eISSN 1981-1829

Ciência e Agrotecnologia
Science and Agrotechnology

# Thermal sum and phyllochron of cut sunflower genotypes in southwestern Mato Grosso, Brazil

## Soma térmica e filocrono de genótipos de girassol de corte na região sudoeste de Mato Grosso, Brasil

Sebastião Marcos Silva Valentim[1*], Petterson Baptista da Luz[2], Antônio Carlos Silva Moreira[2], Elaidy Laura Oliveira Cardoso[2], Gabriel Moretto[2], Regina Tomiozzo[3]


### ABSTRACT

Cut sunflower holds significant potential for the floriculture market in Brazil, with its development being strongly influenced by air temperature. This study aimed to determine the thermal sum required for the emergence of various phenological stages and to estimate the phyllochron of 12 newly cut sunflower genotypes in southwestern Mato Grosso, Brazil. The research was conducted in Cáceres, MT, where seedlings were planted in two beds, and ten central plants per genotype in each bed were marked to track reproductive stages, classified as R1, R4, and R5. Air temperature measurements were used to calculate the accumulated thermal sum for the stages emergence–R1, R1–R4, R4–R5, and emergence–R5. A linear regression analysis was performed to assess the relationship between the number of leaves accumulated on the stem and the accumulated thermal sum, enabling phyllochron estimation for each genotype. The accumulated thermal sum for emergence–R1 ranged from 445.29 ºC/day to 791.08 ºC/day, and for emergence–R5, it ranged from 806.51 ºC/day to 1139.10 ºC/day. The relationship between leaf number on the stem and accumulated thermal sum was linear, with a coefficient of determination between 0.98 and 0.99, and phyllochron values ranged from 20 to 26 °C day leaf$^{-1}$. Thus, the sunflower genotypes assessed exhibited values consistent with standards observed in other genotypes and ornamental species on the market, indicating that they possess commercialization potential and that the region's climate conditions are suitable for cultivation.


**Index terms:** *Helianthus annuus* L; floriculture; cut flower; ornamental plant.


### RESUMO

O girassol de corte possui potencial para o mercado de floricultura no país, onde seu desenvolvimento está fortemente reacionado à temperature do ar. O objetivo da pesquisa foi determinar a soma térmica necessária para o surgimento dos diferentes estágios fenológicas e estimar o Filocrono de 12 novos genótipos de girassol de corte na região Sudoeste de Mato Grosso. A pesquisa foi desenvolvida em Cáceres, MT, onde no campo, as mudas foram plantadas em dois canteiros, onde dez plantas centrais por genótipo em cada canteiro, foram marcadas para serem determinadas as fases reprodutivas, classificadas como R1, R4 e R5. A temperatura do ar foi mensurada, onde a soma térmica acumulada entre as fases emergência-R1, R1-R4, R4-R5 e emergência-R5, foi obtida. Realizou-se uma regressão linear entre o número de folhas acumuladas na haste e a soma térmica acumulada e estimado o Filocrono para cada genótipo de girassol. A soma térmica acumulada entre a emergência-R1 foi entre 445,29 ºC/dia e 791,08 ºC/dia e entre emergência-R5, foi entre 806,51 ºC/dia e 1139,10 ºC/dia. A relação entre o número de folhas na haste e a soma térmica acumulada foi linear, com coeficiente de determinação entre 0.98 e 0.99 e os valores de Filocrono foram entre 20 e 26 ºC dia folha-1. Conclui-se que os genótipos de girassol avaliados exibiram valores dentro do padrão em comparação com outros genótipos e espécies ornamentais já presentes no mercado, demonstrando que os mesmos possuem atributos para a comercialização e que a região possui condições climáticas favoráveis para o cultivo.


**Termos para indexação:** *Helianthus annuus* L.; floricultura; flor de corte; planta ornamental.

Agricultural Sciences

Ciênc. Agrotec., 49:e017024, 2025
http://dx.doi.org/10.1590/1413-7054202549017024

Editor: Renato Paiva

[1]Universidade Federal de Lavras/UFLA, Departamento de Ciências Florestais. Lavras, MG, Brasil
[2]Universidade do Estado de Mato Grosso/UNEMAT, Departamento de Engenharia Agronômica, Cáceres, MT, Brasil
[3]Universidade Federal de Santa Maria/UFSM, Departamento de Fitotecnia. Santa Maria, RS, Brasil

Corresponding author: sebastiao.valentim@estudante.ufla.br

*Received in August 7, 2024 and approved in November 29, 2024*

## Introduction

The Southeast region has traditionally been the main center for the production and consumption of flowers and ornamental plants in Brazil, with the State of São Paulo playing a prominent role in the floriculture industry (Souza et al., 2020). Despite limited investment in marketing and advertising to promote floriculture, this sector has been expanding into other regions of Brazil, with notable growth in ornamental floriculture over the past five years (IBRAFLOR, 2022).

The expansion of floriculture in Brazil has transformed the cultivation of cut flowers into a significant economic activity for small-scale farmers, serving as a vital source of income for family farming. In 2019, the sector experienced a 7% increase in revenue, reaching about 8.7 billion reais (IBRAFLOR, 2020). Growth accelerated in the subsequent years, with a 10% rise in 2020, totaling 9.6 billion reais. By 2021, revenue increased by

15% compared to the previous year, reaching 10.9 billion reais. Currently, there are around 8,000 producers cultivating over 2,500 species and about 17,500 varieties of flowers and plants across the country (IBRAFLOR, 2022).

Among the species suitable for cut flower cultivation, the sunflower (*Helianthus annuus* L.) stands out for its aesthetic appeal and high acceptance within the ornamental market. The sunflower is recognized for its hardiness, low production cost, ease of management, and adaptability to various edaphoclimatic conditions (Silva et al., 2022).

Air temperature is one of the most influential climate factors affecting plant development, significantly impacting growth and interacting with other variables, such as light, which is critical for photosynthesis (Silva et al., 2021). The impact of air temperature on plant growth can be quantified using the thermal sum, defined as the accumulation of degree-days needed to complete a growth cycle, stage, process, or developmental sub-period of a plant species (Pereira, Campelo Júnior, & Ferronato, 2010). This measure is considered a more accurate indicator of biological time compared to calendar days or days after sowing (Teixeira, 2014).

Counting the number of leaves is a method used to monitor plant development (Biai et al., 2021). It represents a key indicator for assessing crop growth, as the vegetative phase morphogenesis of a plant is often characterized by measuring the rate of leaf emergence (Cruz et al., 2021).

The phyllochron can be used to simulate the emergence of leaves on the main stem (Munareto et al., 2021) and refers to the time interval required for a new leaf to develop on the stem (Paula & Streck, 2008). Its calculation relies on the daily accumulation of thermal sum, expressed in degree-days, needed for a leaf to appear on the stem (°C day leaf$^{-1}$). This method provides an efficient way to assess plant adaptation under various environmental conditions. Bergamaschi (2007) highlighted that the thermal sum is a critical determinant of a plant's thermal requirements and serves as a valuable parameter for developing effective crop management strategies.

This research, therefore, aimed to determine the thermal sum required for the emergence of distinct phenological stages and to estimate the phyllochron of 12 newly developed cut sunflower genotypes in southwestern Mato Grosso, Brazil.

## Material and Methods

The study was conducted at the State University of Mato Grosso-UNEMAT, located on the Cáceres-MT campus, Brazil. The regional climate, classified as tropical savanna (Aw) according to the Köppen system, has a mean annual temperature of 28.8 °C, with July having the lowest average temperatures at 24.3 °C. The area experiences a hot summer, a dry winter, and an annual precipitation average of 1,500 mm (Cáceres, 2020). The study site lies at an altitude of 126 m, with geographic coordinates of 16°04′01″ South latitude and 57°41′12″ West longitude (Cáceres, 2020).

The genotypes assessed were Amalfi Gold (AG-01), Amalfi Orange (AO-02), DD Black Center (DD-03), Favola (FA-04), Luxor Tangy (LT-05), Magic Pro (MP-06), Stromboli Pro (SP-07), Stromboli Tangy (ST-08), Vesuvio Orange (VO-09), Vesuvio Pro (VP-10), Vesuvio Tangy (VT-11), and Vincent's Choice (VC-12). These were selected based on their availability for potential commercial distribution in Brazil.

Seeds of the 12 genotypes were sown on September 2, 2022, in 12 Styrofoam trays, with one seed per cell. The trays contained Carolina Soil® commercial substrate and were placed in a greenhouse covered with transparent plastic film. Daily irrigation was provided by sprinklers until the tenth day after sowing. Seedling emergence was defined as the point when 50% of the seedlings were visible above the substrate level, with cotyledons fully open at 180° during germination.

The seedlings were transplanted into two beds, each measuring 25 m in length and 1 m in width, oriented in the northwest-southeast direction. The genotypes were randomly arranged in these beds. Transplanting occurred when seedlings had cotyledon leaves open at 180°, the first leaf pair with blades between 1 cm and 2 cm in length, and a root system firmly embedded in the substrate.

The experiment was conducted on soil classified as a Plinthosol (Plintossolo Pétrico concrecionário 123 distrófico) with a texture of 617 g kg$^{-1}$ sand and 145 g kg$^{-1}$ silt. Chemical analysis indicated 28.0 g dm$^{-3}$ organic matter, a pH of 6.1, 125 mg dm$^{-3}$ P, 0.33 cmol dm$^{-3}$ K, 5.19 cmol dm$^{-3}$ Ca, and base saturation of 89.40%. To protect the soil from adverse weather conditions, conserve moisture, and limit weed growth, grass straw was applied as a mulch.

The seedlings were arranged in four rows with 20 cm spacing between rows and 12.5 cm spacing between plants within each row, resulting in a planting density of 32 plants m$^{-2}$ for each genotype. Ten central plants per genotype in each bed, totaling 20 plants, were marked to observe reproductive stages, categorized as R1: floral bud emergence, R4: petal appearance, and R5: harvest point—when ligulate flowers align at 90° with the capitulum disc, indicating the conclusion of the cut sunflower cycle (Schneiter, Miller, & Berglund, 2013). The transition to new plant phases was assessed four times a week, with corresponding dates recorded.

Irrigation was conducted daily using a Santeno-type perforated hose. Top-dressing fertilization was applied 11 days after transplanting, using 25 g m$^{-2}$ urea and 25 g m$^{-2}$ potassium chloride in the designated formulation, without soil incorporation.

Air temperature throughout the field experiment was monitored using the weather station located at the University. The thermal sum accumulated for the emergence-R1 (EM-R1), R1–R4, R4–R5, and emergence-R5 (EM-R5) stages was recorded. Additionally, daily maximum and minimum temperatures were measured, which facilitated the calculation of the daily thermal sum (TSd) (Equation 1) based on the method described by Villalobos et al. (1996).

$$TSd = \{(Topt - Tb)*[(TB - Tm)/(TB - Topt)]\} \quad (1)$$

When:
If Tm > TB, TSd = 0
If Tm < Tb, TSd = 0
If Tm < Topt, TSd = Tm – Tb
If Tm > Topt, TSd = (Topt – Tb)*{(Tm – TB)/(Topt – TB)}

In this study, Tb, Topt, and TB represent the cardinal temperatures for the leaf appearance rate in sunflower crops, corresponding to the base, optimum, and maximum temperatures of 4, 28, and 40 °C, respectively (Villalobos et al., 1996). The mean air temperature is denoted as Tm.

The thermal sum was calculated individually for each plant, and the average thermal sum was then determined for each genotype. Linear regression analysis was conducted between the accumulated number of leaves on the stem, and the accumulated thermal sum (TSa), starting from the date leaf counting began. TSa represents the total of the daily thermal sums (TSd). The phyllochron for each sunflower genotype was derived as the inverse of the slope of the linear regression line, expressed in °C day leaf$^{-1}$ (Raddatz et al., 2023).

## Results and Discussion

Some genotypes required a greater accumulation of thermal sum to initiate R1, marking the start of the sunflower reproductive phase, such as LT-05 and SP-07. Conversely, other genotypes, like VO-09 and VC-12, needed a lower thermal sum, with values ranging from 445.29 ºC/day to 791.08 ºC/day (Table 1).

**Table 1:** Accumulated thermal sum (TSa) between the development stages of 12 cut sunflower genotypes, represented by ºC days (ºC/day).

| Genotype | EM-R1 | R1-R4 | R4-R5 | EM-R5 |
|---|---|---|---|---|
| VT-11 | 574.71 | 339.22 | 34.25 | 911.42 |
| ST-08 | 663.60 | 308.55 | 37.20 | 987.36 |
| AO-02 | 662.55 | 225.55 | 19.29 | 987.36 |
| DD-03 | 597.40 | 330.65 | 76.96 | 1,006.07 |
| AG-01 | 640.50 | 308.3 | 56.8 | 1,028.10 |
| MP-06 | 641.60 | 313.82 | 29.26 | 986.28 |
| FA-04 | 663.60 | 431.45 | 35.10 | 1,139.10 |
| VP-10 | 556.71 | 249.29 | 50.62 | 846.48 |
| VC-12 | 504.59 | 260.51 | 44.03 | 827.07 |
| SP-07 | 687.90 | 286.38 | 66.93 | 1,045.39 |
| LT-05 | 791.08 | 334.16 | 51.54 | 1,158.07 |
| VO-09 | 445.29 | 278.99 | 44.92 | 806.51 |

Sunflower genotypes S430, S530, and GR16, cultivated in Porto Alegre-RS, displayed accumulated thermal sums between emergence and R1 of 940 ºC/day, 844 ºC/day, and 817 ºC/day, respectively (Silva, Rocha, & Silva, 1994). In contrast, the genotypes evaluated in the current study exhibited lower thermal sums, indicating faster development under the specific climatic conditions of the experiment.

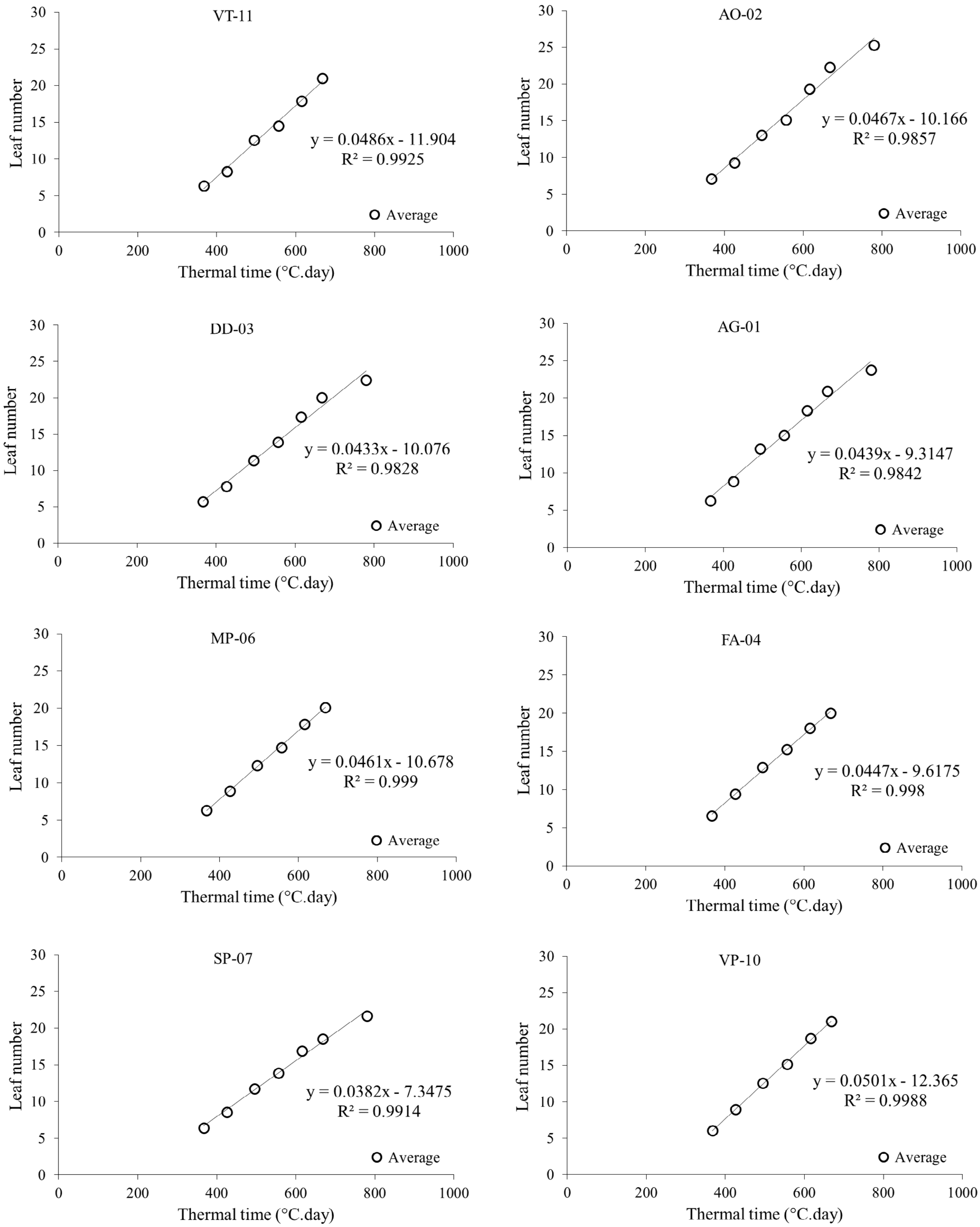
Gladiolus (*Gladiolus* x *grandiflorus* Hort.) in Curitibanos-SC required a thermal sum of about 870 ºC/day between emergence and R1, while in Concórdia-SC and Rio do Sul-SC, the values were about 1030 ºC/day (Stanck et al., 2020). Consequently, the thermal sum needed for gladiolus to reach R1 was greater than for the sunflower genotypes in Cáceres, highlighting quicker development and a lower thermal sum requirement in comparison to other ornamental species.

The sunflower genotypes in this study had thermal sums between 806.51 ºC/day and 1139.10 ºC/day for the full cycle from emergence to R5 (EM-R5). VO-09 required the least thermal sum to complete its cycle, while LT-05 required the most. For comparison, gladiolus completed its cycle with a thermal sum of about 1140 ºC/day in Curitibanos-SC and about 1300 ºC/day in Concórdia-SC and 1280 ºC/day in Rio do Sul-SC (Stanck et al., 2020), reflecting higher values than those of the sunflower genotypes.

Rapid development is considered a favorable agronomic trait, as it facilitates accelerated leaf emergence and a swift increase in leaf area. According to Borella et al. (2020), leaf area is a critical factor influencing the photosynthetic process, where a larger leaf area enhances the photosynthesis rate, thereby optimizing energy supply for physiological development and reducing cultivation costs.

The phyllochron is determined using the thermal sum, representing the degree-days required for a leaf to appear on the stem (°C day leaf$^{-1}$). The relationship between the number of leaves on the main stem and the accumulated thermal sum was found to be linear. This indicates that as the accumulated thermal sum increased, more leaves were produced on the stems, with determination coefficients ($R^2$) for the genotypes ranging from 0.98 to 0.99 (Figure 1). This strong correlation suggests that mean temperature significantly influences leaf emergence in sunflowers, accounting for 98% to 99% of the variation in leaf emission, which is identified as the primary factor for this trait (Chein, 2019).

Furthermore, the linear relationship observed between the number of leaves on the stem and the accumulated thermal sum indicates that the mean daily temperature during the experiment in Cáceres remained within the range between the base temperature (Tb) and the maximum temperature (TB), staying close to the optimum temperature (Topt) for sunflower. This suggests that the region's climate is well-suited for cultivating the evaluated genotypes.


VT-11
y = 0.0486x - 11.904
R² = 0.9925
AO-02
y = 0.0467x - 10.166
R² = 0.9857
DD-03
y = 0.0433x - 10.076
R² = 0.9828
AG-01
y = 0.0439x - 9.3147
R² = 0.9842
MP-06
y = 0.0461x - 10.678
R² = 0.999
FA-04
y = 0.0447x - 9.6175
R² = 0.998
SP-07
y = 0.0382x - 7.3475
R² = 0.9914
VP-10
y = 0.0501x - 12.365
R² = 0.9988
Leaf number
Thermal time (°C.day)
Average
0
5
10
15
20
25
30
200
400
600
800
1000

Continue...

**Figure 1:** Continuation.

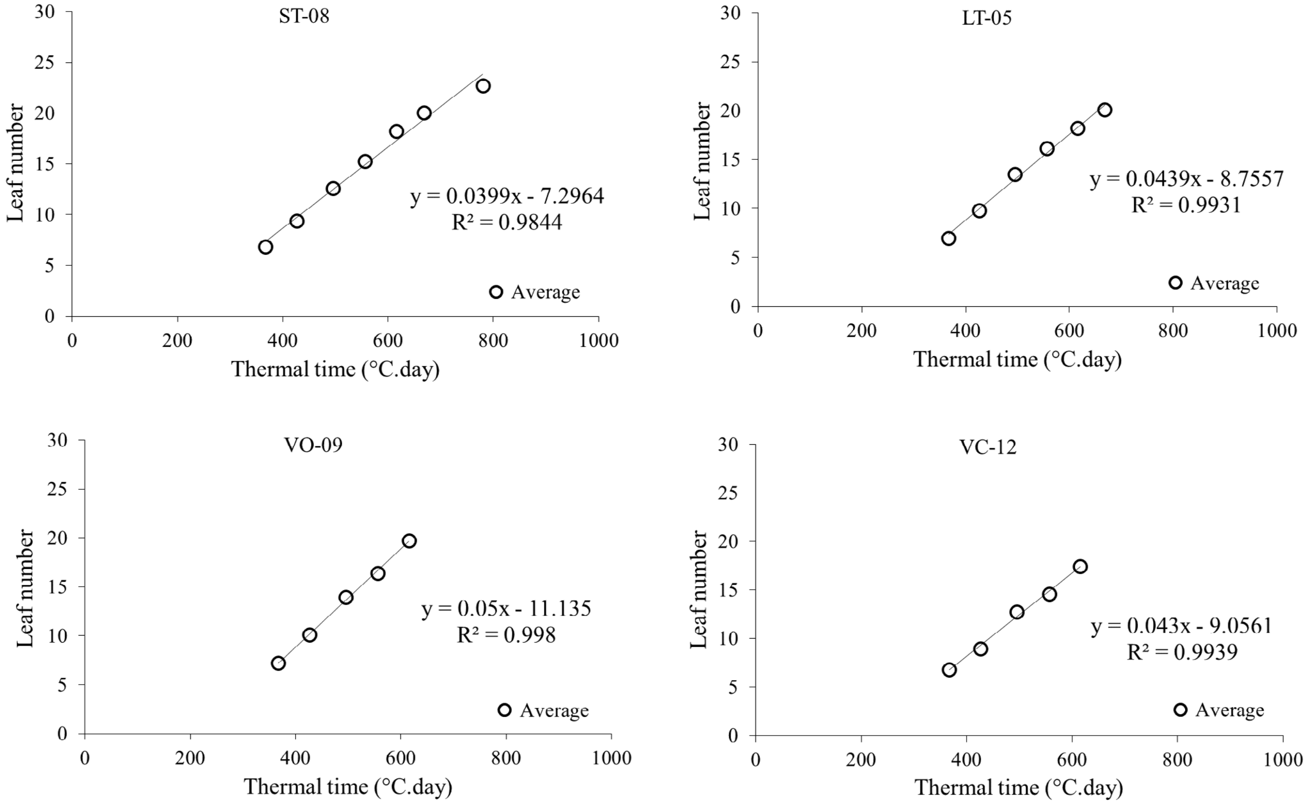



**Figure 1:** Relationship between the number of leaves accumulated on the main stem and the accumulated thermal sum used to estimate the phyllochron of the 12 cut sunflower genotypes.

Phyllochron values varied among the sunflower genotypes, with the highest estimated value for SP-07 at 26 °C day leaf$^{-1}$ and the lowest values for VT-11, VP-10, and VO-09 at 20 °C day leaf$^{-1}$. This implies that the genotype SP-07 required a daily accumulated thermal sum of 26 °C for a leaf to emerge on the stem, whereas VT-11, VP-10, and VO-09 needed only 20 °C to produce a leaf (Table 2).

Counting the number of leaves on plants, as done to estimate the phyllochron, is an effective method for monitoring growth (Peixoto, Cruz, & Peixoto, 2011). It serves as a crucial characteristic for evaluating crop development and understanding vegetative phases (Gazzola et al., 2012). The phyllochron simulates leaf emergence on the main stem, representing the time interval needed for a new leaf to appear (Paula & Streck, 2008). This estimation aids in assessing the physiological development of genotypes and contributes to crop management and planning.

In an experiment conducted with the ornamental plant dahlia, a phyllochron value of 69.6 °C day leaf$^{-1}$ was recorded in the State of Rio Grande do Sul (Fernandes et al., 2023). Lettuce, another member of the Asteraceae family like sunflower, showed an estimated phyllochron of 52.1 °C day leaf$^{-1}$ in Santa Maria-RS (Schwab et al., 2020). These values are higher than those observed in the sunflower genotypes of this study, indicating that dahlia and lettuce require more accumulated temperature and time for leaf production, reflecting a longer developmental cycle.

**Table 2:** Estimated phyllochron of 12 sunflower genotypes.

| Genotype | Phyllochron (°C day leaf$^{-1}$) |
|---|---|
| VT-11 | 20 |
| AO-02 | 21 |
| DD-03 | 23 |
| AG-01 | 23 |
| MP-06 | 24 |
| FA-04 | 22 |
| VP-10 | 20 |
| SP-07 | 26 |
| ST-08 | 25 |
| LT-05 | 23 |
| VO-09 | 20 |
| VC-12 | 23 |

The phyllochron for the ornamental sunflower genotype Double Sungold was found to range between 22.0 and 25.4 °C day leaf$^{-1}$ (Fagundes et al., 2007). Similarly, marigold, another ornamental species in the Asteraceae family, had an estimated phyllochron of 15.9 to 24.5 °C day leaf$^{-1}$ (Koefender et al., 2008). The phyllochron values observed for the sunflower genotypes in Cáceres are comparable to these findings, suggesting that the genotypes possess agronomic traits well-suited for the floriculture market. According to Estevam, Reges, and Santos (2023), a shorter cycle indicates good adaptation to prevailing climatic conditions.

Variations in phyllochron values between different genotypes and plant species reflect differences in temperature accumulation requirements for leaf emergence. These variations can be attributed to diverse physiological needs influenced by air temperature.

## Conclusions

The findings for thermal sum and phyllochron indicate that the sunflower genotypes assessed in Cáceres, MT displayed values consistent with standards observed in other genotypes and ornamental species within the floriculture market. Some genotypes exhibited lower temperature accumulation needs, suggesting their potential for commercialization. Furthermore, the Southwest region of Mato Grosso demonstrates suitable climatic conditions for sunflower cultivation. The phyllochron estimates confirm that mean air temperature is a significant factor influencing leaf emergence in the studied sunflower genotypes.

## Author Contribution

Conceptual idea: Valentim, SMS; Luz, PB; Tomiozzo, R; Methodology design: Valentim, SMS; Luz, PB; Tomiozzo, R; Data collection: Valentim, SMS; Moreira, ACS; Cardoso, ELO; Moretto, G.; Data analysis and interpretation: Valentim, SMS; Luz, PB; Tomiozzo, R; Moretto, G.; Writing and editing: Valentim, SMS; Luz, PB.

## Acknowledgments

To the Coordination for the Improvement of Higher Education Personnel – CAPES, for granting the Master's scholarship, the State University of Mato Grosso – UNEMAT, the company Mansuino Breeding Emotions, and the PhenoGlad Team from UFSM.

## References

Bergamaschi, H. (2007). O clima como fator determinante na fenologia das plantas. In G. M. Rego., R. R. B. Negrelle., & L. P. C. Morellato. *Phenology: A tool for the conservation, improvement and management of arboreal plant resources*. Colombo- PR, Embrapa Florestas, (pp.291-310).

Biai, A. et al. (2021). Avaliação das características agronômicas e produtivas de acessos de amendoim sob adubação orgânica. *Revista em Agronegócio e Meio Ambiente*, *14*:e 8732.

Borella, D. R. et al. (2020). Exigências térmicas e filocrono de *Dipteryx alata* sob níveis de sombreamento na transição Cerrado-Amazônia. *Scientia Plena*, *16*(5):1-15.

Cáceres. (2020). Cáceres City Hall; Plano Municipal de Saneamento Básico. Final report, p. 01-605, Cáceres-MT. Available in: <https://www.caceres.mt.gov.br/fotos_noticias_downloads/57.pdf>.

Chein, F. (2019). *Introdução aos modelos de regressão linear*. Brasília-DF, Enap. 77p.

Cruz, N. T. et al. (2021). Fatores que afetam as características morfogênicas e estruturais de plantas forrageiras. *Research, Society and Development*, *10*(7):e5410716180.

Estevam, V. S., Reges, N. P. R., & Santos, M. P. (2023). Uso do índice NDVI para deteminação fenológica da cultura da soja. *Revista Uniaraguaia*, *18*(1):106-115.

Fagundes, J. D. et al. (2007). Crescimento, desenvolvimento e retardamento da senescência foliar em girassol de vaso (*Helianthus annuus* L.): Fontes e doses de nitrogênio. *Ciência Rural*, *37*(4):987-993.

Fernandes, M. E. S. et al. (2023). Determining the phyllochron and final leaf pair number in on-farm cut dahlia cultivars. *Ornamental Horticulture*, *29*(2):299-312.

Gazzola, A. et al. (2012). *Cultura do girassol*. Universidade de São Paulo, Escola Superior de Agricultura Luiz de Queiroz- ESALQ, Piracicaba- SP, 69p. Available in: <https://www.bibliotecaagptea.org.br/agricultura/culturas_anuais/livros/A%20CULTURA%20DO%20GIRASSOL.pdf>.

Instituto Brasileiro de Floricultura- IBRAFLOR. (2020). *Crescimento do setor em 2019*. Available in:<https://www.ibraflor.com.br/post/crescimento-do-setor-em-2019>

Instituto Brasileiro de Floricultura- IBRAFLOR. (2022). *O mercado de flores no Brasil*. P. 01-04, Holambra- SP. Available in: <www.ibraflor.com.br>.

Koefender, J. et al. (2008). Estimativa do filocrono em calêndula. *Ciência Rural*, *38*(5):1246-1250.

Munareto, J. D. et al. (2021). Estimativa de temperatura base e filocrono em quinoa. *Revista Brasileira Multidisciplinar*, *24*(1):143-152.

Paula, G. M., & Streck, N. A. (2008). Temperatura base para emissão de folhas e nós, filocrono e plastocrono das plantas daninhas papuã e corriola. *Ciência Rural*, *38*(9):2457-2463.

Peixoto, C. P., Cruz, T. V. da., & Peixoto, M. de F. da. S. (2011). Análise quantitativa do crescimento de plantas: Conceitos e prática. *Enciclopédia Biosfera*, *7*(13):51-72.

Pereira, L. C., Campelo Júnior, J. H., & Ferronato, A. (2010). Comparação de métodos para estimativa do plastocrono em algodoeiro em condições tropicais. *Pesquisa Agropecuária Tropical*, *40*(2):213-220.

Raddatz, R. I. et al. (2023). Desenvolvimento vegetativo e reprodutivo, associado a emissão de folhas em cultivares de trigo. *Enciclopedia Biosfera*, *20*(44):127-135.

Schneiter, A. A., Miller, J. F., & Berglund, D. R. (2013). *Stages of sunflower development*. North Dakota State University Fargo, North Dakota, p. 1-2.

Schwab, N. T. et al. (2020). Produtividade e filocrono de alface conduzida sobre diferentes coberturas de solo. *Ambiência*, *16*(1):1083-1095.

Silva, P. R. F., Rocha, A. B., & Silva, P. R. A. (1994). Exigências térmicas e caraterísticas agronômicas de cultivares comerciais e experimentais de girassol na depressão central do Rio Grande do Sul. *Ciência Rural*, *24*(1):55-58.

Silva, T. R. G. et al. (2021). Fatores abióticos no crescimento e florescimento das plantas. *Research, Society and Development*, *10*(4):e19710413817.

Silva, S. D. P. da. et al (2022). Morphophysiological aspects of ornamental sunflowers grown in different growing seasons under semi-arid conditions. *Revista Brasileira de Engenharia Agrícola e Ambiental*, *26*(4):299-305.

Souza, J. N. C. et al. (2020). Panorama econômico de flores e plantas ornamentais no Brasil. *Arquivos Científicos Eletrônicos*, *13*(5):96-102.

Stanck, L. T. et al. (2020). Análises fenológicas de gladíolo em diferentes condições edafoclimáticas em Santa Catarina. *Agrometeoros*, *27*(1):199-207.

Teixeira, A. H. C. (2014). Relação entre os parâmetros agrometeorológicos e a cultura da melancia. In M. F. Lima. *A cultura da melancia*. Brasília-DF, Embrapa Hortaliças, (pp.107-130).

Villalobos, F. J. et al. (1996). A development, growth, and yield model of the sunflower crop. *Agronomy Journal*, *88*:403-415.