Trends and challenges in bioinputs development over 2021-2025 using Brazilian Cerrado plants

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ABSTRACT. The Brazilian Cerrado constitutes a biome of exceptional ecological significance that remains substantially underexplored from a scientific standpoint. Distinguished by its remarkable richness of native plant species, the Cerrado represents a valuable reservoir for sustainable agricultural innovation. This review synthesizes research conducted between 2021 and 2025, focusing on numerous Cerrado species as promising sources of bioinputs, allelopathic agents, biocides, and fungicides for applications relevant to agricultural sciences. We identified 481 publications, of which 30 met inclusion criteria. Publications were lower in 2023 and 2024 than 2021, 2022 and 2025. The most-cited author was Franco et al. (2022) with 30 citations on Google Scholar. Both ethnopharmacological records and rigorous scientific investigations have demonstrated a broad spectrum of biological activities, including antioxidant, allelopathic, cytotoxic, and phytotoxic effects. Recent advances have facilitated the isolation and characterization of key active metabolites, such as flavonoids, phenolic acids, diterpenes, and essential oils, whose roles in regulating germination, seedling development, and pest control have been systematically evaluated. These findings underscore the significance of Cerrado flora as prospective candidates for the development of natural herbicides, pesticides, and functionally diverse bioinputs, which can make a substantial contribution to sustainable agriculture and environmental stewardship within Brazil. Ongoing research into Cerrado-derived plant metabolites supports pioneering strategies for agroecological resilience and the preservation of biodiversity.

Key words: botanical inputs; Brazilian Cerrado; allelochemical; biocide; herbicide

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INTRODUCTION

Natural Products Chemistry (NPC) is a branch of classical chemistry focused on investigating of chemical constituents extracted from biological sources such as plants, microorganisms, and animals. These extracts are typically composed of a broad spectrum of molecules, each of which fulfills defined biological roles within the source organism, participating in both primary and secondary metabolic pathways. NPC aims to characterize the structure, function, and biosynthetic pathways of these compounds, elucidating their ecological significance as well as their potential for pharmaceutical, agricultural, and biotechnological applications (Rodrigues; Bessa, 2025). Specifically in plants, we focus on compounds produced via secondary metabolism. These secondary metabolites are typically characterized by low-to-medium molecular weight and exhibit a wide range of polarities, volatilities, and chemical reactivities, contingent upon their physiological roles within the plant organism. In contrast to primary metabolites, which are directly involved in energy production and essential survival processes, secondary metabolites generally do not participate directly in these pathways. Nonetheless, these compounds play essential roles in the perpetuation of plant species, functioning within a broad spectrum of ecological interactions. Their activities include the attraction of pollinators, deterring herbivores, mitigating ultraviolet radiation damage, and regulating chemical signaling pathways that govern both intra- and interspecific communication. The multifaceted nature of these metabolites

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underscores their significance in the adaptive strategies and ecological success of plants (Lima et al, 2022).

In this context, molecules originating from secondary metabolism, or sometimes referred to in the literature as special metabolism, are of substantial significance to the organisms that produce and utilize them. A primary objective within NPC is to elucidate the chemical constitution of these compounds and establish correlations with their biological targets, thereby clarifying their roles within the metabolic networks of their source organisms. To achieve these aims, NPC employs a comprehensive array of organic compound identification methodologies, encompassing isolation and purification procedures as well as advanced physical and chemical characterization techniques. The implementation and continuous advancement of these analytical methods constitute a central aspect of NPC and underscore the discipline's wide-ranging practical applications (Reshi et al, 2023).

Finally, NPC is devoted to the discovery of novel functions for fractions of natural products (NPs) and biomolecules, with the goal of advancing their broad utilization in applications of interest to humanity. Through detailed elucidation of molecular identity, it becomes feasible to bioprospect these substances, thereby facilitating their application in diverse contexts beyond those of the original producing organism. Such bioprospecting initiatives drive innovations in pharmacology, agriculture, biotechnology, and related disciplines, underscoring the multidisciplinary significance of NPC (Dixon; Dickinson, 2024). The historical record documents a myriad of applications for natural products across various domains. For instance, the flower buds of *Syzygium aromaticum* (cloves) have been employed since antiquity for the management of dental ailments. These buds are notably rich in eugenol, a compound recognized for its anesthetic, antiseptic, and anti-inflammatory properties. In the plant, eugenol is synthesized and released as a defensive agent against herbivores and pathogenic microorganisms. The capacity to harness the bioactive chemical profiles of such natural compounds for targeted applications is a central objective of NPC (Reshi et al, 2023).

The Brazilian Cerrado represents the second largest biome in both Brazil and South America, occupying nearly 23% of the national territory. It is distinguished by a unique physiognomy that includes low, twisted trees with thick trunks and prominent bark, as well as shrubs and grasses adapted to a range of soil types, which are generally acidic and nutrient-poor. This edaphic adversity imposes stringent selective pressures, making adaptability a key determinant for species survival, particularly for plant organisms (Souza et al, 2016). In this context, the development and utilization of chemical signaling constitute fundamental adaptive strategies for plant survival within the biome (Baluska; Souza, 2024). Consequently, the Brazilian Cerrado ranks among the world's most biologically diverse biomes and stands out as an exceptional reservoir of secondary metabolites, offering unparalleled opportunities for research in NPC.

One application of plant metabolites that has garnered significant attention is their use in bioprospecting as agricultural bioinputs. Traditional pest management and control methods in agriculture are known to cause several problems, including soil depletion and degradation, diverse environmental impacts, and the destruction of riparian forests due to the indiscriminate use of fire for pest control, among other practices (Guzman-Gusman et al, 2023). In this context, the use of traditional pesticides for pest control is widespread. However, the indiscriminate application of these chemicals is associated with a multitude of adverse effects, including pollution of waterways, the gradual reduction of agricultural productivity, the development of chemical resistance among pests, and the emergence of new, adaptive forms that are resistant to conventional pesticides (Riedo; Rillig; Walder, 2025).

Therefore, bioinputs may serve as nontraditional alternatives for the biological control of common crop pests. In Brazil, a noteworthy example is neem extract (*Azadirachta indica*), which was the first botanical extract approved by the Brazilian Ministry of Agriculture and Livestock (MAPA) in 2000 for use as an insecticide, repellent, and growth regulator. This regulatory milestone highlights the potential of plant-derived metabolites for sustainable pest management strategies in agriculture (Campos et al., 2016). From that period onward, both legislation and investment in Brazil related to the use of bioinputs and the development of agronomic formulations evolved rapidly and in an increasingly structured manner. This progress has been particularly pronounced since the enactment of Decree n°. 10.375 of May 27, 2020, which constitutes a landmark for the expansion, regulation, and production of bioinputs in the country. This regulatory development has substantially contributed to fostering innovation and consolidating the bioinputs sector within Brazilian agriculture (Ramalho; Lopes, 2022). In this regard, Brazil, as a major global agricultural producer, has actively invested in the development of new technologies for the sector. Among the most promising alternatives is the use of botanical fractions derived from plant species of the Cerrado biome for the production of bioinputs.

However, a scientometric study with a comprehensive mapping of citations, metrics, temporal trends, and influential institutions contributing to the development of Cerrado bioinputs has not yet been conducted. Scientometrics is the quantitative study of scientific literature, centered on metrics such as publication counts, citations, and keyword mapping. This focus allows for the identification of temporal

trends, leading authors/institutions, and research gaps (Chen et al., 2023). Therefore, the objective of this work is to highlight the main advances and future perspectives regarding inputs derived from plants native to the Brazilian Cerrado.

MATERIAL AND METHODS

The present study employs a qualitative methodological approach, wherein the data collected from 2021 to 2025 are critically examined in relation to pertinent theoretical frameworks. A bibliographic review was conducted as a foundation; this type of research, as stated by relevant literature, is "[...] based on already elaborate material, consisting mainly of books and scientific articles" (Gil, 2002). To ensure methodological rigor in the technical procedures, bibliographic research was restricted to sources that constitute the theoretical basis for the present research. Parameters for the selection of these references were established, as summarized in Table 1, with the objective of providing a comprehensive and nuanced analysis of the topic under investigation and thereby facilitating the development of robust explanations.

Table 1. Search and selection parameters for publications

Period of publications	Keywords	Search tools
2021-2025	- allelochemistry - bioinput - Brazilian Cerrado	- Google Scholar - Boolean operators AND and OR, where AND represents an intersection and OR represents a union. - Scientific manuscripts

Regarding the parameters adopted for the analysis of bioinputs, these are established based on the application contexts identified in the selected bibliographic sources, which relate potential bioinputs to plant species found in the Brazilian Cerrado. In accordance with the aforementioned parameters, the research development encompasses a bibliographic survey for the construction of a theoretical review on the selected topic, as well as an investigation into the development of bioproducts with technological potential. A scientometric analysis was employed to quantitatively characterize the research output on bioinputs derived from Cerrado plants between 2021 and 2025, as well as to complement the qualitative assessment. We calculated and extracted the indicators of the included works: number of publications year by year; more productive research groups; and citations using Google Scholar in June 2026. The central objective is to deepen scientific knowledge and to apply this knowledge toward the innovation and synthesis of new bioinputs suitable for the ecological and biodiversity characteristics of the Cerrado biome.

RESULTS AND DISCUSSION

The Brazilian Cerrado, despite being one of the most ecologically significant biomes in Brazil and South America, remains scientifically understudied. Emphasizing the value of this biome, which constitutes the second largest in the country, is essential for supporting its conservation and sustainable management. Recent literature demonstrates an increasing effort to elucidate the biochemical potential of metabolites from Cerrado plant species, particularly regarding their applications for human health and pharmacological uses (Carvalho; Barcia; Schmiele, 2025; Rocha et al, 2022). However, for agronomic applications, a substantial knowledge gap remains concerning the use of NP fractions as agrochemicals in the Cerrado context. Accordingly, this research seeks to highlight the most noteworthy applications of Cerrado plant species as bioinputs for sustainable agriculture. An initial scoping identified 481 scientific publications; of these, 30 met the criteria established in Table 1, and the corresponding data were analyzed and synthesized in Table 2.

According to our final assessment, the majority of publications over the last five years were concentrated in 2021 and 2022 (9 and 10 papers, respectively), followed by a significant decline in 2023 and 2024 (1 and 4 papers, respectively), and a subsequent resurgence in 2025 (6 papers). Among these publications, a prominent increase in citations was observed for articles from 2021 and 2022, with Franco et al. (2022) being the most-cited manuscript (30 citations, source Google Scholar, June 2026). This study is particularly noteworthy as it stems from the Adolpho Ducke Laboratory research group in collaboration with the Federal University of Pará, both of which are key national research centers in natural products, phytochemistry, and biodiversity. Regarding prominent researchers, our findings indicate that the groups led by Dr. Sandro Barbosa (Universidade Federal de Juiz de Fora – MG) and Dr. Rosemary Matias (Universidade Anhanguera – MS) have distinguished themselves in recent years with the highest number of publications in this field. Conversely, only two of the 30 publications involved international co-authorship, demonstrating a low level of internationalization for research involving Cerrado plants during this period. Nevertheless, it is crucial to highlight the active engagement of various universities and research institutes in this field, particularly those embedded within the Cerrado biome. Finally, regarding the most frequently occurring keywords, 'allelopathy' (5) and 'allelochemicals' (5) led the field, followed by 'weed control' (3) and 'phytochemistry' (2).

One of the most prominent species of the Cerrado is *Caryocar coriaceum*, commonly known as "pequi" in Brazil, the most cited species in the analyzed papers. This species is renowned for the widespread

use of its fruits in the traditional cuisine of states such as Minas Gerais and Goiás, where it holds considerable cultural and gastronomic significance. Almeida-Bezerra et al. (2022) conducted a comprehensive literature review addressing its ethnomedicinal uses, diverse biological activities, and phytochemistry. Due to its extensive application, ranging from culinary and medicinal to industrial uses, pequi is among the main Cerrado plants recognized for its biochemical and economic value (Almeida-Bezerra et al, 2022). However, Silva et al. (2021) also investigated the effects of hydroethanolic leaf extract from *C. coriaceum* on the germination and early development of *Lactuca sativa* L. seedlings. The extract, prepared with a 1:1 (v/v) ethanol-water ratio, was tested at concentrations ranging from 0.1 to 10,000 mg L^{-1}. The authors reported that concentrations above 100 mg L^{-1} induced a 15% reduction in root length compared to the control group, and severe adverse effects on seedling survival were observed at 10,000 mg L^{-1}. Furthermore, phytochemical analysis by high-performance liquid chromatography (HPLC) revealed the presence of metabolites such as flavonoids (rutin, quercetin) and phenolic acids (chlorogenic, caffeic, and gallic acids), which may contribute to the observed biological effects. (Silva et al, 2021).

The "pequi" belongs to different genera in the Brazilian Cerrado, with *C. brasiliense* representing the genus most characteristic of this biome. Vargas et al. (2021) investigated the allelopathic potential of aqueous extract fractions from multiple Cerrado species, including *Davilla elliptica*, *Combretum laxum*, *Himatanthus obovatus*, *Diteryx alata*, *Curatella americana*, *Qualea grandiflora*, *Aspidosperma macrocarpon*, and *C. brasiliense*. With the exception of *H. obovatus*, all tested species promoted positive variations in the germination rate of *L. sativa*. Notably, the authors identified clear allelopathic effects in *D. elliptica*, *C. laxum*, *C. brasiliense*, and *Q. grandiflora*, as evidenced by negative, dose-dependent values for the Allelopathic Response Index (IR). To investigate the chemical basis of these effects, the authors employed Fourier transform infrared spectroscopy (FT-IR), revealing the presence of major compound classes, proteins, fatty acids, carbohydrates, and lignans. Thin-layer chromatography (TLC) analyses further identified phenols and terpenoids in all extracts, flavonoids in *D. elliptica* and *C. brasiliense*, and alkaloids in *D. elliptica*, *C. laxum* and *C. brasiliense* (Vargas et al, 2021).

Many species are deeply embedded in the traditional culture of the Brazilian Cerrado. Among these, the "marolo" or "araticum" (*Annona coriacea*) stands out for its highly prized fruits, which are commonly used in the production of jams, liqueurs, sweets, and ice cream. Recently, Novaes et al. (2024) investigated the phytotoxic potential of isoflavonoids isolated from *A. coriacea* in germination assays with seeds of *L. sativa*, *Solanum lycopersicum* L., and *Urochloa decumbens*. Ten isoflavonoids, including quercetin, rutin, hyperin, biorubin, nicotiflorin, and cacticin, were isolated from ethanolic extracts of *A. coriacea* via classical column chromatography and HPLC, with nuclear magnetic resonance spectroscopy (NMR) employed for structural identification. In germination assays, the isohamnetin-3-*O*-glucoside isolate significantly inhibited germination of *U. decumbens* seeds at all tested concentrations, displaying biocidal effects particularly relevant to weed control, thus highlighting its potential as a novel bioinput for sustainable agriculture (Novaes et al., 2024).

Eugenia florida DC is a shrubby species within the Myrtaceae family, popularly known as "guamirim" or "pitanga-preta" due to its production of small, dark-colored fruits. These fruits are widely consumed fresh and feature prominently in regional culinary preparations, including jams, preserves, juices, and liqueurs. In addition to their gastronomic importance, fruits are valued in folk medicine for their antioxidant properties and high content of vitamins A and C, as well as phosphorus, calcium, and iron. Furthermore, *E. florida* is recognized as a source of nectar for honey production, underscoring its ecological and economic relevance in the Cerrado region (Silva et al, 2007). Recently, Alves et al. (2025) reported the allelopathic effects of aqueous leaf extracts of *E. florida* on lettuce germination index, shoot length, root elongation, frequency of abnormal seedlings, and cytogenetic variables. Using thin-layer chromatography (TLC), the authors identified multiple compound classes, flavonoids, phenols, tannins, catechins, saponins, and terpenes in the extract. The assessed extract exhibited negative allelopathic potential, demonstrated by the suppression of the gonadosomatic index and reduced germination rates in *L. sativa*. Morphological abnormalities were observed among seedlings, along with a mitodepressive effect on the meristematic cell cycle, with no evidence of genotoxicity. Based on these results, *E. florida* extract is proposed as a promising candidate for development as a bioherbicide for sustainable weed management (Alves et al., 2025).

It is noteworthy that several species investigated for bioherbicidal properties in the Cerrado are also distributed in other major Brazilian biomes. *Tapirira obtusa*, known locally as "pombeiro" or "pau-pombo", is a native species found in the Atlantic Forest, Cerrado, and Amazon, distinguished by its high adaptability but sharing many morphological and ecological characteristics with Cerrado flora. Matias et al. (2021) evaluated the allelopathic activity of ethanolic leaf extracts from *T. obtusa*. Using thin-layer chromatography (TLC) and classical phytochemical analysis, they confirmed the presence of phenolic compounds, triterpenes, flavonoids, tannins, steroids, saponins, and reducing sugars; TLC further identified flavonoids such as quercetin and pinocembrin, along with coumarin and gallic acid. Germination assays with

L. sativa, *Senna obtusifolia* (L.), and *S. lycopersicum* L. revealed that increasing concentrations of the extract negatively affected germination, with the root system exhibiting greater sensitivity to the allelopathic compounds than the shoot system. This suggests a pronounced inhibitory effect on root development and highlights the potential of *T. obtusa* extracts as candidates for bioherbicidal application (Matias et al., 2021).

Matayba guianensis Aubl., known as "mataíba" or "camboatá", is a tree species native to South America and predominantly found in the Brazilian Cerrado. Ethnopharmacological studies have documented its traditional use for wound treatment via bark oil applications (Bao et al., 2014). Building on this knowledge, Nascimento et al. (2022) investigated the phytochemical profile and biological effects of aqueous leaf extracts on seed germination in *L. sativa* and *Cenchrus echinatus* L. Their analyses identified phlobaben tannins, flavones, flavonols, and xanthones; chalcones, and aurones. Germination bioassays revealed inhibitory effects on germination rates and velocity indices, alongside positive influence on stem elongation and marked inhibition of radicle growth. The authors emphasize the necessity of isolating individual metabolites to elucidate their specific contributions and bioactivities (Nascimento et al., 2022).

However, there are species that are exclusive to the Cerrado that have been studied in recent years to determine the potential of their metabolites as bioherbicides. One of these species is *Pouteria ramiflora* (Mart.) Radlk., popularly known as "curriola" or "figo-do-Cerrado". This species is popularly used as a source of wood, as well as for digestive uses of extracts from its leaves, although this information is quite limited. Its fruits are highly valued, however they are not used commercially (Gama; Barbosa; Oliveira, 2011). Gomes and colleagues investigated the phytochemical profile, antioxidant capacity, antifungal, allelopathic, and cytotoxic activities of *Pouteria ramiflora*. The researchers fractionated the ethanolic extract of dried leaves into low, medium, and high polarity fractions. Phytochemical analysis demonstrated the presence of phenolic compounds, flavonoids, triterpenes, steroids, and reducing sugars in all fractions, with reducing sugars predominant in the most polar fraction. Despite the fractions lacking notable allelopathic activity or antifungal effect against *Trichoderma* sp., they were effective against *Aspergillus* sp. Additionally, samples exhibited appreciable antioxidant activity, suggesting their value for environmental restoration in degraded areas (Gomes et al., 2024).

A well-known species in the Cerrado biome is the "mamica-de-porca" or "mamica-de-cadela" (*Zanthoxylum rhoifolium* Lam.), which has been traditionally used for the treatment of toothache, earaches, and inflammations through preparations made from its bark. Additionally, preparations using its leaves are recognized for their antibacterial and antifungal activities, and the plant is also valued as a natural repellent (Krause et al., 2013). Pereira et al. (2022) evaluated the biocidal efficacy of essential oils from *Z. rhoifolium* fruits, both encapsulated in nanoparticles and non-encapsulated, against *Bemisia tabaci* (whitefly). Using gas chromatography-mass spectrometry (GC-MS), the essential oil was characterized by 14 constituents, with β-phellandrene (76.8%) as its major component. The study showed that nanoparticle encapsulation offered photoprotection to the essential oil, reduced whitefly oviposition by 71%, and induced mortality in second-instar nymphs. Under severe light conditions, nanoparticles preserved the insecticidal activity at 84%, while the oil alone dropped to about 65%. These findings highlight the technological potential of encapsulated essential oils as high-quality, field-applicable bioinputs for pest management. (Pereira et al., 2022).

Piptocarpha rotundifolia (Less.) Baker is commonly found across diverse Cerrado vegetation types, including sparse cerrado, typical cerrado, riparian forests, and gallery forests, exemplifying the biome's ecological plasticity. This species is among those with the highest frequency, density, and dominance within Cerrado flora, indicating its adaptability and major ecological importance in these formations (Batalha & Martins, 2007). Anese et al. (2021) investigated *P. rotundifolia*, popularly known as "black heart" or "candeia," as a potential bioinput. They fractionated the aqueous extract of dried leaves using ethyl acetate, followed by classical column chromatography and HPLC to isolate compounds including piptocarphin C, aromadendrane-4β,10α-diol, tamarixetin-3-O-β-galactoside, quercetin-3-O-β-galactoside, quercetin-3-O-β-glucoside, disyfolide, 1α-11-dihydroxy-5-eudesmene, (9β)-caryolane-1,9-diol, alloaromadendrane-4β,10α-diol, and spathulenol. Phytotoxicity assays on wheat coleoptiles and sensitive weeds revealed that inhibition of weed growth is attributed specifically to piptocarphin C, positioning it as a promising bioherbicide and valuable bioinput for sustainable agriculture (Anese et al., 2021).

The species commonly known as 'murici' are recognized in the Cerrado for their resilience to environmental stressors, as well as for the exotic taste and aroma of their fruits, which are widely used in regional cuisine. Amâncio et al. (2021) investigated the allelopathic activity of *Byrsonima verbascifolia* Rich. ex A. Juss. and *B. intermedia* A. Juss. using aqueous and ethanolic leaf extracts in *L. sativa* germination assays. The authors reported that the analyzed extracts exhibited distinct cytotoxic and phytotoxic effects, which also varied depending on the extraction method. Furthermore, the authors stated that *Byrsonima* spp. extracts induce chromosomal abnormalities, likely due to their aneugenic effect (Amâncio et al., 2021).

Another study focusing on the identification of allelopathic effects on *L. sativa* seeds was conducted by Bitencourt et al. (2021), who investigated extracts from *Schinus terebinthifolius* Raddi, commonly known as 'aroeira vermelha' (Brazilian pepper tree). This species is well regarded for its ornamental value, particularly during its flowering season, as well as for its utility in apiculture, structural construction, and traditional medicine applications. To evaluate its allelopathic activity, the authors performed an ultrasound-assisted extraction using ethanol as the solvent. The resulting extract exhibited negative allelopathic effects at concentrations of 50% and 100%, significantly affecting germination, early seedling growth, and root development, which led to morphological anomalies. Furthermore, the authors conducted a phytochemical screening to identify the classes of compounds present in the extract, detecting flavonoids, terpenes, tannins, anthocyanins, and heterosides. The authors concluded that these secondary metabolites are likely linked to the observed negative allelopathic effects (Bitencourt et al., 2021).

Essential oils (EOs) comprise a class of volatile, lipophilic, and low-molecular-weight compounds utilized by plants to attract pollinators, deter predators, and facilitate chemosignaling, among other ecological functions. Their application for agrochemical purposes, such as their role as allelochemicals, has been extensively documented in the literature (Souza et al., 2025). Franco et al. (2022) investigated the phytochemical profile and herbicidal activity of the essential oils from three specimens of *Calycolpus goetheanus*, a plant popularly known as 'ameixa da praia'. The EOs obtained via hydrodistillation were analyzed by GC-MS and GC-FID, revealing oxygenated sesquiterpenes, such as β-eudesmol and α-cadinol, as their major components. The authors evaluated the molecular docking *in silico* with the enzyme 4-hydroxyphenylpyruvate dioxygenase (HPPD). The findings described high phytotoxic potential against the receiver species *Mimosa pudica* L., particularly for the EOs from two of the three analyzed *C. goetheanus* specimens. Furthermore, the *in silico* studies identified van der Waals forces and hydrophobic interactions between the major compounds and HPPD, demonstrating the formation of a receptor-ligand complex responsible for the phytotoxic activity (Franco et al., 2022).

The genus *Moquiniastrum*, which evolved from *Gochnatia*, encompasses 21 species native to the physiogeography of the Brazilian Cerrado. This group is notable for a range of ethnopharmacologically recognized and scientifically validated biological activities, particularly related to treatments for respiratory ailments. In phytochemical studies, extracts from *M. pulchrum* have been characterized as sources of six marker compounds for the genus, one flavone and five kaurane-type diterpenes, distinguished mainly by substitutions in acetyl and hydroxyl groups, including moquinian A and moquinian B. Vela et al. (2021) isolated and characterized these markers NMR and FT-IR analyses, then evaluated their phytotoxic effects through wheat coleoptile assays. The results demonstrated that moquinian A is the main contributor to the extract's phytotoxicity, while the other identified diterpenes are potent inhibitors of weed root growth (Vela et al., 2021).

Table 2. Studies found in the literature from 2021-2025 that correlate the capacity of plants from the Brazilian Cerrado to act as bioinputs in comparison with their chemical composition.

Author	Year	Species	NC*	Traditional name of the species	Chemical compounds/class of compounds used on bioinputs	Active fraction	Application as bioinput	
Almeida-Bezerra et al.	2022	*Caryocar coriaceum* Wittm. (Caryocaraceae)	20	Pequi	Do not describe the chemicals	Aqueous extract of leaves, fruits and stem	In germination tests, interfere with the growth of roots, length of aerial and underground parts	[1]
Alves et al.	2022	*Phoradendron ensifolium*	2	Erva-de-passarinho	Alkaloids, flavonoids, coumarins, steroids and triterpenes, anthocyanidins, saponins, and tannins.	Crude extract and fractions of the aerial parts of the plant	It interferes with the germination rate, hypocotyl development, and radicle growth	[2]
Alves et al.	2025	*Eugenia florida* DC	1	Guamirim	Catechins, flavonoids, phenols, tannins, saponins, and terpenes	Aqueous extract of leaves	In germination tests, root length, shoot length, number of abnormal seedling and fresh mass	[3]

Amâncio et al.	2021	*Byrsonima verbascifolia; Byrsonima intermedia*	17	Murici-do-cerrado; Murici-do-campo ou Muricí anão	Do not describe the chemicals	Aqueous and ethanolic extract of leaves	Seed germination, elongative, growth, masses gain, and mitotic index and the occurrence of *Lactuca sativa* seedling chromosomes	[4]
Anese et al.	2021	*Piptocarpha rotundifolia*	5	Coração de Negro; Candeia	Piptocarphin C, aromadendrane-4β,10α-diol, tamarixetin-3-O- β-galactoside, quercetin-3-O-β-galactoside, quercetin-3-O-β-glucoside, disyfolide, 1α-11-dihydroxy-5-eudesmene, (9β)-caryolane-1,9-diol, alloaromadendrane-4β,10α-diol, and spathulenol.	Aqueous extract and partitioned with ethyl acetate of leaves	Evaluate the phytotoxic activity of leaves in the search of new environmentally friendly tools for weed control.	[5]
Arcanjo et al.	2021	*Anacardium othonianum* Rizz.	2	Caju-de-árvore-do-cerrado	Do not describe the chemicals	Aqueous extracts of the leaves	Germination and initial growth tests of lettuce and radish seedlings	[6]
Azevedo et al.	2025	*Smilax fluminensis* Steud. (Smilacaceae)	0	Cipó-quina / japicanga	Dioscin, Glyceroglucolipid, Kaempferol, Kaempferol *O*-coumaroyl *O*-hexoside, Kaempferol *O*-deoxyhexosyl hexoside, Luteolin *O*-caffeoyl *O*-hexoside, Luteolin *O*-deoxyhexosyl hexoside, Luteolin *O*-hexoside, *O*-Caffeoyl shikimic acid, *O*-Methyl quercetin *O*-deoxyhexosyl-hexoside, Polypodioside A, Pseudoprotodioscin or Taccoside A, Quercetin 3-*O*-β-galactopyranoside, Quercetin *O*-deoxyhexosyl-hexoside, Quercetin *O*-hexoside, Quercetin *O*-pentoside, Quercetin *O*-pentosyl-hexoside, Saponin, Steroidal saponin.	Extract ethanolic and ethyl acetate, hexane, dichloromethane fractions	Assess the influence on seeds germination and seedling development of mono and eudicotyledonous species.	[7]
Bitencourt et al.	2021	*Schinus terebinthifolius* Raddi.	21	Aroeira - Vermelha	Phenolic compounds, flavonoids, tannins, terpenes, anthocyanins, and heterosides	Ethanolic extract of the leaves	Evaluate germination and seedling growth of *Lactuca sativa* L. and *Eucalyptus camaldulensis*.	[8]

Dilkin et al.	2024	*Anacardium humile Saint Hill; Baccharis dracunculifolia* DC.; *Cenchrus echinatus L.; Commelina erecta L.; Erigeron bonariensis L.; Digitaria horizontalis* Willd.; *Digitaria insularis* L.; *Porophyllum ruderale* Jacq. Cass; *Richardia brasiliensis* Gomes; *Sida rhombifolia* L.; *Turnera ulmifolia* L.; *Smilax fluminensis* Steu.	11	Cajuzinho-do-cerrado; Alecrim-do-campo; Capim-carrapicho; Trapoeraba; Buva; Capim-colchão; Capim-amargoso; Couvinha / arnica paulista; Poaia-branca; Guanxuma; Flor-do-guarujá/ chanana; Salsaparrilha.	Phenolic compounds, cardiotonic heterosides, steroids, flavonoids, anthraquinones, a lkaloids, saponins, reducing sugars.	Ethanolic extract of leaves	Fungicidal potential and antifungal activity	[9]
Franco et al.	2022	*Calycolpus goetheanus* (Myrtaceae)	30	Ameixa-da-praia	Hydrocarbon, sesquiterpenes, especially (E)-caryophyllene, germacrene D, δ-cadinene, oxygenated sesquiterpenes, mainly γ-eudesmol, α-cadinol, epi-α-muurolol.	Essential oil of the leaves	The antioxidant capacity of the evaluated against two weed species	[10]
Giombelli et al.	2025	*Psidium guajava* L.	0	Guava	Saponins, alkaloids, flavonoids, steroids and tannins	Aqueous extract of dried leaves	Interference in the germination process and initial seedling development of *Phaseolus vulgaris*	[11]
Gomes et al.	2024	*Pouteria ramiflora*	0	Curriola; figo do Cerrado	Total phenols, flavonoids, triterpenes, steroids, and reducing sugars	Ethanolic extract of leaves	Germination, fungistatic potential, allelopathic and antioxidant activity	[12]
Grossi et al.	2021	*Hymenaea stigonocarpa* (Fabaceae)	1	Jatobá-do-cerrado	It does not describe the chemical compounds	Aqueous root extract	Germination and elongation of wheat coleoptiles	[13]
Mata et al.	2025	*Callistemon viminalis; Enterolobium contortisiliquum*	0	Escova- de-garrafa; Tamboril; Timbaúva	It does not describe the chemical compounds.	Aqueous extract of dried leaves	Percentage of germination, radicle length, shoot length, germination speed index, and germination time	[14]
Matias et al.	2021	*Tapirira obtusa*	2	Pombeiro; pau-pombo	Phenolic compounds and triterpenes, flavonoids, tannins, and steroids. Coumarins, saponins and reducing sugars	Ethanolic extract of leaves	Seed germination and vigor, and seedling growth	[15]

Nascimento et al.	2022	*Matayba guianensis* Aubl.	0	Mataíba; Camboatá	Tannins; flavones, flavonols and xanthones; chalcones, aurones and flavononols, leucoanthocyatidines, Catechins.	Aqueous extract and extract by infusion	Germination and development of seedlings of *Lactuca sativa* L., (lettuce) and *Cenchrus echinatus* L., (burr), in addition to identifying the classes of secondary compounds present in these extracts	[16]
Novaes et al.	2024	*Annona coriacea* (Annonaceae)	2	Marolo (Araticum)	11 glycosylated flavonols, five quercetin (1–5), two kaempferol (6–7) and four isorhamnetin derivatives (8–11), identified as: Quercetin-3-*O*-gentiobioside (1), Quercetin-3-*O*-robinobioside (2), Rutin (3), Hyperin (4), Isoquercitrin (5), Biorobin (6), Nicotiflorin (7), Keioside (8), Narcissin (9), Cacticin (10) and Isorhamnetin-3-*O*-glucoside (11).	Ethanolic extract of leaves	Elongation of wheat coleoptiles and on germination of diaspores and initial growth of seedlings of standard target species (lettuce and tomato) and a weed	[17]
Oliveira et al.	2022	*Norantea guianensis* (Marcgraviaceae)	0	Rabo-de-arara; Mel-de-arara	Reducing sugars, cardioactive heterosides, saponins, steroids, triterpenes, coumarins, flavonoids, tannins, anthraquinones e phenolic compounds.	Aqueous and ethanolic extract of leaves	Germination and growth leaves and initial growth of lettuce, tomato and coffee senna seedlings.	[18]
Oliveira et al.	2025	*Tapirira obtusa*	0	Pau-pombo	Phenolic compounds, tannins, saponins, triterpenes, flavonoids, steroids, reducing sugars and coumarins	Aqueous extract of leaves	Germination and growth, formation of seedlings of target species (lettuce, tomato and sicklepod),	[19]
Pereira et al.	2022	*Zanthoxylum rhoifolium* (Sapindales: Rutaceae)	9	Mamica-de-porca; mamica-de-cadela	β-myrcene, β-phellandrene, Linalool, Cryptone, 2-undecanone, δ-elemene, α-copaene, Geranyl acetate, Caryophyllene, γ-muurolene, Germacrene D, Bicyclogermacrene, α-cadinene or naphthalene, Spathulenol	Essential oil of the fruits	Photostability and insecticidal activity against *Bemisia tabaci* via nanotechnology	[20]
Pinto; Roma; Kolb.	2023	*Byrsonima intermedia, Moquiniastrum polymorphum, Luehea candicans, Miconia chamissois, and Qualea cordata*	7	Murici-do-campo; Cambará; Açoita-cavalo; Pixirica; Pau-terrinha	Alkaloids, anthraquinones, coumarins, steroids, triterpenoids, flavonoids, saponins, and tannins	Hexane, ethyl acetate, and methanol extracts.	Phytotoxicity on the initial growth of cucumber seedlings and candidates for use as natural herbicides	[21]
Silva et al.	2021	*Caryocar coriaceum* Wittm.	3	Pequi	Flavonoids (Rutin, Quercetin); Phenolic acids (Chlorogenic acid, Caffeic acid, Gallic acid)	Hydroethanolic extract of the leaves	Germination and initial development of lettuce (*Lactuca sativa* L.).	[22]

Silveira et al.	2022	*Amburana cearensis* (Allemão)	15	Umburana-de-cheiro / cerejeira	Coumarins, flavonoids, phenolic glycosides, phenolic acids, phenylpropanoid derivatives, and triterpenoids	Fractions of stem bark, seeds, leaves and resins	Antimicrobial, antinociceptive, anti-inflammatory, antioxidant, neuroprotective, and myorelaxant activities	[23]
Souza et al.	2024	*Eucalyptus urograndis*	0	Eucalipto-urograndis / Urograndis	Monoterpenes, sesquiterpenes, triterpenes and fatty acid derivatives	Aqueous and ethanolic extract of leaves	Germination and growth of *Lactuca sativa* and *Cedrela fissilis* species	[24]
Souza et al.	2025	*Andropogon gayanus*; *Andropogon bicornis*	1	Capim-gamba; Capim-rabo-de-burro.	Do not describe the chemicals	Leaves and roots	Initial growth of two native (*Andropogon fastigiatus* Sw. and *Lepidaploa aurea* (Mart. Ex DC.) H. Rob.) and two exotic species (*Melinis minutiflora* P. Beauv. and *Stapfochloa elata* (Desv.) P.M. Peterson)	[25]
Tahira et al.	2022	*Machaerium amplum*	2	Jacarandá	Apigenin and luteolin C-glycoside derivatives, quinic acid, the A-type proanthocyanidin dimer and trimer, and a saponin Soyasapogenol B type.	Hydroethanolic extract of leaves	Germination, hypocotyl growth, and root length	[26]
Vargas et al.	2021	*Davilla elliptica, Combretum laxum, Himatanthus obovatus, Diteryx alata, Curatella americana, Qualea grandiflora, Aspidosperma macrocarpon, Caryocar brasiliense, Pleroma candolleanum and Miconia albicans.*	1	Lixeirinha; Pombeiro-branco; Pau-de-leite; Cumbaru; Lixeira; Pau-terra; Guatambu; Pequi; Quaresmeira; Folha-branca.	Phenols, alkaloids, flavonoids and terpenes	Aqueous extract of leaves	Germination and initial development of lettuce seedlings	[27]
Vasconcelos et al.	2022	*Myrcia vitoriana* (Myrtaceae)	16	It does not have a common or widely known popular name.	Sesquiterpenes, hydrogenated sesquiterpenes, oxygenated sesquiterpenes, germacrene D, germacrene B, and bicyclogermacrene, all hydrogenated sesquiterpenes.	Essential oil and aqueous and ethanolic extracts	Germination and initial development and cytogenotoxic effects on the cell cycle	[28]
Vela et al.	2021	*Moquiniastrum pulchrum*	4	Cambará	One flavone and five kaurane-type diterpenes, with two of them being described for the first time in the literature: moquinian-A and moquinian-B.	Ethyl acetate, acetone, and methanol extracts of leaves.	Weed Control	[29]
Ximenez et al.	2022	*Miconia auricoma* *M. ligustroides*	9	Jacatirão	Flavonoids, isolated myricetin, and a mixture of quercetin and myricetin	Crude extracts and fractions of *Miconia*	Reduction of weed growth	[30]

* NC = number of citations. Data obtained by Google Scholar, on June 24th, 2026

CONCLUSION

The Brazilian Cerrado harbors a remarkable diversity of endemic and adapted plant species acknowledged for their bioactive metabolites and significant biotechnological promise. Both ethnopharmacological tradition and rigorous scientific scrutiny have identified multiple extracts and isolated compounds capable of phytotoxic, biocidal, antioxidant, antimicrobial, and cytotoxic activities. As demonstrated throughout recent research, several Cerrado species highlighted between 2021 and 2025 possess metabolites with notable potential for sustainable agricultural use, including the development of natural herbicides, pesticides, and functional bioinputs.

The increasing body of knowledge underscores the relevance of harnessing plant-derived fractions as alternatives to conventional agrochemicals, supporting reductions in environmental impact and the restoration of degraded ecosystems. Nevertheless, the transition toward widespread application of Cerrado-derived bioinputs in Brazil still faces regulatory, developmental, and research challenges, as evidenced by the limited number of commercialized and approved biotechnological products. Substantial investment in fundamental research and translational studies remains critical for advancing these discoveries from controlled laboratory assessments to practical, field-level implementation. Ultimately, the systematic integration of natural Cerrado compounds into agroecological frameworks is poised to play a vital role in biodiversity conservation and the evolution of sustainable, technologically advanced agricultural models in Brazil.

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CONFLICT OF INTEREST

We have no conflict of interest to declare

REFERENCES

Almeida-Bezerra, J. W., Bezerra, J. J. L., Silva, V. B. D., Coutinho, H. D. M., Costa, J. G. M. D., Cruz-Martins, N., Hano, C., Menezes, S. A., Morais-Braga, M. F. B. & Oliveira, A. F. M. D. (2022). *Caryocar coriaceum* Wittm.(Caryocaraceae): botany, ethnomedicinal uses, biological activities, phytochemistry, extractivism and conservation needs. *Plants*, *11*(13), 1685. DOI: https://doi.org/10.3390/plants11131685

Alves, P. I., Calvelli, J. V. B., Braga, D. V. B., Neto, A. R. C., Lima, M. N., Bastos, R. G., Silva, M. A., & Barbosa, S. (2025). Comparative evaluation of the allelopathic interference of inside and peripheral extracts of *Eugenia florida* DC leaves on the primary development, mitotic index and chromosomal abnormalities of *Lactuca sativa* L. *Journal of Toxicology and Environmental Health, Part A*, 1–13. DOI: https://doi.org/10.1080/15287394.2025.2552807

Amâncio, B. C. S., Govêa, K. P., Cunha Neto, A. R., Trindade, L. O. R., Souza, T. C., Silva, G. A., & Barbosa, S. (2021). Allelopathic activity of different *Byrsonima* spp. leaf extracts on *Lactuca sativa* L. bioassay. *Biologia*, *76*(11), 3201–3209. https://doi.org/10.1007/s11756-021-00872-0

Anese, S., Rial, C., Varela, R. M., Torres, A., Molinillo, J. M. G., & Macías, F. A. (2021). Search of new tools for weed control using *Piptocarpha rotundifolia*, a dominant species in the Cerrado. *Journal of Agricultural and Food Chemistry, 69*(31), 8684–8694. DOI: https://doi.org/10.1021/acs.jafc.1c01880

Baluska, F., & Souza, G. M. (2024). Plant signaling, behavior and communication. *Plants*, *13*(8), 1132. DOI: https://doi.org/10.3390/plants13081132

Batalha, M. A., & Martins, F. R. (2007). The vascular flora of the cerrado in Emas National Park (Central Brazil): A savanna flora summarized. *Brazilian Archives of Biology and Technology, 50*, 269–277. DOI: https://doi.org/10.1590/S1516-89132007000200012

Bao, F., Lima, L. B. D., & Luz, P. B. D. (2014). Caracterização morfológica do ramo, sementes e plântulas de *Matayba guianensis* Aubl. e produção de mudas em diferentes recipientes e substratos. *Revista Árvore*, *38*, 63-71. DOI: https://doi.org/10.1590/S0100-67622014000100006

Bitencourt, G. A., Gonçalves, C. C. M., Rosa, A. G., Zanella, D. F. P., & Matias, R. (2021). Fitoquímica e alelopatia da aroeira-vermelha (*Schinus terebinthifolius* Raddi) na germinação de sementes. *Ensaios e Ciência: Ciências Biológicas, Agrárias e da Saúde*, *25*(1), 02–08. https://doi.org/10.17921/1415-6938.2021v25n1p02-08

Campos, E. V., Oliveira, J. L., Pascoli, M., De Lima, R., & Fraceto, L. F. (2016). Neem oil and crop protection: From now to the future. *Frontiers in Plant Science, 7*, 1494. DOI: https://doi.org/10.3389/fpls.2016.01494

Carvalho, H. J. M., Barcia, M. T., & Schmiele, M. (2025). Underexploited fruits from the Brazilian Cerrado: Biodiversity, phenolic composition and biological activities. *Food Bioscience, 66*, 106269. DOI: https://doi.org/10.1016/j.fbio.2025.106269

Chen, H., Tsang, Y. P., & Wu, C. H. (2023). When text mining meets science mapping in the bibliometric analysis: A review and future opportunities. *International Journal of Engineering Business Management*, *15*, 1-18. https://doi.org/10.1177/18479790231222349

Dixon, R. A., & Dickinson, A. J. (2024). A century of studying plant secondary metabolism—From "what?" to "where, how, and why?". *Plant Physiology, 195*(1), 48–66. DOI: https://doi.org/10.1093/plphys/kiad596

Franco, C. J. P., Ferreira, O. O., Cruz, J. N., Varela, E. L. P., Moraes, Â. A. B., Nascimento, L. D., Cascaes, M. M., Souza Filho, A. P. S., Lima, R. R., Percário, S., Andrade, E. H. A., & Maia, J. G. S. (2022). Phytochemical profile and herbicidal (phytotoxic), antioxidants potential of essential oils from *Calycolpus goetheanus* (Myrtaceae) specimens, and in silico study. *Molecules*, *27*(15), 4678. https://doi.org/10.3390/molecules27154678

Gama, L. U., Barbosa, A. A. A., & Oliveira, P. E. A. M. (2011). Sistema sexual e biologia floral de *Pouteria ramiflora* e *P. torta* (Sapotaceae). *Brazilian Journal of Botany, 34*, 375–387. DOI: https://doi.org/10.1590/S0100-84042011000300011

Gil, A. C. (2002). *Como elaborar projetos de pesquisa* (4ª ed.). Atlas.

Gomes, P. D. M. F., Oliveira, F. C. V., Oppliger, E. A., Correa, B. O., Bono, J. A. M., & Dalmagro, H. J. (2024). Potencial fungicida, alelopático, antioxidante e citotóxico das folhas de *Pouteria ramiflora*. *Ensaios e Ciência: Ciências Biológicas, Agrárias e da Saúde, 28*(4), 525–531. DOI: https://doi.org/10.17921/1415-6938.2024v28n4p525-531

Guzmán-Guzmán, P., Kumar, A., de Los Santos-Villalobos, S., Parra-Cota, F. I., Orozco-Mosqueda, M. D. C., Fadiji, A. E., Hyder, S., Babalola, O. O., & Santoyo, G. (2023). *Trichoderma* species: Our best fungal allies in the biocontrol of plant diseases—A review. *Plants, 12*(3), 432. DOI: https://doi.org/10.3390/plants12030432

Krause, M. S., Bonette, A., Turnes, J., Dias, J., MiguelL, O., & Duarte, M. (2013). Fitoquímica e atividades biológicas de *Zanthoxylum rhoifolium* Lam., Rutaceae—Mini revisão. *Visão Acadêmica, 14*(4), 118–127. DOI: https://doi.org/10.5380/acd.v14i4.33992

Lima, L. P., Pinheiro, E. B. F., Gois, K. M. S., Silva, N. C. O., & Silva, C. Y. (2022). A utilização de produtos naturais como alternativa para o ensino de química: Uma revisão. *Research, Society and Development, 11*(7), e2111729588–e2111729588. DOI: https://doi.org/10.33448/rsd-v11i7.29588

Matias, R., Pauliquevis, C. F., Ojeda, P. T. A., Pina, J. C., & de Oliveira, A. K. M. (2021). Potencial alelopático de extratos etanólicos e pó de folhas de *Tapirira obtusa* na germinação e formação de plântulas de diferentes espécies-alvo. *Research, Society and Development, 10*(4), e25210413841–e25210413841. DOI: https://doi.org/10.33448/rsd-v10i4.13841

Nascimento, M. P., Torquato, I. H. S., Costa, N. C., Campos, N. B., Santos, M. A. F., & Silva, M. A. P. (2022). Atividade alelopática de *Matayba guianensis* Aubl. sobre *Lactuca sativa* L. e *Cenchrus echinatus* L. *Research, Society and Development, 11*(12), e444111233352–e444111233352. DOI: https://doi.org/10.33448/rsd-v11i12.33352

Novaes, P., Lopes, J. C., Ferreira, M. J. P., & Santos, D. Y. A. C. (2024). Phytotoxicity of glycosylated flavonols extracted from *Annona coriacea* (Annonaceae) on germination and initial growth of standard target species and an invasive grass. *Brazilian Journal of Botany, 47*(3), 625–635. DOI: https://doi.org/10.1007/s40415-024-01018-7

Pereira, K. C., Quintela, E. D., Nascimento, V. A., Silva, D. J., Rocha, D. V. M., Silva, J. F. A., Arthurs, S. P., Forim, M. R., Silva, F. G., & Cazal, C. M. (2022). Characterization of *Zanthoxylum rhoifolium* (Sapindales: Rutaceae) essential oil nanospheres and insecticidal effects to *Bemisia tabaci* (Sternorrhyncha: Aleyrodidae). *Plants, 11*(9), 1135. DOI: https://doi.org/10.3390/plants11091135

Ramalho, P. I. S., & Lopes, A. V. (2022). Reforming the regulatory reform: General law on independent agencies in Brazil. *Revista de Administração Pública, 56*(4), 550–561. DOI: https://doi.org/10.1590/0034-761220220056x

Reshi, Z. A., Ahmad, W., Lukatkin, A. S., & Javed, S. B. (2023). From nature to lab: A review of secondary metabolite biosynthetic pathways, environmental influences, and *in vitro* approaches. *Metabolites, 13*(8), 895. DOI: https://doi.org/10.3390/metabo13080895

Riedo, J., Rillig, M. C., & Walder, F. (2025). Beyond dosage: The need for more realistic research scenarios to understand pesticide impacts on agricultural soils. *Journal of Agricultural and Food Chemistry, 73*(17), 10093–10100. DOI: https://doi.org/10.1021/acs.jafc.4c12818

Rocha, J. D., Carneiro, F. M., Fernandes, A. S., Morais, J. M., Borges, L. L., Chen-Chen, L., Almeida, L. M., & Bailão, E. F. L. C. (2022). Toxic potential of Cerrado plants on different organisms. *International Journal of Molecular Sciences, 23*(7), 3413. DOI: https://doi.org/10.3390/ijms23073413

Rodrigues, J. M. M., & Bessa, E. (2025). A química dos produtos naturais no Brasil: Um estudo a partir das linhas de pesquisa cadastradas no Conselho Nacional de Desenvolvimento Científico e Tecnológico. *Desafios – Revista Interdisciplinar da Universidade Federal do Tocantins, 12*(4), 1–18. DOI: https://doi.org/10.20873/2025_jul_20294

Silva, A. C., Berg, E. V. D., Higuchi, P., & Oliveira Filho, A. T. (2007). Comparação florística de florestas inundáveis das regiões Sudeste e Sul do Brasil. *Brazilian Journal of Botany, 30*, 257–269. DOI: https://doi.org/10.1590/S0100-84042007000200010

Silva, M. S., Miranda, P. H. O., Maciel, P. M. C., Santos, R. L. S., Sousa, K. M. O., Brito, A. M. S. S., Menezes, I. R. A., & Saraiva, R. A. (2021). Efeito alelopático do extrato etanólico das folhas de *Caryocar coriaceum* Wittm. sobre a germinação e desenvolvimento inicial de plântulas de *Lactuca sativa* L. *Revista Brasileira de Meio Ambiente, 9*(3), 040-047. DOI: https://doi.org/10.66205/rvbma.v9i3.896.

Souza, C. M. R., Vaz, C. F., Bazon, J. N., Vieira, T. M., Groppo, M., Crotti, A. E. M., Dias, P. A. S., & Dias, H. J. (2025). Evaluation of biocide effects of *Aloysia gratissima* (Gillies & Hook.) Tronc. essential oils. *Biotechnologie, Agronomie, Société et Environnement, 29*(1), 1–11. https://doi.org/10.25518/1780-4507.20991

Souza, R. C., Mendes, I. C., Reis-Junior, F. B., Carvalho, F. M., Nogueira, M. A., Vasconcelos, A. T. R., Vicente, V. A., & Hungria, M. (2016). Shifts in taxonomic and functional microbial diversity with agriculture: How fragile is the Brazilian Cerrado?. *BMC Microbiology, 16*(1), 42. DOI: https://doi.org/10.1186/s12866-016-0657-z

Vargas, S. H., Camili, E. C., Coelho, M. F. B., Vasconcelos, L. G., Soares, M. A., Sampaio, O. S. M., & Vendruscolo, S. J. (2021). Phytotoxic activity and chemical composition of aqueous foliar extracts of Cerrado species. *Floresta e Ambiente, 28*(3), e20210011. DOI: https://doi.org/10.1590/2179-8087-FLORAM-2021-0011

Vela, F., Anese, S., Varela, R. M., Torres, A., Molinillo, J. M., & Macías, F. A. (2021). Bioactive diterpenes from the Brazilian native plant (*Moquiniastrum pulchrum*) and their application in weed control. *Molecules, 26*(15), 4632. DOI: https://doi.org/10.3390/molecules26154632

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