions, to optimize planting dates, for planning harvesting schedules, and for the fine tuning of management practices aiming to improve farmers profits and sustainability (Streck and Ulhmanm, 2021).



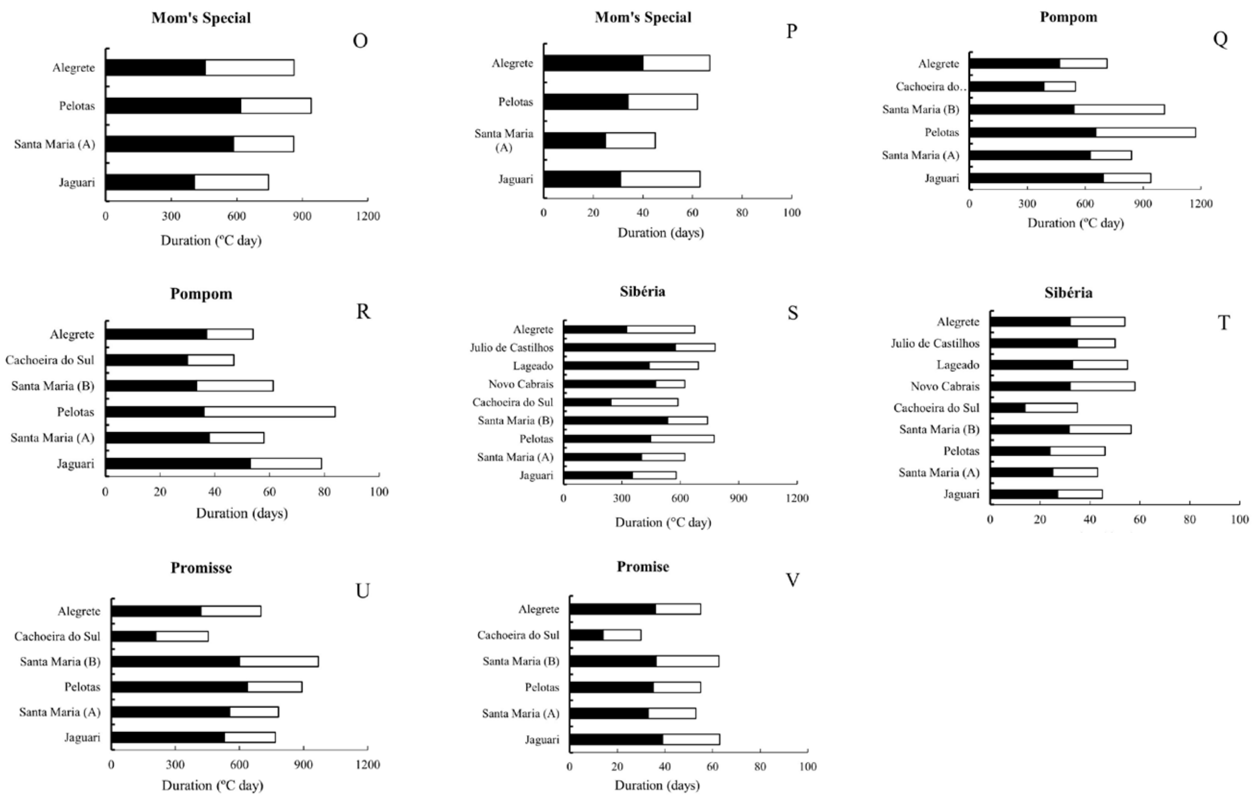


Fig. 1. Duration in °C day (A, C, E, G, I, K, M, O, Q, S, U) and in days (B, D, F, H, J, L, N, P, R, T, V) of the vegetative phase (from emergence to the first visible floral bud, solid bars) and the reproductive phase (from the first visible floral bud to the first flower with the first layer of petals fully open, open bars) on the main shoot of dahlia cultivars grown on farm in several locations in Rio Grande do Sul State, Southern Brazil.

Pooling all data together, the duration of the total developmental cycle (vegetative + reproductive phases) showed a high positive linear relationship with the duration of the vegetative phase (Fig. 2A) and a less but significant positive linear relationship with the duration of the reproductive phase (Fig. 2B). The rate of increase in the duration of the total developmental cycle is about 112 °C day (100 °C day of the vegetative phase)$^{-1}$ and 140 °C day (100 °C day of the reproductive phase)$^{-1}$. The duration of the vegetative phase showed a positive linear relationship with the phyllochron (Fig. 2C) and no relationship with the final number of leaf pairs (Fig. 2D). These results indicate that the timing for the onset of harvest in cut dahlia cultivars is primarily driven by the duration of the vegetative phase which in turn is driven by the phyllochron (or its inverse the leaf appearance rate), and have practical applications for famers, consultants, and breeders. For instance, if farmers need cultivars with earliness, they should grow dahlias that have high leaf appearance rate (low phyllochron) regardless of the final leaf pair number. For breeders, final leaf number is a trait that does not affect earliness whereas the phyllochron is indeed a trait that should be considered for flowering earliness breeding programs.

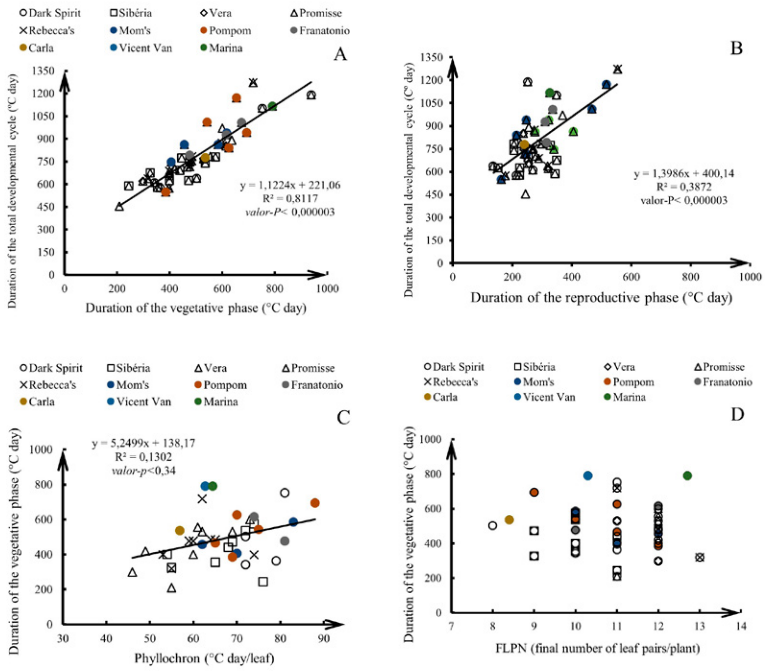


Fig. 2. Relationship between (A) duration of the total developmental cycle (from plant emergence to the first flower with the first layer of petals fully opened) and the duration of the vegetative phase (emergence until the first visible floral bud), (B) duration of the total developmental cycle and the duration of the reproductive phase (from the first visible flower bud to the first flower with the first layer of petals fully opened), (C) relationship between the duration of the vegetative phase and the phyllochron, and (D) relationship between the duration of the vegetative phase and the (FNPL) final number of pairs of leaves in 11 cultivars of cut dahlias (Dark Spirit, Pompom, Frantonio, Vera, Rebecca's World, Promise, Carla, Vicent Van, Mom's Special, and Marina) grown on-farm in 8 locations in Rio Grande do Sul State, Southern Brazil. Linear regression lines with *p*-value lower than 0.05 (5% probability) are presented in each panel.

Studies on basic processes that drive the development of flower crops are scarce. These results are similar to those found for gladiolus by Streck et al. (2012), who found a direct and positive relationship between the duration of the total cycle and the vegetative phase, which had a significant relationship with the phyllochron, the same found in this work. In other words, high dependence on leaf appearance rate, important information for the calibration and validation of mathematical models with dahlia. While final leaf number drives vegetative development in gladiolus, our results indicate that in dahlia the different final leaf pair number of cultivars (Fig. 2D) is compensated by a different rate that leaves appear (Fig. 2C), i.e. cultivars that have a lower final leaf pair number have a lower phyllochron (higher leaf appearance rate) and vice versa. This cross compensation indicates a high adaptation in the dynamics of leaf development in dahlia compared to gladiolus and other agricultural crops like rice (Streck et al., 2006) and wheat (Streck et al., 2009). These results have practical applications for famers, consultants, and breeders, such as to select cultivars for specific regions, to optimize planting dates, for planning harvesting schedules, and for fine tuning of management practices.

Conclusions

The duration of the vegetative phase and the reproductive phase in cut dahlia vary with planting date and cultivar. The duration of the vegetative phase is driven by the phyllochron (or its inverse the leaf appearance rate). The duration of the total developmental phase from plant emergence to the first flower with the first layer of petals fully opened is dependent on the duration of both the vegetative phase (from emergence to visible bud) and the reproductive phase (from visible bud to the first flower with the first layer of petals fully opened).

Acknowledgments

To the farmers Milton Cauzzo, Maria Elza Silva de Carvalho and Diesser Artier Mota, Leonir Fátima de Oliveira de Freitas, Clóvis Fernando de Freitas, Mara Elaine Scortegagna Flores, Newton Flores, and Sandra Puper for allowing measurements and observations on their dahlia crops. Authors thank to The PhenoGlad Team for helping in collecting data.

Author Contribution

MESF: conceptualization, investigation, data curation, formal analysis, writing – original draft, writing – review & editing. **CPOF:** investigation. **RT:** conceptualization, investigation, data curation, writing – review & editing. **MLS:** investigation, data curation, formal analysis. **LGOS**: investigation. **LOU:** investigation, supervision, writing – review & editing. **AJZ:** supervision. **NAS:** conceptualization, methodology, supervision, formal analysis, project administration. writing – review & editing

Declaration of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

Data will be available on request.

References

ALKAÇ, O.S.; BELGUZAR, S.; ONDES, E.; OKATAR, F. KAYAASLAN, Z. The effects different rhizobacteria and mycorrhiza applications on seedling growth and development of starflower (*Dahlia variabilis*). **Mustafa Kemal University Journal of Agricultural Sciences**, v.27, n.2, p.331-339, 2022. https://doi.org/10.37908/mkutbd.1092636

ALKAÇ, O.S.; OCALAN, O.N.; GUNES, M. The effect of some solutions on the vase life of star flowers. **Ornamental Horticulture**, v.26, n.4, p.607-613, 2020. https://doi.org/10.1590/2447-536X.v26i4.2184

ARNOLD, C.Y. Maximum-minimum temperatures as a basis for computing heat units. **Proceedings the American Society for Horticultural Sciences**, v.76, n.1, p.682-92, 1960.

AZUMA, M.; ONOZAKI, T.; ICHIMURA, K. Difference of ethylene production and response to ethylene in cut flowers of dahlia (*Dahlia variabilis*) cultivars. **Scientia Horticulture**, v.273, p.1-12, 2020. https://doi.org/10.1016/j.scienta.2020.109635.

BRONDUM, J.J.; HEINS, R.D. Modeling temperature and photoperiod effects on growth and development of dahlia. **Journal of the American Society Horticultural Science**, v.118, n.1, p.36-42, 1993. https://doi.org/10.21273/JASHS.118.1.36

FERNANDES, M.E.S.; ROSO, T.P.; FERRONATO, L.; FREITAS, C.P.O.; TOMIOZZO, R.; UHLMANN, L.O.; ZANON, A.J.; STRECK, N.A. Determining the phyllochron and final leaf pair number in on-farm cut dahlia cultivars. **Ornamental Horticulture**, v.29, n.2, p.299-312, 2023b. https://doi.org/10.1590/2447-536X.v29i2.2650

FERNANDES, M.E.S.; TOMIOZZO, R.; FREITAS, C.P.O.; ROSO, T.P.; SOUSA, M.H.L.; UHLMANN, L.O.; ZANON, A.J.; STRECK, N.A. Damage and lethal temperature due to heat stress in field grown dahlia. **Ornamental Horticulture**, v.29, n.2, p.218-225, 2023a. https://doi.org/10.1590/2447-536X.v29i2.2624

GILMORE, E.C.; ROGERS, J.S. Heat units as a method of measuring maturity in corn. **Agronomy Journal**, v.50, n.10, p.611-615, 1958.

HILTY, J.; MULLER, B.; PANTIN, F.; LEUZINGER, S. Plant growth: the what, the how, and the why. **New Phytologist**, v.232, n.1, p.25-41, 2021. https://doi.org/10.1111/nph.17610

KOEFENDER, J.; MENEZES, N.L.; BURIOL, G.A.; TRENTIN, R.; CASTILHOS, G. Influência da temperatura e da luz na germinação da semente de calêndula. **Horticultura Brasileira**, v. 27, n. 2, p. 207–210, 2009.

KOTTEK, M.; GRIESER, J.; BECK, C.; RUDOLF, B. World map of the Koppen-Geiger climate classification updated. **Meteorologische Zeitschrift**, v.15, n.3, p.259-263, 2006. https://10.1127/0941-2948/2006/0130

KUINCHTNER, A.; BURIOL, G.A. Clima do estado do Rio Grande do Sul segundo a classificação climática de Köppen e Thornthwaite. **Disciplinarum Scientia**, **Série: Ciências Exatas**, v.2, n.1, p.171-182, 2001.

KUMAR, N.; PRASAD, V.M.; YADAV, N.P. Effect of chemical fertilizers and bio fertilizers on flower yield, tuberous root yield and quality parameter on dahlia (*Dahlia variabilis* L.) cv. Kenya Orange. **Journal Pharmacognosy and Phytochemistry**, v.8, n.4, 2019.

McMASTER, G.S. Phytomers, phyllochrons, phenology and temperate cereal development. **Journal of Agricultural Science**, v.143, p.137-150, 2005. http://dx.doi.org/10.1017/S0021859605005083

NATIONAL DAHLIA SOCIETY. **Dahlia:** Overview / Classification / Family Tree / Species / Cultivation. West Midlands, Englad: National Dahlia Society, 2021. Available at: https://www.dahlia-nds.co.uk/about-dahlias/overview/. Accessed on: may 10th 2024.

PARENT, B.; MILLET, E.J.; TARDIEU, F. The use of termal time in plant studies has a sound theoretical basis provided that confounding effects are avoided. **Journal of Experimental Botany**, v.70, n.9, p.2359-2370, 2019.

PROIETTI, S.; ESCARIOTE, V.; DE PASCALE, S.; PARADISO, R. flowering mechanisms and environmental stimuli for flower transition: bases for production scheduling in greenhouse floriculture. **Plants**, v.11, n.432, 2022. https://doi.org/10.3390/plants11030432

SANTILLI, M.; BAS-NAHAS, S.S.; MEDRANO, N. Occurrence and duration of phenological phases of *Freesia* x *hybrida* grown at different planting dates. **Ornamental Horticulture**, v.29, n.2, p.200-207, 2023. https://doi.org/10.1590/2447-536X.v29i2.2568

SCHNECK, K.K; BOYER, C.R.; MILLER, C.T. Supraoptimal rootzone temperatures affect dahlia growth and development. **HortTechnology**, v.31, n.6, p.667-678, 2021. https://doi.org/10.21273/HORTTECH04896-2

SCHUH, M.; STRECK, N.A.; NARDI, C.; BURIOL, G.A.; BELLÉ, R.A.; BRACKMANN, A. Vernalização afeta o filocrono em lírio. **Bragantia**, v.64, n.1, p. 25-32, 2005.

SHIMIZU-YUMOTO, H.; TSUJIMOTO, N.; NAKA, T. Acid invertase activities of dahlia 'Kokucho' petals during flower opening and following cutting and treatment with 6-benzylaminopurine. **Scientia Horticulture**, n.272, 2020. https://doi.org/10.1016/ j.scienta.2020.109525

STEINMETZ, S.; CUADRA, S.V.; ALMEIDA, I.R.; MAGALHÃES JÚNIOR, A.M.; FAGUNDES, P.R.R. Soma térmica e estádios de desenvolvimento da planta de grupos de cultivares de arroz irrigado. **Agrometeoros**, v.25, n.2, p.405-414, 2017.

STRECK, N.; UHLMANN, L. Flowers for all; bridging the gap between science and society. **Chronica Horticulturae**, v.61, n.3, p.32-34. 2021.

STRECK, N.A.; BELLÉ, R.A.; BACKES, F.A.A.L.; GABRIEL, F.K.; UHLMAN, L.O.; BECKER, C.C. Desenvolvimento vegetativo e reprodutivo em gladíolo. **Ciência Rural**, v.42, n.11, p.1968-1974, 2012. https://doi.org/10.1590/S0103-847820120011 00010

STRECK, N.A.; BOSCO, L.C.; MICHELON, S.; WALTER, L.C.; MARCOLIN, E. Duração do ciclo de desenvolvimento de cultivares de arroz em função da emissão de folhas no colmo principal. **Ciência Rural**, v.36, n.4, p.1086-1093, 2006. https://doi.org/10.1590/S0103-84782006000400007

STRECK, N.A.; FAGUNDES, J.D.; SANTIAGO, G.; MELLO, A.M.; BELLÉ, R.A. Crescimento, desenvolvimento e retardamento da senescência foliar em girassol de vaso (*Helianthus annuus* L.): efeito de fontes e doses de nitrogênio. **Ciência Rural**, v.37, p.987-993, 2007. https://doi.org/10.1590/S0103-84782007000400011

UHLMANN, L. **Produção de flores como forma de renda**. Revista Arco, Santa Maria, RS, janeiro de 2022. Available at: https://www.ufsm.br/midias/arco/producao-flores-forma-renda/. Accessed on: May 10th 2024.

UHLMANN, L.O.; BECKER, C.C.; TOMIOZZO, R.; STRECK, N.A.; SCHONS, A.; BALEST, D.S.; BRAGA, M.S.; SCHWAB, N.T.; LANGNER, J.A. Gladiolus as an alternative for diversification and profit in small rural property. **Ornamental Horticulture**, v.25, n.2, p.200-208, 2019. https://doi.org/10.14295/oh.v25i2.1541

WALTER, L.C.; STRECK, N.A.; ROSA, H.T.; ALBERTO, C.M.; OLIVEIRA, F.B. Desenvolvimento vegetativo e reprodutivo de cultivares de trigo e sua associação com a emissão de folhas. **Ciência Rural**, v.39, p.2320-2326, 2009. https://doi.org/10.1590/S0103-84782009005000169