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Diagnosis of the production chain of flowers, turfgrass, and ornamental plants: proposal for an innovation agenda

Agenda de inovação na cadeia produtiva de flores, gramas e plantas ornamentais

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Abstract: Sectoral and Thematic Chambers are forums for dialogue created by the Ministry of Agriculture and Livestock (MAPA), through which greater interaction with productive chains is sought, as well as the identification of opportunities and the definition of priority actions for developing Brazilian agriculture. The Thematic Chambers can contribute to the development of agriculture by identifying demands from the productive sector and linking them to proposals for research, development, and innovation by creating innovation agendas. For that, the analysis of productive chains and their practices allows a better understanding of agribusiness, which consequently enables the development of effective strategies to promote the growth and development of a sector. The objective of the agenda in Flower, Turfgrass, and Ornamental Plant is to present an analysis of the main problems and opportunities for innovation in the productive chains. A diagnosis of the current situation focusing on a vision for the future was required to prepare this Innovation Agenda. The methodological approach was divided and conducted through different analyses: a) Analysis of the evolution of the Flower and Ornamental Plant Market; b) Analysis of contributions, impact, and expectations of the links in the production chain; c) Mapping of human capital in Brazilian science with the potential to contribute to technological innovations for the market of flowers, grasses, and ornamental plants. The Innovation Agenda prioritizes the most relevant obstacles, establishes their level of importance, and identifies ten significant Innovation Challenges to be addressed by the public and private sectors of the country. Through the agenda, strategic actions are suggested for research, technology transfer, and public policies, which are essential for the technological development of the sector, without neglecting its socioeconomic and environmental sustainability. For each Innovation Challenge, Strategic Actions were suggested to be pursued, and Brazil has the technical competence distributed across the country, in nationally recognized universities and research institutes and enterprises.

Keywords: floriculture, innovation agenda, sustainability.

Resumo: As Câmaras Setoriais e Temáticas são fóruns de diálogo criados pelo Ministério da Agricultura e Pecuária (MAPA), por meio dos quais se busca uma maior interação com as cadeias produtivas, bem como a identificação de oportunidades e a definição de ações prioritárias para o desenvolvimento da agricultura brasileira. As Câmaras Temáticas podem contribuir para o desenvolvimento da agricultura identificando demandas do setor produtivo e vinculando-as a propostas de pesquisa, desenvolvimento e inovação, criando agendas de inovação. Para isso, a análise das cadeias produtivas e suas práticas permite uma melhor compreensão do agronegócio, o que, consequentemente, possibilita o desenvolvimento de estratégias eficazes para promover o crescimento e desenvolvimento do setor. O objetivo de uma agenda em Flores, Gramas e Plantas Ornamentais é apresentar uma análise dos principais problemas e oportunidades de inovação nas cadeias produtivas. Um diagnóstico da situação atual, focado em uma visão para o futuro, foi necessário para a construção desta Agenda de Inovação. A abordagem metodológica foi dividida e conduzida por meio de diferentes análises: a) Análise da evolução do Mercado de Flores e Plantas Ornamentais; b) Análise das contribuições, impacto e expectativas dos elos da cadeia produtiva; c) Mapeamento do capital humano na ciência brasileira com potencial para contribuir com inovações tecnológicas para o mercado de flores, gramas e plantas ornamentais. A Agenda de Inovação prioriza os obstáculos mais relevantes, estabelece seu nível de importância e identifica dez Desafios de Inovação significativos a serem abordados pelos setores público e privado do país. Por meio da agenda, ações estratégicas são sugeridas para pesquisa, transferência de tecnologia e políticas públicas, essenciais para o desenvolvimento tecnológico do setor, sem negligenciar sua sustentabilidade socioeconômica e ambiental. Para cada Desafio de Inovação, foram sugeridas Ações Estratégicas a serem perseguidas, e o Brasil possui a competência técnica distribuída por todo o país, em universidades e institutos de pesquisa e empresas reconhecidas nacionalmente.

Palavras-chave: agenda de inovação, floricultura, sustentabilidade.

Introduction

Sectoral and Thematic Chambers are forums for dialogue created by the Ministry of Agriculture and Livestock (MAPA), through which greater interaction with productive chains is sought, as well as the identification of opportunities and the definition of priority actions for the development of Brazilian agriculture (MAPA, 2009). These Chambers function as a permanent advisory board to the Minister of Agriculture for the implementation of public policies. One way in which Sectoral and Thematic Chambers can contribute to the development of agriculture is by identifying demands from the productive sector and linking them

to proposals for research, development, and innovation. This process involves the creation of innovation agendas, which promote the reduction of efforts and resource dispersion and enhance prioritization capabilities. The involvement of representatives from different sectors is fundamental for constructing these agendas, considering diverse perspectives on research, education, technology transfer, production, commercialization, and public policies, among others.

In 2011, a Strategic Agenda 2010-2015 for Flower, Turfgrass and Ornamental Plants was created with the aim of establishing a work plan for the production chain during this period, identifying the network

involved in research, development, and innovation. The result would also be important for strengthening the chambers as tools for developing public and private policies for agribusiness (MAPA, 2011).

Multiple forms of exploitation and diversity of cultivation exist among tropical and subtropical species (Paiva and Beckmann-Cavalcante, 2023), divided into cut flowers, potted flowers and plants, foliage, and seedling production for gardens and indoor plants (Landgraf and Paiva, 2007; Neves and Pinto, 2015).

The analysis of productive chains and their practices allows a better understanding of agribusiness, enabling the development of effective strategies that can promote growth (Maia et al., 2016). The stratification modeling of the Production Chain (Fig. 1) consists of Agricultural Producers supported by the Inputs industry, with consumers in domestic and export markets represented at the end.

The supplies segment includes the production of seedlings and seeds, substrates, fertilizers, chemical and biological pesticides, tools, cases and packaging, trays and boxes, structures (greenhouses and shading nets), equipment, water, and energy (Neves and Pinto, 2015).

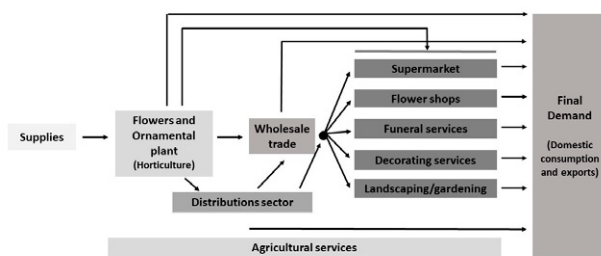


Fig. 1. Stratification of the Main Sectors constituting the Gross Domestic Product (GDP) of the Flower and Ornamental Plant Production Chain Source: (Adapted from IBRAFLO, 2022).

The state of São Paulo hosts the most important flower and ornamental plant wholesale market in Brazil, although there are supply centers in other states (Silva et al., 2015). The main wholesalers include Veiling-Holambra, Cooperflora, and CeaFlor. Other significant markets, though smaller in size, are CEAGESP-ETSP, CEASA-Campinas, CADEG (Companhia de Abastecimento e Distribuição do Estado da Guanabara), and AFLORD (Associação dos Floricultores da Região da Via Dutra). These markets demonstrate a positive history of growth and development in Brazilian floriculture.

In a study conducted by IBRAFLO/CEPEA/ESALQ/USP during the years 2022 and 2023, innovative data were presented on the Market of Flowers and Ornamental Plants in Brazil (IBRAFLO/CEPEA, 2024). This research provided a comprehensive contextualization of the significance of this sector, by addressing social, economic (including Market Share), and land use aspects. These insights are crucial for the formulation of an Innovation Agenda aimed at fostering the sector's development.

The relevance of this study aligns with the broader global initiatives set by the United Nations (UN) particularly the Sustainable Development Goals (SDGs) with a focus on ending poverty, protecting the planet, and ensuring peace and prosperity for all. Addressing environmental, political, and economic challenges, this Innovation Agenda for the flower, turfgrass, and ornamental plant market can contribute to several key SDGs, including the eradication of poverty, promotion of sustainable agriculture, improvement of health and well-being, and access to quality education. Additionally, it aligns with goals related to clean and affordable energy, decent work and economic growth, infrastructure innovation, reduction of inequalities, sustainable cities and communities, climate change action, preserving life on land and water. As the sector progresses, it is also essential to consider and address contemporary issues such as the implications of Artificial Intelligence (Cunha Neto, 2023) and the ongoing challenges posed by climate change (Paiva, 2023). These global challenges highlight the importance of international collaboration and knowledge exchange, areas where Brazil has been increasing.

Brazil's role on the international stage, particularly in fields like horticulture has grown significantly in recent years. This expansion is evidenced by the active 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. Furthermore, Brazil's commitment to international integration is demonstrated by its active membership and leadership roles within the International Society for Horticultural Science (ISHS). The Brazilian Society for Floriculture and Ornamental Plants, in collaboration with the Brazilian Society for Fruit Science and the Brazilian Association of Horticulture, holds seats on the Council, representing the nation's interests. Since 2018, Brazil has also been represented on the ISHS Board representing all of South America, an elected position. Currently, Brazil not only serves as Vice-President but also leads all initiatives under the Young Minds program (ISHS, 2024).

Given Brazil's active role in international horticulture, the pressing contemporary issues, and the need to analyze the current situation while outlining a future perspective for the growth and development of the grass, flowers, and ornamental plants sector, the Sectorial Chamber of Flowers and Ornamental Plants of MAPA (Ministry of Agriculture and Livestock) has led the creation of an innovation agenda in this segment.

This agenda aims to provide an in-depth analysis of the main problems and opportunities for innovation within the productive chains of grass, flowers, and ornamental plants. This agenda suggests strategic actions in research, technology transfer, and public policies, which are essential for the technological advancement of the sector while ensuring its socioeconomic and environmental sustainability.

Material and Methods

The preparation of an Innovation Agenda requires a diagnosis of the current situation focusing on a vision for the future. For the Agenda organization, a joint effort was made, involving representatives from different sectors, including universities and research institutes, IBRAFLO, the Brazilian Society of Floriculture and Ornamental Plants, EMBRAPA, and the Flower and Ornamental Plant Sectorial Chamber of the Ministry of Agriculture.

For the Agenda preparation, the methodological approach was divided and conducted through different analyses: a) Analysis of the evolution of the Flower and Ornamental Plant Market; b) Analysis of contributions, impact, and expectations of the links in the production chain; c) Mapping of human capital in Brazilian science with potential to contribute to technological innovations for the market of flowers, grasses, and ornamental plants.

Evolution of the Flower and Ornamental Plant Market

An analysis of the market situation in Brazil was conducted using available data from 2017 to 2023 published in articles, documents, and websites. This analysis considered GDP, cultivated areas and groups, and jobs generated.

Analysis of the contributions, impact, and expectations of the links in the production chain

To gather information, representatives from the productive sector appointed by the Sectorial Chamber of Flowers and Ornamental Plants were consulted to form a Working Group to lead the development of this agenda. This was supported by a structured questionnaire distributed online to various representatives of the productive sector (Producers, Wholesalers, Retailers). The questionnaire included several requirements, such as:

1. Identification and location of the respondent;
2. Current address and contact information;
3. Main area and branches of activity;
4. Time in the market;
5. Main activities in the chain of Flowers, Grasses, and Ornamental Plants (Production, Marketing, supply of inputs, Research and Development, Agricultural Extension, Technical assistance/consulting).
6. Respondents were asked to evaluate the current and future importance (over a 10-year horizon) using the criteria: Very Important, Important, Somewhat Important, Reasonable, and Not Important.

6.1 Based on their area of activity, respondents were asked to rate the importance of the following items: seeds, seedlings, nurseries, propagation laboratories, NCR = National Cultivar Registry; NPVPS = National Plant Variety Protection Service; TRA = Technical Responsibility Annotation

6.2 Optimizing Flower and Plant Production Technologies for Consistent Supply and Quality concerning automation, irrigation,

substrates, hydroponics, renewable energy, rainwater harvesting, climate control, protected cultivation, and shading.

6.3 Phytotechnical aspects of production and its relationship with productivity, profitability, and quality of flowers and plants regarding aspects such as fertigation, fertilizers and nutrition, composting, good production practices, quality certification, and processes.

6.4 Occurrence of pests and diseases, considering the current and future situation, for aspects such as Integrated pest and disease management, Expansion of registered product quality, Pesticide application technology, Laboratory analysis, Rational use of products, and streamlining the pesticide registration process.

6.5 Legislation and structuring of the flowers and plants sector, current and future for aspects such as professionalization, Agricultural Extension, Family farming, Cooperativism, Economy, and Marketing.

7. Other comments.

The survey was distributed via email to representatives across the production chain, including producers, wholesalers, and retailers. Additionally, a link to the survey was shared on social media. Invitations to participate in the survey were also made available on various websites and social media platforms.

Mapping of human capital in Brazilian science with the potential to contribute to technological innovations for the market of flowers, grasses, and ornamental plants

Responding to a demand from the Sectoral Chamber of the Ministry of Agriculture in 2022, the Brazilian Society of Flowers and Ornamental Plants (SBFPO) conducted a survey of professional staff within ICTs (Institutes of Science and Technology) and Brazilian academia, with the potential to contribute to the generation of knowledge, technologies, products, and services to enhance the innovation capacity of this market in Brazil. This initiative served as a starting point, although it was noted that some active professionals did not respond to the survey. The mapping was carried out by analyzing SBFPO membership records, searching on the Lattes Curriculum Platform, contacting universities, and exploring professional networks like LinkedIn and the websites of universities and research institutions, totaling 105 professionals, from all regions.

The professors and researchers were organized by state/region and type of institutions with which they are affiliated.

Results and Discussion

The analysis of the evolution of the Flowers and Ornamental Plants Market in Brazil was based on data collected from specialized agencies and institutions. Over the past 7 years, the Flower and Ornamental Plant Sector in Brazil has doubled its revenue, growing from 10 billion Brazilian reais in 2017 to approximately 20 billion reais in 2023. During this period, from 2020 to 2022, Brazil faced a National Health Emergency due to the Covid Pandemic, and the flower market in Brazil reached its peak growth, especially in 2021, when its financial value surged from R\$ 11.9 billion in 2020 to R\$ 15.7 billion, a 32% increase (Fig. 2). Despite this exceptional growth persisting, albeit to a lesser extent, until 2022, where growth still recorded 17% compared to the previous year. Looking ahead, there is a potential for average annual growth of 7% to 8% for the Flower and Ornamental Plant Market in Brazil (IBRAFLOR/CEPEA, 2024).

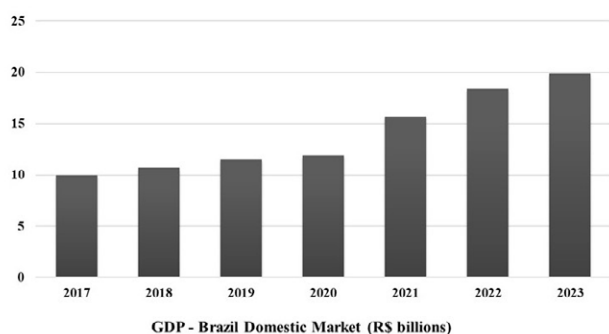


Fig. 2. Evolution of the Flower and Ornamental Plant Market in Brazil from 2017 to 2023. Source: (IBRAFLOR/CEPEA, 2024).

As a reference, the global market for Flowers and Ornamental Plants reached US\$ 24.1 billion in 2022. In this market, Brazil does not appear among the exporting countries, but in 2022, it imported products worth US\$41.8 million, accounting for 0.17% of the global total, mainly sourced from the Netherlands (71.6%) (OEC, 2024).

During the pandemic years, e-commerce through social media (WhatsApp) and Instagram was the most frequent method used to restart sales. To face the crisis, actions such as offering discounts on purchases, providing free delivery, and marketing in neighborhoods were also implemented. The governance model led by retail trade could result in a recovery plan and guide both consumers and producers, promoting the continuity of flows and ensuring that the sector continues to maintain jobs, besides providing effective income for thousands of people in Brazil (Anacleto et al., 2021).

Currently, the Brazilian market involves 8.300 producers, utilizing only 15,600 hectares of land, and generating 8 direct jobs per hectare (IBRAFLOR/CEPEA, 2024) (Table 1). This demonstrates the significant social impact of this activity, not only contributing to job creation but also to labor retention.

Table 1. Estimation of numerical and financial values of factors contributing to the GDP of the Flower and Ornamental Plant Market Sector in Brazil (IBRAFLOR, 2022 and IBRAFLOR/CEPEA, 2024).

Flower and Ornamental Plant Sector 2023	Brazil	São Paulo
Market Size – GDP (R\$ billions)	19,872,000,000.00	7,885,209,600.00
Population (millions)	203,080,756	45,140,000
Per capita consumption (R\$)	97.89	174.68
Number of producers	8,300	4,200
Cultivated area (ha)	15,600	8,160
Average production area size (ha)	1.88	2.05
Direct jobs per hectare	8	8
Total workforce involved	272,000	127,495
Number of species produced	2,500	2,500
Number of varieties/cultivars produced	17,500	17,500
Number of wholesale centers	60	25
Number of wholesale companies	680	480
Number of retail points of sale	25,000	8,000
Number of fairs/exhibitions	35	15

The Flower and Ornamental Plant Sector generates over 272,000 direct jobs (Table 2), which corresponds to 1.17% of Brazilian agribusiness employment, according to IBRAFLOR/CEPEA (2024) and IBRAFLOR (2022), along with 800.000 indirect jobs. It is the agricultural sector that employs the most women, accounting for 48% of the total workforce, and in some locations, this number reaches 63%. It is also important to consider the seasonality of labor demand, as production tends to increase around significant holidays (Franco et al., 2023).

Table 2. Contributions of different Brazilian regions to the Flower and Ornamental Plant market in 2023.

Flower and Ornamental Plant production chain region	Number of Producers	Production area (ha)	Jobs	GPD (R\$)
Southeast	5,637	9,707	152,539	12,718,080,000.00
South	1,021	2,589	62,059	3,576,960,000.00
Northeast	857	1,772	32,640	1,848,096,000.00
Midwest	343	701	14,688	1,331,424,000.00
North	442	831	10,074	397,440,000.00
Total	8,300	15,600	272,000	19,872,000,000.00

The majority of these jobs are in retail, which employs 54% of the workforce with 146,000 employees, followed by agricultural production, which accounts for 39% with 105,980 employees (Fig. 3).

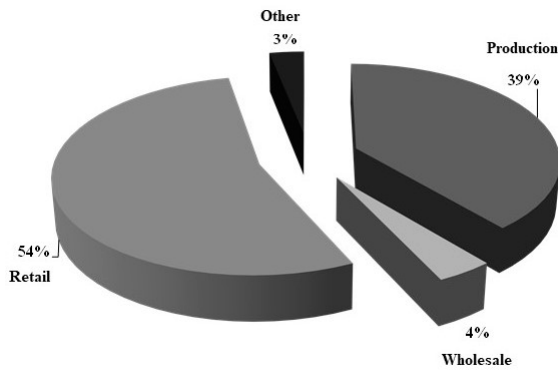


Fig. 3. Workforce segmentation in the production chain, considering a total of 272,000 direct jobs. Source: IBRAFLOR/CEPEA (2024).

It is important to highlight the importance of the Southeast region in the National GDP of the Flower and Ornamental Plant Market (Table 2). However, the significant role of the state of São Paulo in this sector should be emphasized, contributing 40% to the National GDP (IBRAFLOR/CEPEA, 2024). São Paulo utilizes just over half of the cultivated area with flowers and ornamental plants in the country (8,160 hectares) and employs 46% of the total sector workforce (Table 1). In São Paulo, 70% of wholesale companies are located, which certainly drives the annual per capita consumption to nearly R\$ 175.00, 77% higher than the national average of R\$ 98.00 (IBRAFLOR/CEPEA, 2024). Despite the greater development of the sector in the Southeast region, government actions driven by the strategies defined in the Innovation Agenda could play a significant role in expanding floriculture agribusiness into less active regions of the country. The Innovation Agenda provides a detailed diagnosis of the sector, highlights regional differences, and can stimulate and support the creation of public policies that promote the sector's growth across various regions.

Additionally, 17,500 varieties/cultivars of flowers and ornamental plants available in the market were identified (Table 1), positioning this sector in an indisputable leadership role in contributing to species diversity and products among all agricultural production chains in Brazil (IBRAFLOR/CEPEA, 2024).

Further exploration of cultivated areas by production segment (Fig. 4) reveals that potted flowers and foliage production lead with 58% of the occupied area, followed by ornamental plants occupying 24% of cultivated areas. Surprisingly, cut flowers and foliage occupy only 15% of the utilized areas.

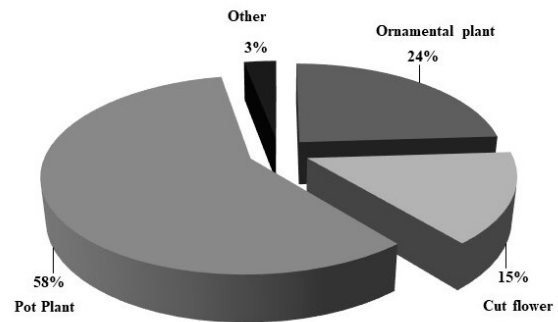


Fig. 4. Cultivation area occupation according to segmentation of the production of Flowers and Ornamental plants in Brazil. Source: IBRAFLOR/CEPEA (2024).

Analysis of contributions, impacts, and expectations of the production chain links

In organizing issues and initiatives for the construction of the Innovation Agenda, a methodological approach was employed to gather contributions from segments of the Production Chain (producers, wholesalers, and retailers), enabling the identification of key challenges or opportunities. These were identified as Innovation Challenges, requiring solutions and enhancements to promote greater technological advancement in the sector. These Innovation Challenges necessitate strategic actions at their most operational level, to be executed by Research and Technology Transfer areas linked to Academia and ICTs (Institutes of Science and Technology), supported by well-defined Public Policies, and consistent stimulation and monitoring from the Private Sector.

According to the analysis of the questionnaire results, based on answers by respondents from all regions of the country, the main obstacles identified by members of the Sector Chamber of Flowers and Ornamental Plants were organized and stratified into six groups: 1. Genetics, 2. Production Systems 1, 3. Production Systems 2, 4. Phytosanitary, 5. Post-Harvest, and 6. Production Chain Organization.

In the cultivation of flowers, grasses, and ornamental plants, basic inputs such as seeds and seedlings are used, where all innovation must be applied. This inherently requires greater efficiency and high-quality genetic diversity for the expansion of stable markets, including the use of native species from different ecosystems (Castro et al., 2022). Thus, Innovation should empower the Sector and serve as a facilitator in continuous processes that ensure the Genetic and Sanitary Quality of products destined for consumers. This includes elements such as Pest Risk Analysis (ARP), National Cultivar Registration (RNC), and National

Service for Cultivar Protection (SNPC), which are essential components for the credibility of this production chain.

In Production Systems 1 and 2, efforts should focus on management and production technologies, where innovation should seek operational advantages, consistency in supply, and quality of flowers, grasses, and ornamental plants. In the area of Phytosanitary concerns, challenges involve the need for agility in diagnosis, monitoring, and the adoption of technologies for pest and disease control, which can limit crop growth. The sector aims to ensure that flowers, grasses, and ornamental plants

reach consumers with high quality and efficiency, providing satisfactory experiences through continuous improvement, particularly in pre- and post-production aspects, including post-harvest processes. Lastly, through innovation, driving public policies in legislation, commercialization, and business structuring related to flowers, grasses, and ornamental plants could bring stability to the sector, provided these innovations are cooperatively implemented and well-organized. Respondents rated all obstacles and/or priorities identified by the Sector Chamber of Flowers and Ornamental Plants as listed in Table 3.

Table 3. Prioritized areas and stratifications of components that most influence the Production Chain of Flowers, Grasses, and Ornamental Plant.

Genetic	Production System 1	Production System 2	Phytosanitary	Postharvest	Organization
Seedlings	Automation	Fertigation	Integrated pest and disease management	Packaging	Professionalization
Seed	Irrigation	Fertilizers and Nutrition	Expansion in the number of Registered Products	Preservative solutions	Cooperativism
Nursery	Substrates	Good Agricultural Practices	Application technologies for pesticides	Transportation technologies	Economy
Laboratories	Hydropony	Quality and Process Certification	Rational use of products	Storage technologies	Commercialization
Propagation	Renewable energy		Streamlining the pesticide registration process	Standardization	
*TRA	Rainwater harvest			Exports	
**NCR	Climatization			Postharvest and conservation	
*** NPVPS	Protected cultivation				
	Greenhouses and shade houses				

Note: The items in bold are arranged in the random order in which they appeared in the survey, without implying any order of importance.

* TRA = Technical Responsibility Annotation; **NCR – National Cultivar Registry; ** NPVPS = National Plant Variety Protection Service

Mapping of human capital in Brazilian science with the potential to contribute to technological innovations in the market of flowers, grasses, and ornamental plants

The survey identified 105 qualified professionals in Brazil, distributed across 16 states, contributing to teaching and/or research in the field of Flowers and Ornamental Plants. São Paulo stands out with 20 professionals working in the sector, followed by Minas Gerais with 17, and Rio Grande do Sul with 15. It was observed that 66% of these researchers and/or academics are concentrated in the Southeast (42 professionals) and South (28 professionals) regions of the country, where the majority of the productive potential of Flowers and Ornamental Plants in Brazil is also located (Fig. 5).

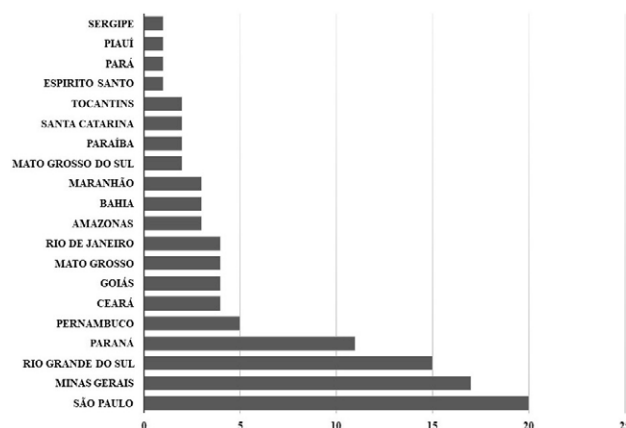


Fig. 5. Professionals with potential contributions to innovation in the market of Flowers and Ornamental Plants per state.

The majority of professionals, accounting for 84%, work in higher education institutions, while only 16% work in research institutes (Fig. 6). This data is relevant as it demonstrates that institutes dedicated exclusively to research have limited participation in the development of technologies and innovations for the sector. Finally, the numerical survey reveals that the intellectual capacity available in Brazil for innovation in the sector of Flower and Ornamental Plant is predominantly female, representing 63% of professionals.

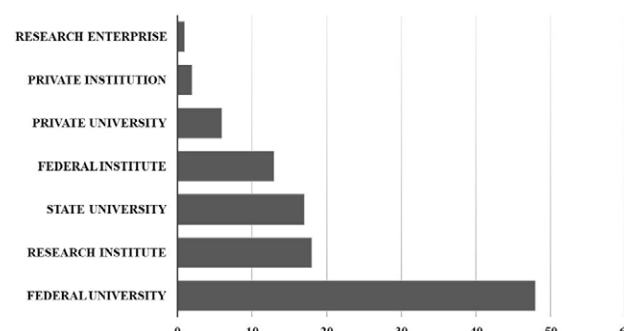


Fig. 6. Professionals distribution per educational and research institutions in Brazil

These origin stratifications are crucial for visualizing intellectual competencies in the science of this sector in the country. Furthermore, they are important for guiding public policies focused on innovation and funding, justifying both the need and feasibility of these initiatives.

The survey conducted by SBFPO allowed the identification of areas of intellectual expertise in their respective fields of knowledge (Table 4).

Table 4. Technical competencies of researchers in Flowers and Ornamental Plants in Brazil as reported by respondents.

	Technical competencies	
Botany	Taxonomy and floristics	
	Botanical identification and classification	
	Studies with orchids	
	Assessment and studies on the potential of native plants	
Plant Genetic and Breeding	Genetic resources of native ornamental plant	
	Genetic Improvement of Flowers, Ornamental plants and grasses	
	Prospecting of New species and cultivars	
	Genetic similarity analysis of species	
Socio-economy	Economics and marketing	
	Socio-economic studies of production chain segments	
	Estudos de distribuição espacial das cadeias produtivas	
	Social organization	
	Analysis of marketing and export of flowers and ornamental plants	
Plant physiology and biotechnology	In vitro propagation	
	Plant growth regulators	
	Postharvest physiology	
	Production physiology	
	Flowering physiology and control	
	Species adaptation to different environments and production systems	
Phytosanitary	Use of light and renewable energy	
	Biological control	
	General phytopathology, diagnosis, and control of diseases (fungal, viral, and bacterial)	
	Post-harvest diseases	
	Pest identification	
Phytotechny	Integrated pest management	
	Plant Nutrition	
	Hydroponic systems	
	Protected cultivation	
	Substrates	
	Ornamental Plants and Flowers (Production and Management)	
	Turfgrass (Production and Management)	
	Tropical Ornamental Plants (Production and Management)	
	Native Plants (Production and Management)	
	Landscaping and Gardening	
	Medicinal/Herbaceous Plants for Ornamental Use	
	Ornamental plant seed technology	
	Irrigation	Water management in agricultural systems
		Evaluation of irrigation in protected cultivations
Modeling applied to irrigated agriculture		
Fertigation		

Analysis of prospects conducted with components of the ornamental flowers and plants production chain in Brazil.

The Prospection carried out by the Sector Chamber of Ornamental Flowers and Plants obtained responses from all geographical regions of Brazil, with nearly 90% originating from the Southeast (66.9%) and South (22.9%) regions, where the largest number of participants in this production chain is concentrated. The remaining responses came from other regions: Central-West (6%), Northeast (3.6%), and North (0.6%). In terms of states, São Paulo contributed 55.4% of the respondents, followed by Santa Catarina with 16.9% of respondents (Fig. 7). Significant contributions also came from the states of Minas Gerais (10%), Espírito Santo (7%), and Rio Grande do Sul (7%). In total, 16 Brazilian states participated in the research conducted by the Sector Chamber.

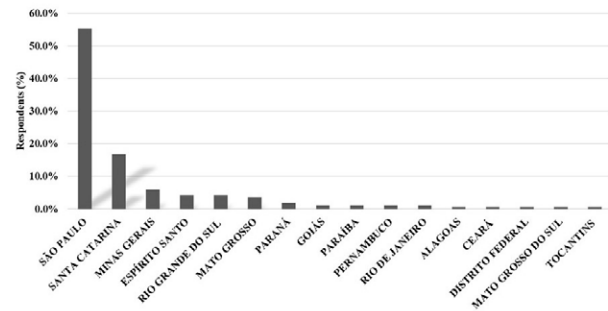


Fig. 7. Respondents (%) per Brazilian state who contributed information to the construction of the Innovation Agenda of Flowers, Turfgrass, and Ornamental Plant.

The majority of respondents in the chain (66.1%) work directly in the Production area, and 16.7% are from the Ornamental Flowers and Plants Marketing sector. Also contributing, to a lesser extent, were representatives from Technical Assistance/Consulting (7.5%), Research and Development (5.7%), Agricultural Extension (3.1%), and Supply of Inputs (0.9%).

In the segmentation of the Production Chain, 35.9% of the contributions came from the Ornamental Plants sector, followed by Cut Flowers (22.4%), Potted Plants (14.8%), and Turfgrass (12.8%), in addition to Others (14.8%).

Finally, among the respondents, it was found that 61% have more than 20 years of experience in the sector, indicating the level of maturity of stakeholders in the Ornamental Plant, Turfgrass, and Flowers Production Chain who contributed to the construction of this Innovation Agenda (Fig. 8).

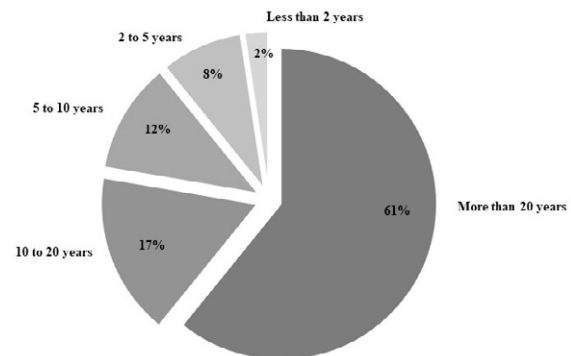


Fig. 8. Length of experience in the production chain of flowers, turfgrass, and ornamental plants of respondents.

The analysis focused on prioritized areas and their stratifications within the Flowers, Turfgrass, and Ornamental Plants Sector regarding the need for innovation in the production chain. Stakeholders and other participants in the sector established the current importance levels for the year 2023 and their future perspectives over a 10-year interval (up to 2032), with a focus on the necessity of innovations for the sector's

socio-economic and productive sustainability. Key stakeholders include producers, cooperatives and associations, distributors and wholesalers, retailers, exporters, suppliers of inputs such as seeds, fertilizers, and irrigation systems; and logistics companies, research institutions, government agencies, and end consumers.

The first area analyzed encompasses the foundation of the entire production system, where the quality and diversity of species are fundamental for the agricultural business's sustainability and longevity.

Continuous innovation in seedlings and seeds is crucial over the next decade, although there is a clear increase in the importance of innovating in propagation methods and establishing Laboratories and Nurseries. Notably, within this grouping, the high importance placed on Pest Risk Analysis, Cultivar Registration, and Protection underscores the sector's future vision, indicating a growing awareness of the importance of complying with legal frameworks and the need for their enhancement (Fig. 9).

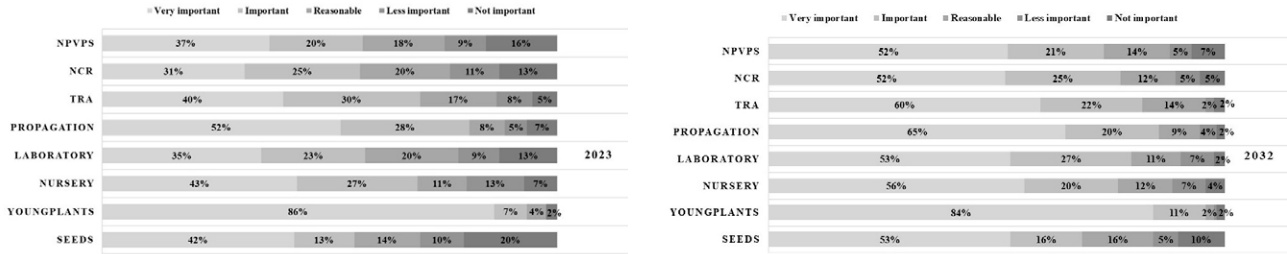


Fig. 9. Expectations of the Production Chain regarding the importance of segments related to the Genetics of Flowers, Turfgrass, and Ornamental Plants over 10 years (2023 to 2032). NCR = National Cultivar Registry; NPVPS = National Plant Variety Protection Service; TRA = Technical Responsibility Annotation

The second area analyzed comprises nine priority segments slated to receive innovation over the next ten years. Among them, Greenhouses and Shade houses, Protected Cultivation, Rainwater Harvesting, Substrates, and Irrigation were identified as focal points requiring continuous innovation, both presently and in the future. Meanwhile, Climate Control, Renewable Energy, Hydroponics, and Automation,

currently deemed less critical, are projected to double in importance within the next decade, according to research, aimed at maintaining sector competitiveness. Therefore, these areas are prime candidates for substantial investments in innovation to meet future demand and foster competitiveness and development within the turfgrass, flowers, and ornamental plants production chain (Fig. 10).

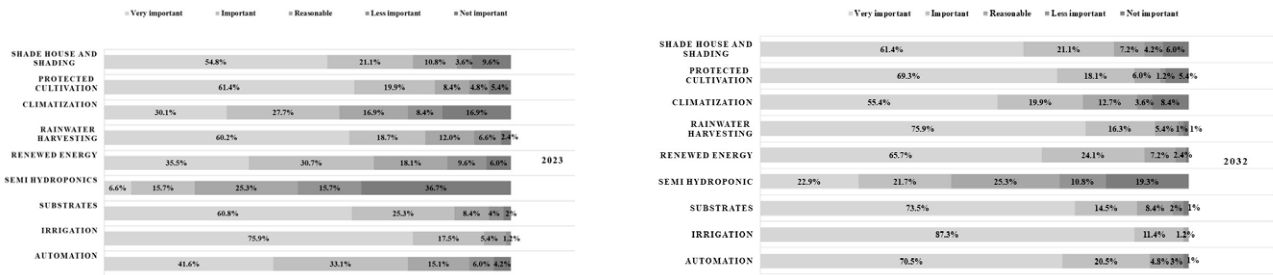


Fig. 10. Expectations of the Supply Chain regarding the importance of segments related to the Production Systems of Flowers, Turfgrass, and Ornamental Plants over 10 years (2023 to 2032).

Five other segments, grouped under area Production Systems 2, have also been prioritized for their importance assessment over the next ten years. Composting has shown a clear decrease in relevance, suggesting that current technological levels are satisfactory for the production chain. Good agricultural practices, mineral nutrition, and fertigation remain highly important, always requiring continuous innovation for sector

sustainability. Quality and process certification is the segment expected to advance the most in the coming years, demanding innovation efforts for enhancement. This segment proves to have the greatest impact on the sector's future outlook. Advancing in this area is crucial for expanding markets in a sustainable manner (Fig. 11).

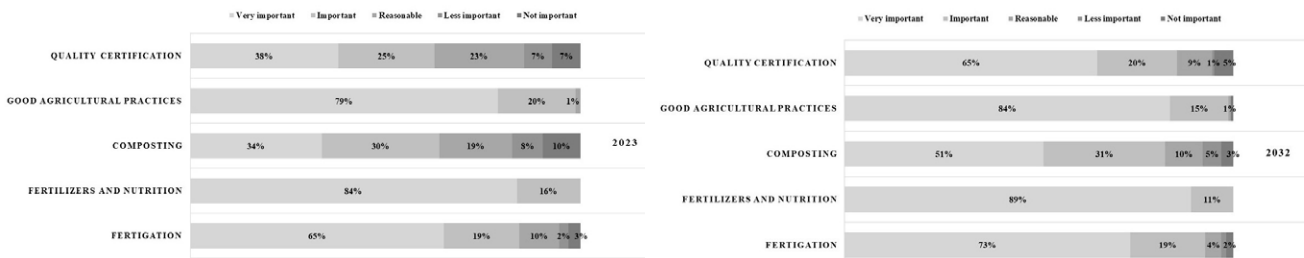


Fig. 11. Expectations of stakeholders in the production chain regarding the importance of segments related to the phytotechnical aspects of Flowers, Turfgrass, and Ornamental Plants Production over 10 years (2023 to 2032).

The fifth area analyzed was phytosanitary measures, which reached the highest average importance level in this survey, deemed very important by over 74% of respondents. Particularly noteworthy is Integrated Pest and Disease Management, where innovation is deemed

necessary by nearly 82% of stakeholders. Additionally, innovations in application technologies, rational use of pesticides, expansion, and expedited registration of new products are consistently on the radar of this production chain, characterized as of significant importance (Fig. 12).

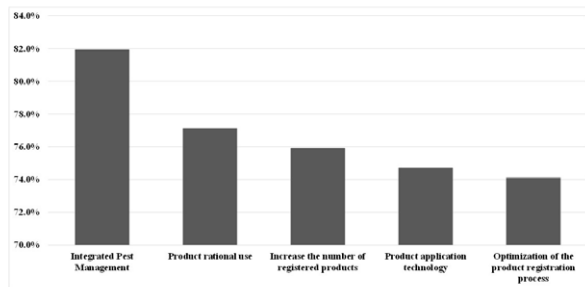


Fig. 12. Expectations of stakeholders in the Flowers, Turfgrass, and Ornamental Plants production chain regarding the importance of segments related to phytosanitary measures.

In the postharvest area, innovation was considered of great importance both for the present and the future, especially in segments such as standardization, storage, and transportation technologies, as well

as preservation and packaging techniques for flower and ornamental plant products. These innovations aim to extend the shelf life of the products and facilitate their commercialization (Fig. 13).

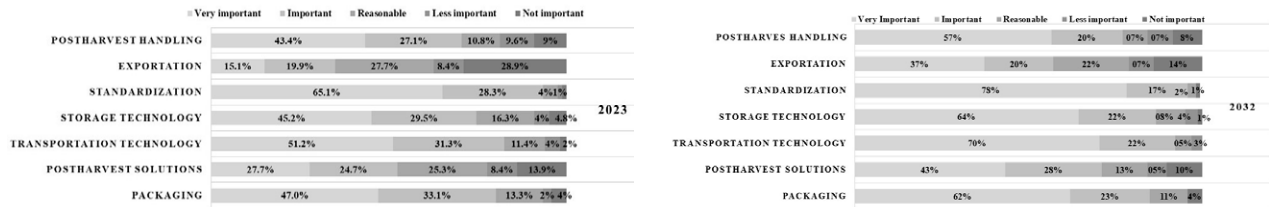


Fig. 13. Expectations of the supply chain regarding the importance of segments related to post-harvest standards in the flowers, turfgrass, and ornamental plants industry over 10 years (2023 to 2032).

However, it is important to highlight that commercialization is indeed the most relevant factor for investments in innovation within organizational processes (Fig. 14). Additionally, the expansion of professionalization,

cooperativism, and the economics of flowers and ornamental plant production in Brazil has been prioritized with high importance, both for the current realities and the future.

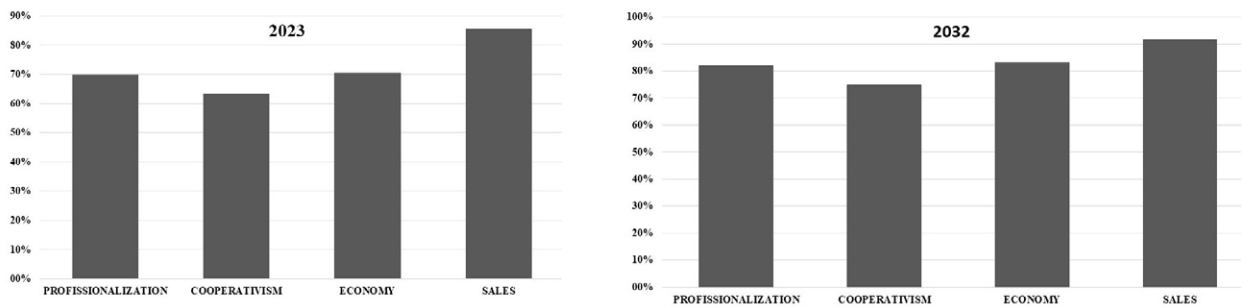


Fig. 14. Expectations of stakeholders in the production chain regarding the importance of segments related to the organizational standards of the flowers, turfgrass, and ornamental plants sector over 10 years (2023 to 2032).

Proposal of Innovation Challenges and Action Strategies

The systematization and analysis of sector data have enabled the identification of its demands, limitations, and capacities. This process also allowed for a clear identification of the needs and challenges within the production chain, which will henceforth be referred to as Innovation

Challenges. These challenges should be closely aligned with the UN Sustainable Development Goals (SDGs).

Ten Innovation Challenges were prioritized, and for each, the main strategic actions were outlined. If undertaken, these actions could positively impact the technological transformations the sector needs to achieve (Table 5).

Table 5. Suggested Strategic Actions

Innovation Challenges I	
To expand the diversity of genetic materials of flowers, turfgrass, and ornamental plants in the Brazilian market	I.1 Promote research lines for genetic improvement of flowers, turfgrass, and ornamental plants for different production systems.
	I.2 Conduct studies to adapt improved varieties to different cultivation systems.
	I.3 Develop methodologies for on-farm seed conservation by rural producers and long-term conservation.
	I.4 Prospect and validate genetic materials already available in different regions of the country, aiming for resilience and adaptation to climate change.
	I.5 Conduct surveys and promote the exchange of existing genetic material.
	I.6 Integrate agroecological practices in the cultivation of flowers, turfgrass, and ornamental plants to promote sustainability.
	I.7 Evaluate the behavior and identify new resilient species/varieties adapted to the challenges of climate change.
Innovation Challenges II	
Expand the supply and enhance the sanitary and physiological quality of seedlings and seeds of flowers, turfgrass, and ornamental plants.	II.1 Promote the organization of seed fairs in different production regions.
	II.2 Strengthen and encourage better structuring and modernization of public and private seed banks relevant to the Flower, Turfgrass, and Ornamental Plant Industry.
	II.3 Develop innovative technological processes for asepsis and cleaning to produce seedlings free from systemic and non-systemic diseases and pests.
	II.4 Develop innovative techniques for tissue culture seedling production that can be scaled up.
Innovation Challenges III	
Modernize and streamline both protected and unprotected cultivation systems for the production of flowers, turfgrass, and ornamental plants, aiming for greater sustainability and lower CO2 emissions into the atmosphere.	III.1 Promote the development of agricultural practices through automated and digitally monitored systems, by Precision Horticulture.
	III.2 Develop innovative irrigation and climate control systems that promote greater water savings, higher wetting efficiency, and environmental control in conventional and/or hydroponic production environments in protected areas and/or under shade structures and greenhouses.
	III.3 Encourage the improvement and/or adaptation of technologies for rainwater harvesting associated with the production systems of flowers, turfgrass, and ornamental plants.
	III.4 Modernize technologies for the preparation and use of agroecological and sustainable substrates.
	III.5 Promote the development of sustainable agricultural practices, prioritizing the use of renewable energies and aiming to reduce CO2 emissions.
	III.6 Promote professional training, including the use of artificial intelligence as a practice to make production systems efficient at a high technological level.
Innovation Challenges IV	
Promote the development and use of new sources of nutrients in a sustainable manner to reduce CO2 emissions into the atmosphere, as well as their adaptation to new application processes that increase use efficiency and reduce costs.	IV.1 Test new mineral sources to expand the diversity in fertilization and plant nutrition with lower effective costs, which also promotes the reduction of fertilizer imports and enhances sustainability.
	IV.2 Develop monitored fertigation systems that use embedded artificial intelligence to achieve greater use efficiency, reduced environmental contamination, and cost savings in application.
	IV.3 Develop efficient and economical nanocomposite products with controlled release for use as fertilizers in agricultural production systems.
	IV.4 Implement the use of organic nutrient sources, connecting them with agroecological practices, to improve the sustainability of production systems.
	IV.5 Promote professional training and encourage technological innovation to identify practices in production systems that contribute to sustainability and the reduction of gas emissions.
Innovation Challenges V	
Expand and encourage the adoption of Good Agricultural Practices in the production of flowers, turfgrass, and ornamental plants, promoting the certification of quality processes adopted.	V.1 Promote the adoption of digital recording techniques for monitoring and controlling the agricultural practices adopted (digitized field notebook) with the aid of Precision Horticulture and Artificial Intelligence.
	V.2 Establish minimum quality criteria for the development of metrics to monitor Good Agricultural Practices and the adoption of self-regulation.
	V.3 Develop models for the creation of Quality Seals to certify the quality of sustainable agricultural processes adopted.
	V.4 Identify and validate globally recognized sustainable technologies that promote the adoption of low-carbon agriculture applicable to the flower, turfgrass, and ornamental plant sectors.

Innovation Challenges VI	
Promote the rational use of pesticides with the adoption of Integrated Pest and Disease Management and innovative technologies for product application.	VI.1 Develop processes and techniques for monitoring pests and diseases using traps, photo-sensing, drones, digital instrumentation records, and Precision Horticulture.
	VI.2 Improve application techniques for bioproducts and synthetic products through irrigation or spraying by drones or other innovative systems in both protected and unprotected cultivation of flowers, turfgrass, and ornamental plants.
	VI.3 Calibrate models and algorithms of epidemiological data to establish tolerance thresholds for pest or disease damage levels in plants, guiding the optimal times for control (Precision Agriculture and Control).
	VI.4 Integrate biological control practices and promote the organic production of flowers, turfgrass, and ornamental plants, aiming for sustainability and environmental health.
	VI.5 Conduct professional training to qualify individuals in the implementation of practices that contribute to the sustainability of production systems.
Innovation Challenges VII	
Expansion of product diversity and streamlining of the pesticide registration process for the market of flowers, turfgrass, and ornamental plants.	VII.1 Establish a national network for testing synthetic products for the control of relevant pests in protected cultivation, to be conducted by leading ICTs (Institutes of Science and Technology), in the country to expedite legal registration with relevant authorities.
	VII.2 Establish a national network for testing synthetic products for the control of diseases causing significant damage in protected cultivation, to be conducted by leading ICTs, to expedite legal registration.
	VII.3 Form a Technical Group of Notable Scientists to provide opinions supported by technical analysis of similarity for the registration of products aimed at minor crops, focusing on the flower, turfgrass, and ornamental plant industry.
	VII.4 Promote practices connected with Agroecology and Regenerative Agriculture.
Innovation Challenges VIII	
Expand the availability of commercial bioinputs and promote the development of technologies, on-farm use, and manufacturing adapted to the production chains of ornamental products in Brazil.	VIII.1 Develop new equipment and evaluate existing equipment for the production of bioinputs suitable for small and medium-sized producers.
	VIII.2 Enable new biological inputs, agricultural practices, and processes that promote plant growth, phytosanitary management, ecological balance, and sustainability of protected cultivation systems.
	VIII.3 Expand the availability of biofertilizers for use in hydroponic systems and fertigation.
	VIII.4 Create models to establish sustainability seals and/or public policies that incentivize the production and commercialization of bioinputs, especially for family farmers and small rural producers in protected cultivation systems.
	VIII.5 Expand the distribution of bioinput biofactories across the country through technological support and incentives for producers.
	VIII.6 Promote the expansion of conservation biological control of pests and diseases in protected cultivation systems with innovative technologies.
	VIII.7 Develop methodological procedures for on-farm production of bioinputs for phytosanitary management.
Innovation Challenges IX	
Promote the development of new post-harvest standardization processes and technologies, extending the shelf life of ornamental agricultural products for storage, transportation, and commercialization in domestic and export markets.	IX.1 To generate technologies for standardizing harvesting and preservation processes without significant damage, reducing losses during transportation, and ensuring product availability on store shelves.
	IX.2 Development of sustainable polymeric films, using innovative nanotechnology techniques for coating cut flowers, increasing their storage, transportation, and shelf life, thereby enhancing the competitiveness of the sector in expanding and consolidating export markets.
	IX.3 Development of synthetic or biological products to protect cut flowers, ensuring protection against post-harvest pests and diseases

Innovation Challenges X	
Strategies that contribute to cost reduction and increased dynamism in the marketing of products offered in the market of flowers, turfgrass, and ornamental plants.	X.1 Map and systematize successful experiences in digital marketing, logistics, and the use of artificial intelligence.
	X.2 Conduct an in-depth study on production costs in the main supply chains of flowers, turfgrass, and ornamental plants.
	X.3 Generate knowledge about product pricing formation and create an information base on price dynamics throughout the life cycle of each species.
	X.4 Promote professional training and facilitate producer access to new marketing channels integrating the use of artificial intelligence.
	X.5 Promote technology transfer processes, such as field days, to demonstrate techniques that promote cost reduction and incremental productivity in production systems.
	X.6 Conduct surveys on consumer satisfaction regarding the acquisition of ornamental products, aiming to identify bottlenecks that require solutions to increase consumption.
	X.7 Develop and manage a collaborative and interactive knowledge management platform for the ornamental sector, utilizing a previously developed database that includes production data, trade shows, producer locations, and other relevant information.
	X.8 Conduct an integrated study of the supply chains of flowers, turfgrass, and ornamental plants to identify common bottlenecks and potential solutions, focusing on improving producer income.
	X.9 Conduct socio-economic studies or impact assessments focusing on the production systems of flowers and ornamental plants to promote technological innovation within the sector.
	X.10 Conduct socio-economic studies integrating national production with global data to promote the integration and globalization of the production system.

Conclusions

The Innovation Agenda in Flowers, Turfgrass, and Ornamental Plants was an initiative by the Sector Chamber of Flowers and Ornamental Plants of MAPA, built with the collaboration of approximately 180 professionals working in various components of the Production Chain, from different regions of Brazil. The Agenda becomes necessary as it represents a sector that employs, directly and indirectly, over 1 million people, contributing more than R\$ 20 billion annually to the country's wealth solely through product revenue.

This industry is expanding, has enormous social and economic importance, and greatly influences people's well-being and quality of life. However, it suffers from various limitations and technological barriers that need to be overcome to promote and consolidate sustainable growth.

The Innovation Agenda prioritizes the most relevant obstacles, establishes their level of importance, and identifies ten significant Innovation Challenges to be addressed by the public and private sectors of the country. For each Innovation Challenge, Strategic Actions were suggested to be pursued, and Brazil has the technical competence distributed across the country, in nationally recognized universities and ICTs such as Embrapa.

The emphasis on the Southeast not only underscores its central role in the industry, but also reflects the prevailing needs articulated in the National Agenda. It is important to integrate insights from all regions to develop a comprehensive agenda that effectively addresses the diverse needs of people across the country. By incorporating data and feedback from regions that are currently underrepresented in surveys, the plan aims to ensure that producers across the country benefit from priority research and development efforts. This approach is critical to promoting growth and addressing disparities in professional participation and production capacity across the country.

Analyzing stakeholders' expectations for the future, it was observed that the quality and certification of products are very important, as a result of good agricultural practices. In terms of production, fertilizers and nutrition, fertirrigation and composting are also considered very important now and in the future. For the production chain, renewable energy and rainwater harvesting are aspects of sustainability that are currently less used but should be of great importance in the future.

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Author contribution

All authors contributed equally to all the stages of this research and article.

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 on request.

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