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Article

Research trends in heliconia propagation

Tendências de pesquisa em propagação de helicônias

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Abstract
Global demand for tropical flowers requires product quality and new standards for plant propagation. Sustainable production and marketing are outstanding challenges. The objective of this study was to identify propagation trends in heliconia as an emerging crop within the global floriculture industry. To this end, a systematic search was conducted in the Web of Science, and bibliometric and textual content analysis techniques were applied using VOSviewer® and Atlas.ti® Scientific Software GmbH, respectively. The global trend in floriculture propagation focuses on acclimatization, multiplication, *in vitro* propagation, organogenesis, somatic embryogenesis, growth regulators, regeneration, callogenesis, protocorms, and Agrobacterium-mediated transformation. The *Heliconiaceae* family is an important floricultural crop in this sector. The Research publications in heliconia is recent and little explored (2000 to 2025). Twenty-two species of *Heliconia* spp. were identified. The propagation trend is plant biotechnology, which accounted for 53.03% of the total. The propagation protocols identified were direct organogenesis, somatic embryogenesis, and temporary immersion systems. The main countries conducting research in this sector are Mexico (23.1%), Cuba (19.2%), and Brazil (15.4%). Both innovations applicable to organic farming were identified: the use of coconut water for germination and explant growth as a substitute for mineral salts MS (Murashige and Skoog), and the use of coconut fiber as an acclimatization substrate. Tropical floriculture, with an emphasis on heliconia, requires research to develop more efficient and sustainable propagation methods.
Keywords: *Heliconiaceae*, micropropagation, plant biotechnology, tropical floriculture.

Resumo
A demanda global por flores tropicais exige qualidade do produto e novos padrões para a propagação de plantas. A produção e a comercialização sustentáveis são desafios significativos. O objetivo deste estudo foi identificar as tendências de propagação da helicônia como uma cultura emergente no setor global de floricultura. Para isso, foi realizada uma pesquisa sistemática na Web of Science, utilizando o VOSviewer® e o Atlas.ti® Scientific Software GmbH para aplicar técnicas de análise de conteúdo bibliométrico e textual, respectivamente. A tendência global na propagação da floricultura concentra-se na aclimatação, multiplicação, propagação *in vitro*, organogênese, embriogênese somática, reguladores de crescimento, regeneração, calogênese, protocórmios e transformação mediada por Agrobacterium. A família *Heliconiaceae* é uma importante cultura florícola neste setor. As publicações de pesquisa em helicônias são recentes e pouco exploradas (2000 a 2025). Foram identificadas 22 espécies de *Heliconia* spp., sendo a biotecnologia vegetal a tendência de propagação, com 53,03% do total. Os protocolos de propagação identificados foram: organogênese direta, embriogênese somática e sistemas de imersão temporária. Os principais países que realizam pesquisas nesse setor são México (23,1%), Cuba (19,2%) e Brasil (15,4%). Foram identificadas duas inovações aplicáveis à agricultura orgânica: o uso de água de coco para germinação e crescimento de explantes como substituto de sais minerais MS (Murashige e Skoog) e o uso de fibra de coco como substrato de aclimatação. A floricultura tropical, com ênfase em helicônias, requer pesquisas para desenvolver métodos de propagação mais eficientes e sustentáveis.
Palavras-chave: biotecnologia vegetal, floricultura tropical, *Heliconiaceae*, micropropagação.

Introduction

Ornamental plant breeding involves the science and art of breeding, propagating and maintaining plants to enhance the natural and human environment (Cardoso and Vendrame, 2022). This opens up the possibility of a floriculture trade (potted flowers, cut foliage and garden plants) that contributes substantially to the economy of various countries, from the Americas to Asia, Europe and Africa (Adebayo et al., 2020). In this segment, ornamental plants are constantly being improved through new technologies and breeding systems to provide new, high quality plant material for one of the most demanding markets in the horticulture sector (Cardoso and Vendrame, 2022).

There are conventional forms of propagation (through seeds and rhizomes) and biotechnological as plant tissue culture serves to obtain large-scale, uniform, and disease-free seedlings for commercial cultivation, as well as to develop new genotypes. Furthermore, it ensures the production of phytosanitary plants year-round in a limited space (Mahanta and Gantait, 2025).

Tropical floriculture including species such as heliconia, ginger, alpinia, zingiber, bromeliads, palms and orchids represent a new market segment compared to conventional floriculture (Paiva and Beckmann-Cavalcante, 2023). Specifically, *Heliconia* spp. are in high demand as cut flowers, potted plants and plants for garden decoration, as well as for use in the pharmaceutical industry and bioremediation (Linares-Gabriel et al., 2023; Kress et al., 2025; Linares-Gabriel et al., 2025). They are distinguished by their erect or pendulous inflorescences, which consist of shaped, textured, dyed and coloured bracts. Their post-harvest durability makes them ideal for cut flowers (Ortiz-Curiel et al., 2023).

The propagation procedures reported for heliconia can be sexual, vegetative or by biotechnological means (i.e. plant tissue culture). There are few studies that mention the most appropriate propagation protocols for each species of heliconia, and the required objectives (Linares-Gabriel et al., 2023). Therefore, it is important to systematize the global knowledge of propagation methods due to its economic importance in tropical floriculture and to the cut flower market (Linares-Gabriel et al., 2020).

The use of new technologies has provided advances in ornamental production systems. However, challenges remain, particularly with regard to sustainable production involving reduced inputs and the development of more resistant cultivars, that need to be addressed (Cardoso and Vendrame, 2022). In this sense, the research was guided by the following question: What are the current trends in heliconia propagation as an emerging crop in global floriculture?

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Materials and methods

Based on the methodology used by Linares-Gabriel et al. (2023) and Sutiharni et al. (2024), a systematized query was performed in *Web of Science* on May 8, 2025. The bibliometric search considered since 2000. Textual content analysis and bibliometric techniques were applied to analyze the selected publications, including the evaluation of publication trends over time with respect to propagation methods in floriculture globally.

First, "floriculture" was used as a keyword, and the query yielded a total of 1,252 documents of 2000 to 2025. In the results analysis, the category of "citation topics micro" was selected and the documents corresponding to "propagation" were selected with a total of 111 documents, from which the bibliometric analysis was performed using VOSviewer, to construct a text-data map to reveal clusters of cooccurrence of keywords (Chimi et al., 2025).

Second, the keyword "Tropical flowers" was used in the search, the query generated a total of 62 publications, inclusion and exclusion criteria were used; the first exclusion was based on the second keyword "heliconia", leaving a total of 32 documents (scientific articles), the second exclusion was by selection, i.e., only documents related to the propagation of heliconia were chosen. This resulted in a total of six documents.

Third, due to the absence of information, Google scholar was consulted. The search criteria were as follows: "propagation in heliconia", "any time", "sort by relevance", "any language". Of the first 10 documents (page 1 and 2) are related to the search topic. On page 3 and 4 there are 8 documents. We did not proceed to the next section due to the repetition of the documents, in addition to the fact that they had no similarity with the objective of the study. The search was deepened and explored in Research Gate, where only two documents were identified.

The search resulted in a total of 26 documents (N = 26). Scientific articles (50%), theses (30%), review articles (15.4%) and technical brochure (3.8%) were identified. Subsequently, a textual content analysis was carried out using categories of analysis (Table 1). The software Atlas ti® Scientific Software GmbH (2025) was used for this purpose.

Table 1. Categories of analysis for methodological ordering

***Heliconia* spp.**	**Identifying varieties, cultivars or hybrids of heliconias**
Countries	Identify countries conducting research on Heliconias propagation
Propagation methods	Identify the type of propagation in Heliconias: - Sexual (seeds) - Vegetative (rhizome) - Plant biotechnology (plant tissue culture, identify medium concentrations)
Temporality of publications (Years)	Start and status of publications

Results and discussion

Network visualization: propagation in floriculture

The bibliometric results show five clusters within the field of global floriculture each highlighting distinct research topics. The red cluster is central to topics such as floriculture, micropropagation, propagation, acclimatization, multiplication. The green cluster focuses on cultivation, *in vitro* propagation, plant propagation, explants, organogenesis, somatic embryogenesis, plant growth regulators.

The blue cluster deals with aspects of tissue culture includes regeneration, callogenesis and other organogenesis pathways. The violet cluster considers research related to protocorm-like bodies (PLB), ornamental plants, *Agrobacterium*-mediated transformation (Fig. 1). Recent advances in biotechnological interventions in orchids essentially contribute to the development of exotic varieties with novel traits, without forgetting the contributions of traditional breeding methods and tissue culture approaches (Tiwari et al., 2024).

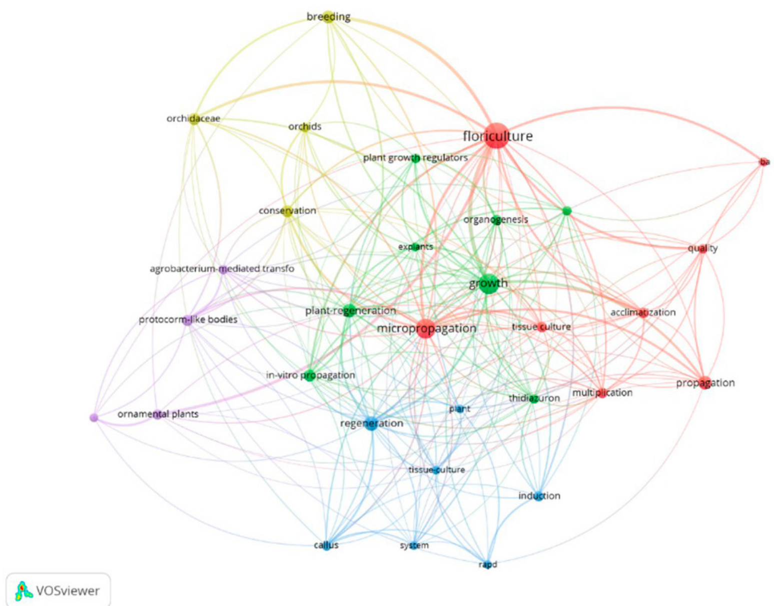

Fig. 1. Visualization of the bibliometric network based on 111 documents Web of Science in relation to floriculture.

The color clusters on the map highlight areas of interest, revealing interconnections between concepts and terms providing a comprehensive understanding (Chimi et al., 2025) for the generation of scientific knowledge in floricultural propagation, due to the expanding market for exotic flowers, which is necessary to meet the growing demand in this sector (Sarvessh et al., 2024).

The eight-year evolution period of research on propagation in floriculture is shown in its global context (Fig. 2). The blue cluster is assembled with the green cluster, including the concentration of micropropagation research in this period. For the yellow cluster, there is evidence of trends in growth regulators, organogenesis and *Agrobacterium*-mediated transformation. This suggests a more detailed exploration of these topics. To have a solid base to optimize genetic transformation methods, improve resistance and crop quality within the floricultural sector (Huang et al., 2024).

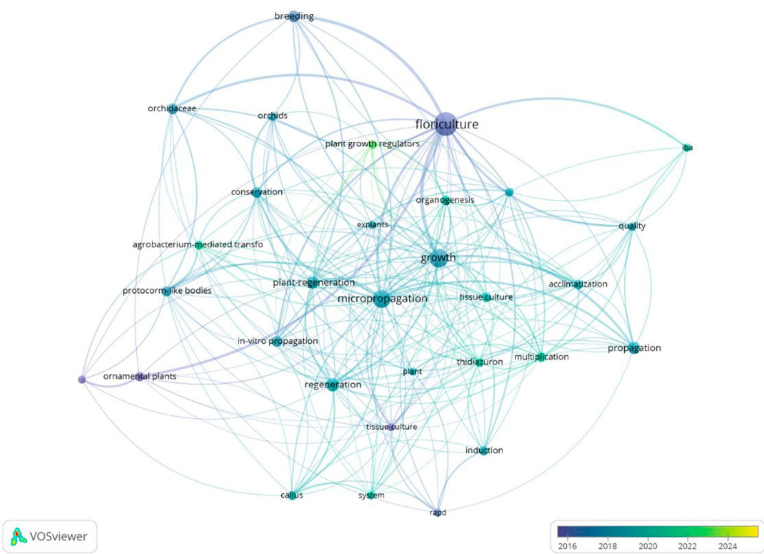

Fig. 2. Visualization of overlapping research period 2000 to 2025.

A bibliometric search on floriculture did not identify Heliconia, but rather the *Orchidaceae* family. There is clearly a lack of research on Heliconia propagation. Therefore, a scientific approach is pertinent, considering this tropical flower as an emerging crop in world floriculture. In relation to scientific contributions to propagation in floriculture worldwide. Various methods of propagating plant material were identified, with *in vitro* tissue culture being the most widely used technology for large-scale clonal multiplication and applied to various species (Villagran et al., 2024).

Heliconia spp.

Based on frequency analysis (N = 33) 22 species were identified; *H. angusta* Vell., *H. angusta* Vell. 'Flava', *H. aurantiaca* Ghiesbr. ex Lem., *H. bihai* (L.) L., *H. bihai* (L.) L. Lobster Salmón, *H. bihai* x *H. caribaea* 'Jacquinii, *H. caribaea* Lam., *H. champneiana* Griggs cv. Splash, *H. chartacea* (Lane x Barreiros) cv. Sexy Pink, *H. chartacea* Lane ex Barreiros, *H. collinsiana* Griggs, *H. curtispatha* Petersen, *H. latispatha* Benth, *H. orthotricha* L. Andersson, *H. psittacorum* L.f., *H. psittacorum* Sesse & Moc. x *H.* 'Golden Torch', *H. rostrata* Ruiz & Pav. (2), *H. standleyi* J.F. Macbr, *H. stricta* Huber 'Dwarf Jamaican', *H. wagneriana* Petersen, *H.* x 'Golden Torch' and *H. x nickeriensis* Maas & deRooij.

H. latispatha Benth, *H. collinsiana* Griggs, *H. stricta* Huber 'Dwarf Jamaican' and *H. psittacorum* L.f. are considered to have the greatest impact on research for propagation as tropical cut flowers.

The diversity of species identified, provides a guideline for future research and indicates that genetic importance may be one of the central points in the propagation of heliconia. An important opportunity is the structural uniqueness and dazzling hues of Heliconia genotypes that place it at the forefront of the global floriculture trade (Malakar et al., 2023). Given the genetic diversity of species identified (Cheng et al., 2025), it is crucial to implement sustainable practices to improve of stress-resistant and nutrient-efficient cultivars to improve production (Zhang et al., 2024).

Countries

Based on the frequency analysis (N = 26), the main countries with scientific contributions are Mexico (23.1%), followed by Cuba (19.2%), Brazil (15.4%) and Colombia (15.4%). It should be noted that this is a function of progress in scientific research. Thus, within the cut flower industry, *Heliconia spp*. covers certain market particularities at the global level; in this segment, the main producing and exporting countries of these flowers are Colombia, Costa Rica and Brazil (CBI, 2024).

The United States stands out as the partner country with the best opportunities for flower exports from Colombia. This large and demanding market offers great potential for Colombian flower exporters. In addition, other regions such as the United Arab Emirates, the European Union, Canada, and Japan are also considered to have export opportunities for Colombian flowers (Rubio et al., 2025). Brazil's role on the international stage, particularly in fields like horticulture has grown significantly in recent years. With participation of Brazilian professors and researchers in international, regional, and global events, where they present the results of their research findings and build crucial networking relationships (Paiva et al., 2023). In regional terms, there is evidence of a trend between the country with the greatest scientific contribution versus the country with the greatest export of tropical flowers.

Propagation methods

Based on the frequency analysis (N = 66), biotechnological means represent 53.03%, asexual propagation represents 34.84% and finally sexual propagation with 12.12% (Fig. 3). The above represents the advances in plant tissue culture technology, which has uplifted the floriculture industry by allowing a more efficient and cost-effective production of high-quality plant material, thus contributing to the continued growth and development of this important industry (Villagran et al., 2024).

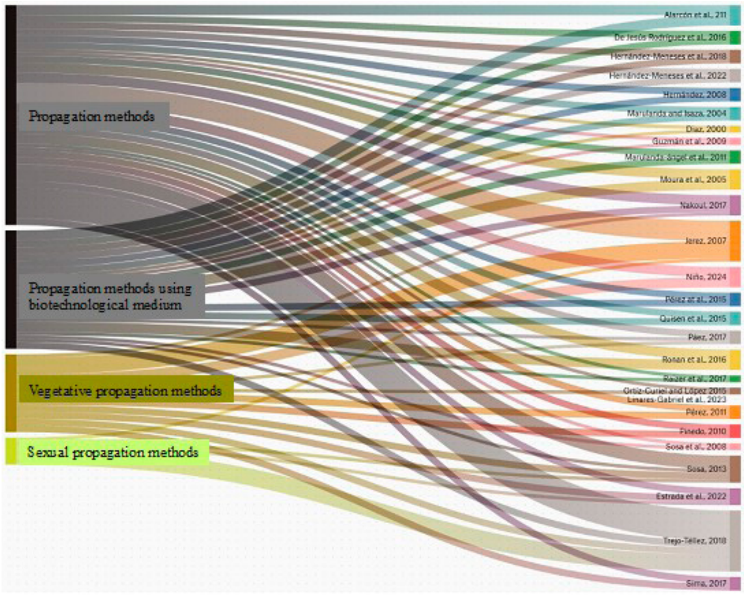

Fig. 3. Co-occurrence analysis by Sankey diagram, illustrating the strength of a relationship between codes: scientific contributions in propagation-authoring methods.

Plant biotechnology in heliconia

Biotechnological means using tissue culture techniques for *heliconia* propagation are among the most widely used methods; different protocols have been developed. For germination (Gómez-Merino et al., 2018), obtaining direct organogenesis (Hernández-Meneses et al., 2018), somatic embryogenesis (Hernández-Meneses et al., 2022) and temporary immersion systems (Rodrígues et al., 2005).

Seed germination can be one of the starting points for the micropropagation of *heliconia*; in this sense, Ortiz-Curiel et al. (2018) found that the balance of 3% sucrose and 0.2% charcoal in MS (Murashige and Skoog) medium favors 100% germination of four heliconia species and propose that it can be useful for other species. Gómez-Merino et al. (2018) suggest seed germination in sterile medium for obtaining *in vitro* seedlings, emphasizes as an essential procedure for the establishment phase, in micropropagation protocols, callus induction and cell suspension culture, or simply to obtain healthy plants.

For *in vitro* establishment, different studies have been carried out for different species, being NaClO one of the disinfectants used. Alarcón et al. (2011), evaluated in *H. curtispatha* in MS (Murashige and Skoog) semisolid and liquid culture media supplemented with cytokinin-type growth regulators. This favored heliconia propagation when liquid MS medium was used without the addition of growth regulators or when semisolid MS medium was used with the addition of 2 mg L^{-1} 6-Benzylaminopurine (BAP) 0.93 shoots $week^{-1}$.

Marulanda-Angel et al. (2011) used 1% NaClO for 20 min and reported studies on the establishment of 250 flower buds in different Heliconias. The MS establishment medium with the best results was BAP (2 mg L^{-1}), IAA (1 mg L^{-1}) and 0.1 mg L^{-1} L-cysteine. In that sense, the highest shoot production in multiplication was obtained with 6 mg L^{-1} of BAP and with a subsequent subculture on medium with 2 mg L^{-1} BAP and 0.5 mg L^{-1} IAA reaching a multiplication rate of three new buds. *In vitro* seedling rooting was achieved with 1.3 mg L^{-1} of IAA. De Jesus-Rodrigues et al. (2016), supports the combined use of BAP and NAA is beneficial for *in vitro* shoot induction in *H. latispatha*. As does Raizer et al. (2015), with addition of coconut water in the *in vitro* propagation of *Heliconia chartacea* 'Sexy Pink'.

Guzmán et al. (2009) suggest the thin cross section system "TCLs" (Thin Cells Layer) as an important tool in *in vitro* culture. In *Heliconia psittacorum* var. choconiana, thin (1 mm) thick cross sections were obtained from the pseudostem and cultured with optimal response, on Murashige and Skoog medium. It was enriched with thiamine 1 mg L^{-1}, pyridoxine 1 mg L^{-1}, nicotinic acid 1 mg L^{-1}, Myoinositol 100 mg L^{-1}, activated charcoal 0.5 g L^{-1}, 2,4-D 1 mg L^{-1}; BAP 1 mg L^{-1}; hydrolyzed casein 1 g L^{-1} and as gelling agent Gelrite 1 g L^{-1}. The findings in the induction of direct organogenesis allowed obtaining vigorous microplantlets, after eleven weeks of culture.

In vitro propagation facilitates a tremendous increase in the rate of propagation and the ability to produce disease-free plant material. Such elements, including cultivars, explant type, explant size, position of explants in the medium, plant growth regulators and certain additives, incubation conditions and subculture time, have a significant impact on *in vitro* clonal propagation of plants (Kumar et al., 2024).

One of the most sought-after morphogenetic routes for the propagation of species is somatic embryogenesis (or clonal propagation), in heliconias studies are almost null. However, through organogenesis (direct and indirect) and somatic embryogenesis, extensive propagation techniques (not only in heliconia) have been developed to create protocols leading to large-scale propagation and long-term *ex situ* and *in vitro* conservation (Balilashaki et al., 2023).

Hernández-Meneses et al. (2022) established a somatic embryogenesis protocol for *Heliconia collinsiana*. In Murashige and Skoog (MS) medium with different concentrations of 2,4-dichlofenoxyacetic acid (2,4-D) to induce callus formation. At embryo maturation and germination stages, the effect of benzyladenine (BA), abscisic acid (ABA). Callus formation occurred in darkness with 18 mg L^{-1} of 2,4-D and 0.5 g L^{-1} of activated carbon. Callus multiplication was obtained with 1 or 2 mg L^{-1} of 2,4-D and 16 hours of light. Maturation and germination of somatic embryos was observed with 0.5 mg L^{-1} of BA, and plant conversion and growth were achieved with half the salt concentration of the MS medium. On the other hand, temporary immersion systems have been successfully employed to increase species multiplication. Rodrígues et al. (2005) used BIT (Bioreactors of Temporary Immersion) temporary immersion systems successfully for multiplication, used for being a simple system in the assembly and with components of easy acquisition.

Acclimatization is one of the most important processes in plant micropropagation. Quisen et al. (2013) evaluated different substrates (Bioplant®; coconut fiber; coconut fiber + Bioplant®; coconut fiber + earthworm humus; coconut fiber + Bioplant® + earthworm humus; sand + vermiculite) and found no significant differences in seedling survival. Therefore, the proposal of Marulanda-Ángel et al. (2011), which demonstrated 92% survival rate in nursery acclimatization from flower buds. Colombo et al. (2016), also suggests that MS culture medium added with 0.5 mg L^{-1} of ANA can be used for *in vitro* propagation of the hybrid *H. bihai* x *H. caribaea* 'Jacquinii'. With this, these authors demonstrated a seedling survival rate during the acclimatization stage of 100%.

Vegetative propagation

With respect to this sub-category, it was found that vegetative propagation by division through rhizomes is preferred to obtain uniform results. For ensure the health of the rhizomes, they can be disinfected by immersion for 15 minutes in a solution of fungicides and nematicides.

Immersion in water at 45 °C for 30 to 60 minutes works, depending on the size of the rhizome and the variety. So does immersion in a 5% sodium hypochlorite (NaClO) solution at a 1:9 ratio for 10 minutes (Gómez-Merino et al., 2018). Generally, it is necessary to renew the plantation every two to three years, because the growth of this species is invasive, which causes a decrease in the production of flowers and their quality.

Sexual propagation

Heliconia seeds consist of a hard cover or testa, stored food material and an embryo. The long dormancy of seeds is because the testa is generally hard and consists of an inner and outer cuticle layer, and one or more layers of thick tissue that serves as protection. Dormancy is the state in which a viable seed does not germinate even under conditions of humidity, temperature and oxygen concentration suitable for germination. Thus, seeds can maintain their viability for long periods of time (Gómez-Merino et al., 2018).

Baltazar-Bernal et al. (2011), suggest steps for germinating Heliconia seeds: the fruits should be harvested when the color changes from orange to navy blue; the seeds are removed from the fruit, washed, and allowed to dry; in a plastic tray with sterile substrate and at field capacity moisture, the seeds are sown one centimeter deep and covered with more substrate; immediately irrigate at field capacity and cover with a transparent cover; and the trays are placed in semi-darkness and at a temperature of 30 °C to 40 °C.

Currently, several scarification methods are available, which can basically be grouped as wet (acids, alkalis, solvents, alcohols) or dry (microwave, impact, manual or mechanical removal of the testa or part of it). Of these, the most frequently used are acids, such as sulfuric or hydrochloric, and bases such as sodium hydroxide (Gómez-Merino et al., 2018).

Temporality of publications (Years)

It was found that scientific contributions began in 2000, with increasing interest in publications now (2025). Similarly, previous studies identified the period of research on heliconias from 1990 to 2020 (Linares-Gabriel et al., 2020). This temporal distribution of contributions is related to the origins of The Heliconia Society International (https://www.heliconia.org), a nonprofit corporation in the USA was formed in 1985 because of rapidly developing interest around the world in these exotic plants and their close relatives of the Zingiberales order.

The intention of considering a temporal analysis was to visualize the chronological progress in relation to the scientific contributions and commercial impact of this tropical ornamental. This contrasts with the scientific contributions in floriculture in its global context. Therefore, scientific contributions related to *heliconia* are supported by leading authors and institutions, which seek to provide alternatives for social, economic, and environmental sustainability in a complex world.

Conclusions

The bibliometric analysis revealed an emerging thematic structure in *Heliconia* propagation within the global context of floriculture. A strong interrelationship was demonstrated between traditional techniques such as micropropagation. Topics covered include micropropagation techniques and tools, acclimatization, multiplication, vegetative plant propagation, explants, organogenesis, somatic embryogenesis, plant growth regulators, regeneration, callogenesis, and protocorms.

Twenty-five cultivars of *Heliconia* spp. were identified that stand out for their ornamental value, particularly in species such as *H. latispatha, H. collinsiana, H. psittacorum*, and *H. stricta* 'Dwarf Jamaican'. Innovations applicable to organic agriculture are emerging for their production.

Vegetative propagation is the most widely used alternative due to its economic implications and adaptation time, in relation not only in relation to production but also to for the creation of germplasm banks. In contrast, sexual propagation has a low germination rate and long dormancy periods of up to three years. There is considerable scope to explore sustainable alternatives for propagation heliconia worldwide that would improve the quality and longevity of flower stems to meet commercial demand.

Finally, most the predominance of studies is conducted is based on biotechnology. There has been a sustained increase in scientific publications has been observed since 2000, with Mexico leading the way in terms of scientific production. However, countries such as Colombia, Brazil, and Costa Rica are major exporters. This highlights the opportunity to link research and commercial strategies, which could drive innovation in the production, conservation, and sustainability of the crop.

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Author Contribution

MAHC: Conceptualization, Data Curation, Formal Analysis, Writing – Review& Editing. **ALG:** Conceptualization, Data Curation, Formal Analysis, Writing – Review & Editing. **MEDM:** Validation, Visualization, Writing – Review & Editing. **GSV:** Resources, Writing – Review & Editing. **NRO:** Validation, Visualization, Writing – Review & Editing.

Conflict of Interest.

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 made available upon request to the authors.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors declare that the use of AI and AI-assisted technologies was not applied in the writing process.

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