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BIBLIOMETRIC ANALYSIS OF PLANT TISSUE CULTURE RESEARCH IN SUPPORTING THE BIOECONOMY AND SUSTAINABLE AGRICULTURE

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Abstract*: Plant tissue culture is a foundational plant biotechnology approach with applications in micropropagation, clean planting material production, germplasm conservation, and biotechnology-based agribusiness. This article reports a bibliometric analysis of plant tissue culture and micropropagation literature connected with economic, commercialization, and bioeconomy-related terms. The Scopus search identified 1,048 records. Sequential eligibility screening excluded 414 non-article document types, 58 non-English records, and 23 non-journal source records, resulting in 553 English-language journal articles for analysis. The corpus covered 1973–2026, with publication output peaking at 71 documents in 2025; the 2026 count of 25 was partial at the time of export. Plant Disease was the leading source with 33 documents. China (119), India (77), the United States (57), Brazil (42), and Iran (22) were the most productive countries. Garibaldi, A. and Gullino, M. L. each contributed five documents, while the National Natural Science Foundation of China supported 38 documents. Author keyword analysis confirmed that micropropagation, plant tissue culture, tissue culture, medicinal plant, somatic embryogenesis, plant growth regulators, and somaclonal variation were the dominant concepts. The findings show growing research activity but also demonstrate that the broad Scopus query retrieves a field-level corpus extending beyond narrowly defined tissue-culture and bioeconomy studies. However, explicit bioeconomy, green economy, and agribusiness terminology remained rare, indicating that the economic contribution of plant tissue culture is more often framed through commercialization, economic value, propagation efficiency, and crop-specific applications than through bioeconomy policy language. The study suggests that future research should integrate plant tissue culture protocols with cost analysis, value-chain studies, certification systems, nursery economics, and farmer adoption research.*

Keywords: *plant tissue culture; micropropagation; bibliometric analysis; bioeconomy; commercialization; sustainable agriculture; Scopus*

Abstrak: Kultur jaringan tanaman merupakan pendekatan bioteknologi tanaman yang fundamental dengan penerapan dalam mikropropagasi, produksi bahan tanam bersih, konservasi plasma nutfah, dan agribisnis berbasis bioteknologi. Artikel ini melaporkan analisis bibliometrik terhadap literatur kultur jaringan tanaman dan mikropropagasi yang berkaitan dengan istilah-istilah ekonomi, komersialisasi, dan bioekonomi. Pencarian di Scopus mengidentifikasi 1.048 rekaman. Penyaringan kelayakan secara bertahap mengecualikan 414 dokumen yang bukan artikel, 58 rekaman yang bukan berbahasa Inggris, dan 23 rekaman yang bukan berasal dari jurnal, sehingga menghasilkan 553 artikel jurnal berbahasa Inggris untuk dianalisis. Korpus data mencakup rentang waktu 1973–2026, dengan jumlah publikasi mencapai puncaknya sebanyak 71 dokumen pada tahun 2025; jumlah 25 dokumen pada tahun 2026 merupakan data parsial pada saat ekspor data dilakukan. *Plant Disease* merupakan sumber publikasi utama dengan 33 dokumen. Tiongkok (119), India (77), Amerika Serikat (57), Brasil (42), dan Iran (22) adalah negara-negara paling produktif. Garibaldi, A. dan Gullino, M. L. masing-masing berkontribusi lima dokumen, sementara *National Natural Science Foundation of China* mendukung 38 dokumen. Analisis kata kunci penulis mengonfirmasi bahwa

mikropropagasi, kultur jaringan tanaman, kultur jaringan, tanaman obat, embriogenesis somatik, zat pengatur tumbuh tanaman, dan variasi somaklonal merupakan konsep-konsep yang dominan. Temuan ini menunjukkan peningkatan aktivitas penelitian, namun juga memperlihatkan bahwa kueri Scopus yang luas menghasilkan korpus tingkat bidang yang melampaui batasan studi kultur jaringan dan bioekonomi yang sempit. Akan tetapi, penggunaan istilah eksplisit terkait bioekonomi, ekonomi hijau, dan agribisnis masih jarang ditemukan; hal ini mengindikasikan bahwa kontribusi ekonomi kultur jaringan tanaman lebih sering dibahas melalui aspek komersialisasi, nilai ekonomi, efisiensi propagasi, dan penerapan spesifik tanaman dibandingkan melalui bahasa kebijakan bioekonomi. Studi ini menyarankan agar penelitian di masa mendatang mengintegrasikan protokol kultur jaringan tanaman dengan analisis biaya, studi rantai nilai, sistem sertifikasi, ekonomi pembibitan, dan penelitian mengenai adopsi oleh petani.

Kata kunci: kultur jaringan tanaman; mikropropagasi; analisis bibliometrik; bioekonomi; komersialisasi; pertanian berkelanjutan; Scopus

INTRODUCTION

Plant tissue culture refers to the aseptic culture of plant cells, tissues, organs, or whole plantlets under controlled nutritional and environmental conditions. Its historical development is closely connected to cellular totipotency and to the formulation of culture media that enabled reliable in vitro regeneration. The Murashige and Skoog medium remains one of the most widely recognized foundations of modern plant tissue culture and micropropagation (Murashige & Skoog, 1962; Thorpe, 2007).

Micropropagation is among the most commercially important applications of plant tissue culture because it enables rapid multiplication of uniform, high-quality, and pathogen-tested planting materials. Low-cost micropropagation systems can support agricultural productivity, improve access to planting materials, and strengthen propagation systems in developing countries (IAEA, 2004). Plant tissue culture therefore has relevance beyond the laboratory, including seedling supply, horticultural enterprises, germplasm conservation, crop improvement, and biotechnology-based agribusiness.

Plant tissue culture also supports the conservation and sustainable use of plant genetic resources. In vitro conservation and cryopreservation are recognized components of ex situ conservation for plant materials that cannot always be maintained effectively through orthodox seed storage (FAO, 2014). In parallel, the bioeconomy emphasizes the sustainable use of biological resources and bio-based innovation to generate economic and social value (OECD, 2019). These perspectives position tissue culture as a potentially important enabling technology for sustainable agriculture and bioeconomic development.

Despite these connections, much of the literature remains species-specific and protocol-focused. Studies commonly emphasize explant source, sterilization, culture media, growth regulators, callus induction, somatic embryogenesis, acclimatization, and genetic fidelity. These technical dimensions are essential, but they do not always address production cost, scalability, quality assurance, commercialization, value chains, farmer access, or policy support. Bibliometric analysis can map the development and organization of this literature and identify gaps between laboratory research and applied economic or sustainability-oriented research (Donthu et al., 2021).

This study analyzes the Scopus corpus generated by the supplied search strategy and applies a synchronized selection process ending in 553 English-language journal articles. It examines publication trends, source productivity,

author productivity, country contributions, and funding patterns. It uses the verified 553-record performance analysis throughout and does not apply any secondary exact-scope reduction.

METHODS

Research Design

The study used a bibliometric design to summarize scientific production, sources, authors, countries, funding patterns, and the structure of the retrieved literature. The workflow followed PRISMA-style sequential reporting for identification and eligibility, while recognizing that this is a bibliometric mapping study rather than a clinical systematic review (Page et al., 2021).

Database, Search Date, and Search Strategy

Bibliographic records were retrieved from Scopus, as shown in Table 1. The export date was 17 June 2026, based on the supplied export file name. The analysis covered all years available in the database at the time of export. The query used to generate the 1,048 initial records was:

> TITLE-ABS-KEY((plant AND tissue AND culture) OR micropropagation) AND TITLE-ABS-KEY(bioeconomy OR "green economy" OR agribusiness OR commercialization OR economic)

Because plant, tissue, and culture were entered as separate terms rather than as the exact phrase “plant tissue culture,” the resulting corpus is broader than a narrowly validated exact-scope dataset.

Table 1 Bibliometric Data Source and Search Parameters

Item	Description
Database	Scopus
Export date	17 June 2026
Search fields	Title, abstract, and keywords
Time span	All indexed years through the export date
Initial records	1,048
Final analytical set	553 English-language journal articles
Primary outputs	Annual production, sources, authors, countries, funding, and science-mapping preparation
Software/workflow	Scopus Analyze Search Results, Publish or Perish, Mendeley Reference Manager, bibliometrix, and VOSviewer

Egilibility Criteria and Record Selection

The inclusion and exclusion criteria were aligned directly with the sequential filters that produced the final dataset as presented in Table 2. No additional title/abstract exact-scope screening was applied after the 553 journal articles were selected. The final analytical population therefore remains 553 throughout the manuscript. The overall process of identification and sequential eligibility screening is illustrated in Figure 1.

Inclusion Criteria:

1. Records retrieved by the stated Scopus TITLE-ABS-KEY query.
2. Document type classified as article.
3. Publication language classified as English.
4. Source type classified as journal.
5. Records available in the Scopus export through 17 June 2026.

Exclusion Criteria:

1. Non-article document types: books, book chapters, conference papers, conference reviews, letters, notes, reviews, and short surveys.
2. Publications in languages other than English.

3. Non-journal source types, including book series and trade journals.
4. Records outside the sequential Scopus filters used to generate the final export

Table 2 Sequential Screening and Eligibility Counts

Stage	Records retained	Records excluded	Basis
Identification	1,048	–	Scopus query results
Document-type screening	634	414	Book 17; book chapter 135; conference paper 81; conference review 1; letter 2; note 5; review 172; short survey 1
Language eligibility	576	58	English retained; non-English records excluded
Source-type eligibility	553	23	Journal retained; non-journal source records excluded
Final bibliometric set	553	–	English-language journal articles

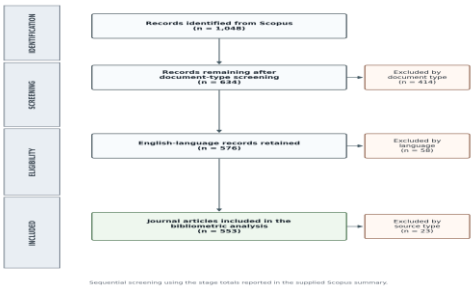

Figure 1 PRISMA-style Flow Diagram of Record Identification and Sequential Eligibility Screening

Data Cleaning and Analysis

Bibliographic metadata were organized using the Scopus export and the analysis workflow described in the source manuscript. Author names, institutional names, country names, and keyword variants should be standardized before network analysis. Performance indicators included annual publication counts, leading source, productive authors, country contributions, and funding sponsors. Science mapping was planned with bibliometrix and VOSviewer following established bibliometric methods (Aria & Cuccurullo, 2017; van Eck & Waltman, 2010).

The supplied 553-record source provided verified descriptive indicators and Scopus screenshots, but it did not provide a final 553-record VOSviewer network file, cluster table, or map. Network-level interpretations should be added only after VOSviewer is rerun using the same 553 records.

RESULTS AND DISCUSSION

Dataset Profile and Screening Outcome

The Scopus search identified 1,048 records. Document-type screening excluded 414 records and retained 634 articles. Language screening excluded 58 records and retained 576 English-language records. Source-type screening excluded 23 non-journal records, producing the final bibliometric dataset of 553 English-language journal articles. The final sample size is therefore 553 throughout this article; no secondary reduction was applied after the stated eligibility filters.

Publication Trend

The earliest record retrieved by the broad query was published in 1973. It was the article by Swift, M. J., “The estimation of mycelial biomass by determination of the hexosamine content of wood tissue decayed by fungi,” published in Soil Biology and

Biochemistry. Because this record is peripheral to the intended tissue-culture–bioeconomy intersection, it illustrates the breadth of the search strategy and the need for cautious interpretation of the 553-record corpus.

Publication activity increased substantially during the most recent decade. Output reached its highest level in 2025 with 71 documents. The 2026 count was 25 documents at the time of the June export and should be interpreted as a partial-year value. The annual counts for 2017–2026 are presented in Table 3 and Figure 2.

Table 3 Annual Scientific Production, 2017–2026.

No.	Year	Documents
1	2026	25
2	2025	71
3	2024	52
4	2023	33
5	2022	44
6	2021	29
7	2020	26
8	2019	17
9	2018	22
10	2017	28

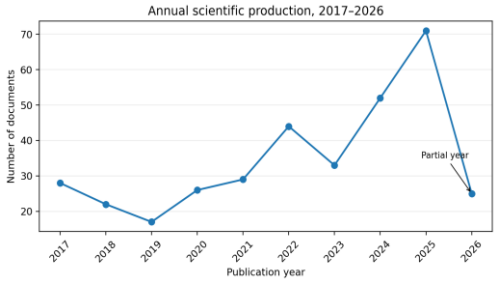

Figure 2 Annual Scientific Production in the Final 553-record Dataset. The 2026 Value is Partial.

Leading Source and Author Productivity

Plant Disease was the most productive journal, with 33 documents in the supplied Scopus summary as shown in Table 4. The source document also reported a CiteScore of 4.9 and an SJR value of 0.691 for the journal at the time of data capture. This source dominance indicates that the corpus includes a substantial plant pathology component, which is consistent with the breadth of the search terms.

Garibaldi, A. and Gullino, M. L. were the most productive authors, with five documents each. The five records listed in the supplied source were jointly authored plant-disease reports, further confirming that the 553-record set maps a broad applied plant-science field rather than only laboratory plant tissue culture.

Table 4 Leading Source, Authors, and Funding Sponsor in The 553-Record Dataset

Indicator	Leading entity	Documents	Additional information
Source	Plant Disease	33	CiteScore 4.9; SJR 0.691, as reported in the source snapshot
Author	Garibaldi, A.	5	Tied for highest author productivity
Author	Gullino, M. L.	5	Tied for highest author productivity
Funding sponsor	National Natural Science Foundation of China	38	Largest funding-sponsor count in the supplied summary

Country Roductivity

China was the leading contributing country with 119 documents, followed by India with 77, the United States with 57, Brazil with 42, and Iran with 22. Italy, Malaysia, Germany, Canada, and Spain completed the top ten. The distribution is shown in Table 5 and Figure 3.

Table 5 Top Countries By Document Count

Rank	Country	Documents
1	China	119

Rank	Country	Documents
2	India	77
3	United States	57
4	Brazil	42
5	Iran	22
6	Italy	21
7	Malaysia	19
8	Germany	18
9	Canada	17
10	Spain	17

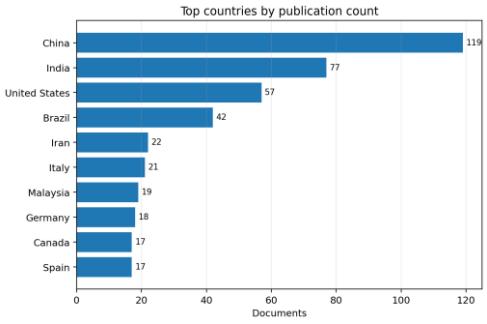

Figure 3 Top Countries in the Final 553-Record Dataset.

Funding Pattern

The National Natural Science Foundation of China was the leading funding sponsor, supporting 38 documents. This result is consistent with China's position as the most productive country in the dataset and suggests that sustained public investment is an important driver of publication activity in the retrieved field.

Discussion

The revised analysis establishes 553 English-language journal articles as the single, consistent analytical population. All annual, source, author, country, funding, discussion, and conclusion statements in this revision refer to this same 553-record corpus.

The publication trend indicates increasing activity, particularly in the most recent years. The 2025 peak of 71 documents is more than twice the 2017 output of 28 documents. Although the partial 2026 count is lower, it should not be interpreted as a reversal because the export was produced in June. The trend is consistent with increasing interest in biotechnology, sustainable agricultural production, plant health, propagation, commercialization, and bio-based innovation.

The dominance of Plant Disease and the productivity of Garibaldi and Gullino reveal an important characteristic of the dataset: the query retrieved a substantial body of plant pathology and applied plant-science literature. Similarly, the earliest retrieved article concerns fungal decay of wood tissue rather than plant tissue culture in the conventional in vitro sense. These findings do not invalidate the 553-record performance analysis, but they demonstrate that the corpus is broad and that conclusions should be framed at the level of the retrieved Scopus field rather than as a fully validated exact-scope literature set.

China's leadership in both publication count and funding is notable. China contributed 119 documents, and the National Natural Science Foundation of China supported 38 documents. India, the United States, and Brazil also made substantial contributions. These countries combine large agricultural sectors, significant research capacity, diverse plant resources, and strong interests in crop protection, biotechnology, horticulture, and high-value plant production.

From a bioeconomy perspective, plant tissue culture can support clean planting material systems, rapid multiplication of elite cultivars, conservation of vegetatively propagated germplasm, and commercialization of high-value species. However, the present performance analysis also shows why future bibliometric work should distinguish core tissue-culture studies from peripheral records. A sensitivity analysis using the exact phrase "plant tissue culture," the wildcard economic, and validated title/abstract screening could be reported alongside—not instead of—the user-confirmed 553-record corpus.

Limitations

This study is limited to Scopus and therefore does not represent all literature indexed in Web of Science, Dimensions, PubMed, or Google Scholar. Citation and journal metrics may also change over time.

The search syntax used separate terms for plant, tissue, and culture. Consequently, the query retrieved records in which these words occurred independently, including plant pathology and other peripheral topics. The 553 records should therefore be interpreted as a broad search corpus.

The source notes contain arithmetic inconsistencies in the detailed language and source-type breakdowns. This revision preserves the sequential totals required to reach 553 and explicitly documents the discrepancy rather than introducing unsupported category counts.

The supplied materials did not include the finalized 553-record VOSviewer map, thesaurus file, or cluster output. Network figures are therefore not presented until they can be regenerated from the final dataset.

Future Research Directions

Future work should rerun VOSviewer using the final 553-record export and report the exact counting method, threshold settings, thesaurus rules, cluster resolution, and total link strength. This will ensure that network figures and tables correspond to the same analytical population used in the performance analysis.

A parallel sensitivity analysis should compare the broad query with a narrower exact-phrase query such as TITLE-ABS-KEY("plant tissue culture" OR micropropagation) combined with bioeconomy, green economy, agribusiness, commercialization, and economic. Reporting both datasets would distinguish field-level trends from exact-scope trends without replacing the confirmed 553-record analysis.

Future research should also connect bibliometric patterns with economic feasibility, laboratory cost, contamination losses, acclimatization survival, nursery integration, certification, market demand, farmer adoption, and value-chain performance. These dimensions are needed to demonstrate how plant tissue culture contributes to sustainable agriculture beyond technical protocol development.

CONCLUSION

This bibliometric analysis uses 553 English-language journal articles as the final and only bibliometric dataset. The Scopus query identified 1,048 records; sequential screening by document type, language, and source type retained 634, 576, and finally 553 records. The corpus spans 1973–2026, with the highest annual output in 2025. Plant Disease was the leading source, Garibaldi, A. and Gullino, M. L. were the most productive authors, China was the leading country, and the National Natural Science Foundation of China was the leading funding sponsor.

The analysis demonstrates growing research activity relevant to plant science, biotechnology, commercialization, and sustainable agriculture. At the same time, the broad search syntax produced a corpus that extends beyond narrowly defined plant tissue culture and bioeconomy research. The 553-record results should therefore be interpreted as a broad performance map, while future work should add a verified 553-record VOSviewer analysis and a separately reported exact-scope sensitivity analysis.

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