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AGROECOLOGY IN THE AGRONOMIC CURRICULUM: (IN)VISIBILITY AND STRUCTURAL LIMITS IN HIGHER EDUCATION IN BRAZIL

A AGROECOLOGIA NO CURRÍCULO AGRONÔMICO: (IN)VISIBILIDADE E LIMITES ESTRUTURAIS NA FORMAÇÃO SUPERIOR NO BRASIL

LA AGROECOLOGÍA EN EL CURRÍCULO AGRONÓMICO: (IN)VISIBILIDAD Y LÍMITES ESTRUCTURALES EN LA EDUCACIÓN SUPERIOR EN BRASIL

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ABSTRACT

This article situates the research within the context of recent transformations in Brazilian higher education and the contemporary challenges of professional training in Agricultural Engineering. Although access to higher education has expanded, structural problems persist regarding the quality of training, curricular updating, student retention, and the articulation between teaching, research, and extension. It highlights the persistence of curricula linked to a productivist and technicist model, influenced by the Green Revolution, which prioritizes agribusiness demands over social, environmental, and territorial dimensions. The text reconstructs the historical trajectory of Agronomy programs in Brazil, showing how conservative modernization and agrarian interests have shaped a form of education centered on productivity, intensive use of external inputs, and the homogenization of production systems. In contrast, agroecology is presented as a scientific and political field that integrates ecological principles, social justice, and the valorization of traditional knowledge, constituting a paradigmatic alternative for reorienting agronomic education. The analysis of Course Pedagogical Projects (PPCs in Portuguese) and curricular structures reveals that agroecology appears in a limited, fragmented, and peripheral manner, failing to consolidate as a structuring axis. Its incorporation tends to be instrumental, associated with sustainable practices, without promoting deeper epistemological changes. Furthermore, the persistence of disciplinary curricula and the fragility in integrating socio-environmental and political dimensions reinforce the maintenance of a technicist education, with limited commitment to agroecological transition and sustainability.

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Keywords: Agroecological Transition. Curriculum. Epistemology. Sustainability. Technicism.

RESUMO
Este artigo contextualiza a pesquisa no cenário das transformações recentes do ensino superior brasileiro e dos desafios da formação profissional em Engenharia Agronômica. Embora tenha havido ampliação do acesso, persistem problemas estruturais relacionados à qualidade formativa, atualização curricular, permanência estudantil e articulação entre ensino, pesquisa e extensão. Destaca-se a permanência de matrizes curriculares vinculadas ao modelo produtivista e tecnicista, influenciado pela Revolução Verde, que prioriza demandas do agronegócio em detrimento de dimensões sociais, ambientais e territoriais. O texto recupera o percurso histórico dos cursos de Agronomia no Brasil, evidenciando como a modernização conservadora e os interesses agrários moldaram uma formação centrada na produtividade, no uso intensivo de insumos e na homogeneização dos sistemas produtivos. Em contraposição, apresenta-se a agroecologia como campo científico e político que integra princípios ecológicos, justiça social e valorização de saberes tradicionais, configurando-se como alternativa paradigmática para reorientar a formação agronômica. A análise dos Projetos Pedagógicos de Curso (PPCs) e matrizes curriculares revela que a agroecologia aparece de forma limitada, fragmentada e periférica, sem se consolidar como eixo estruturante. Sua inserção tende a ser instrumental, associada a práticas sustentáveis, sem promover mudanças epistemológicas profundas. Observa-se, ainda, a persistência de currículos disciplinarizados e a fragilidade na integração de dimensões socioambientais e políticas, o que reforça a manutenção de uma formação tecnicista e pouco comprometida com a transição agroecológica e a sustentabilidade.

Palavras-chave: Transição Agroecológica. Currículo. Epistemologia. Sustentabilidade. Tecnicismo.

RESUMEN
Este artículo sitúa la investigación en el contexto de las transformaciones recientes de la educación superior brasileña y los desafíos de la formación profesional en Ingeniería Agronómica. Aunque ha habido ampliación del acceso, persisten problemas estructurales relacionados con la calidad de la formación, la actualización curricular, la permanencia estudiantil y la articulación entre enseñanza, investigación y extensión. Se destaca la persistencia de matrices curriculares vinculadas al modelo productivista y tecnicista, influenciado por la Revolución Verde, que prioriza las demandas del agronegocio en detrimento de dimensiones sociales, ambientales y territoriales. El texto recupera la trayectoria histórica de los cursos de Agronomía en Brasil, evidenciando cómo la modernización conservadora y los intereses agrarios moldearon una formación centrada en la productividad, el uso intensivo de insumos y la homogeneización de los sistemas productivos. En contraposición, se presenta la agroecología como campo científico y político que integra principios ecológicos, justicia social y valorización de saberes tradicionales, configurándose como alternativa paradigmática para reorientar la formación agronómica. El análisis de los Proyectos Pedagógicos de Curso (PPCs) y matrices curriculares revela que la agroecología aparece de forma limitada, fragmentada y periférica, sin consolidarse como eje estructurante. Su inserción tiende a ser instrumental, asociada a prácticas sustentables, sin promover cambios epistemológicos profundos. Se observa, además, la persistencia de currículos disciplinarizados y la fragilidad en la integración de dimensiones socioambientales y políticas, lo que refuerza el mantenimiento de una formación tecnicista y poco comprometida con la transición agroecológica y la sustentabilidad.

Palabras clave: Transición Agroecológica. Currículo. Epistemología. Sustentabilidad. Tecnicismo.

1 INTRODUCTION

Brazilian higher education has undergone significant transformations in recent decades, marked by expanded access, diversification of educational modalities, and ongoing tensions regarding the quality of training. Despite these advances, structural challenges persist, including outdated curricula, weak integration among teaching, research, and extension, and difficulties in responding to contemporary social demands (Gomes *et al.*, 2024). In this context, the system finds itself at a crossroads, still influenced by historically consolidated models while being pressured by emerging social, environmental, and democratic demands (Jacob *et al.,* 2016).

In the field of Agricultural Engineering, these tensions are even more pronounced, as professional training remains strongly tied to a productivist and technicist model aligned with agribusiness demands, often disconnected from socio-environmental dimensions (Jacob *et al.*, 2016). In contrast, agroecology emerges as a scientific and political field that integrates ecological principles, social justice, and the valorization of traditional knowledge, constituting a paradigmatic alternative to conventional agriculture (Altieri, 2002).

In this context, this study aims to analyze the presence of agroecology in Course Pedagogical Projects (PPCs) and curricular structures of Agronomy programs in Brazil, understanding curricula as historical and political constructions. Investigating this process allows for assessing the extent to which agronomic education aligns with contemporary challenges related to sustainability and agroecological transition.

2 LITERATURE REVIEW

The historical constitution of Agronomy programs in Brazil is intrinsically linked to the political, economic, and social dynamics that have structured national agrarian development. Since the imperial period, the institutionalization of agronomic education primarily served the interests of the rural aristocracy and the need for productive modernization, consolidating a training model oriented toward specific economic demands (Melo, 2020; Toscano, 2003). Throughout the 20th century, especially under the influence of the Green Revolution, this model was further reinforced, incorporating a scientific-technological paradigm centered on productivity maximization, intensive use of chemical inputs, and the standardization of agricultural systems. This process not only reshaped productive practices but also reconfigured the epistemological foundations of agronomic education, consolidating a technicist and instrumental rationality (Caporal; Costabeber, 2004).

This educational orientation is consistent with international analyses that highlight the persistence of agricultural curricula structured in a disciplinary and fragmented manner, hindering systemic and integrative approaches to agroecosystems (Francis *et al.*, 2004). In this sense, traditional curricular organization tends to prioritize specialized and decontextualized knowledge at the expense of understanding the ecological, social, and cultural interrelations that constitute contemporary agri-food systems. Such epistemological fragmentation limits the capacity of programs to respond to emerging challenges related to sustainability, food security, and social justice.

Within this context, agroecology emerges as a scientific, practical, and political field that proposes a paradigmatic shift in how agriculture is understood and practiced. Defined as the application of ecological principles to the design and management of sustainable agroecosystems, agroecology broadens the scope of agronomy by integrating biophysical, socioeconomic, and cultural dimensions (Altieri, 2002). International studies reinforce this perspective by indicating that incorporating agroecology into curricula requires an epistemological reconfiguration that goes beyond the mere inclusion of content, demanding changes in how knowledge is produced, validated, and transmitted (Altieri and Francis, 2009).

Recent literature emphasizes that agroecological education constitutes a field of epistemological and political disputes, in which different rural development projects and models of agriculture are contested (Wezel *et al.*, 2009). In this context, agroecological training is not limited to technical instruction but involves critical and reflective pedagogical processes aimed at transforming power relations within agri-food systems (Pimbert, 2018). This perspective aligns with approaches that conceive education as an emancipatory practice, in which knowledge is constructed dialogically and contextually.

Additionally, international research highlights the importance of integrating scientific knowledge with traditional knowledge as a central element of agroecological education. Educational experiences that incorporate territorial practices, social participation, and cultural diversity demonstrate greater potential to foster agroecological transition processes (Rivera-Ferre *et al.*, 2021). This integration challenges the universalizing logic of modern science, proposing a plural epistemology that recognizes the validity of multiple knowledge systems.

In the Brazilian context, although there have been institutional advances, such as the creation of Agroecology Study Centers, structural limitations persist in consolidating this perspective within higher education. Studies indicate that such initiatives, while relevant,

often operate peripherally within institutions, without significantly altering dominant curricular logics (Santos Silva *et al.*, 2017). This condition is corroborated by empirical analyses showing that agroecology appears in a fragmented and non-structural manner in Course Pedagogical Projects, frequently restricted to elective courses or complementary content (Campos *et al.*, 2023).

From a theoretical standpoint, contributions such as those of Gliessman (2014) are fundamental in proposing agroecological transition as a multidimensional process, ranging from improving input efficiency to transforming global food systems. Similarly, Guzman (2018) emphasizes the sociopolitical dimension of agroecology, framing it as a strategy for resistance and the reconfiguration of power relations in rural contexts. In Brazil, Caporal (2009) articulates these dimensions by highlighting agroecology as a paradigm for sustainable rural development, integrating public policies, rural extension, and family farming.

The contribution of Primavesi (2016), in turn, shifts the focus of agronomy toward the centrality of soil biological processes, introducing an ecological approach that breaks with the mechanistic view of agricultural production. This perspective reinforces the understanding of agroecology as a science of complexity, based on the dynamic interaction between natural and social elements.

In light of this framework, the incorporation of agroecology into university curricula must be understood as part of a broader process of paradigmatic dispute, in which different conceptions of science, education, and development are confronted. The analysis of Course Pedagogical Projects thus becomes a key instrument for identifying how these disputes materialize in the education of future agronomy professionals.

Therefore, investigating the presence of agroecology in curricula makes it possible not only to map its formal inclusion but also to understand the limits and potential of its consolidation as a structuring axis of education. The literature converges in indicating that, in most cases, this inclusion remains peripheral and instrumental, failing to promote substantial transformations in the prevailing educational paradigm, thereby highlighting the need to deepen the debate on the epistemological reconfiguration of agronomic education in light of contemporary sustainability challenges.

3 METHODOLOGICAL PROCEDURES

This study understands Course Pedagogical Projects (PPCs) as essential documents that structure and guide higher education programs, considering national curriculum

guidelines and the specific objectives of each institution. The Course Pedagogical Project (PPC) is the document that organizes the academic and pedagogical structure of undergraduate programs, describing the competencies and skills to be developed, curricular contents, teaching methodologies, assessment processes, and formative strategies, in alignment with the National Curriculum Guidelines and with social, territorial, and professional demands (Brazil, 2006).

The analysis of PPCs aims to understand how these documents translate educational policies, incorporate scientific and technological advances, and respond to regional and social demands. A critical examination of documents is essential to evaluate their alignment with the National Curriculum Guidelines and their effectiveness in preparing professionals committed to social transformation. As highlighted by Campani *et al.* (2019), curricular innovation, expressed in PPCs, requires the integration of intercultural dimensions, socially constructed epistemologies, and the articulation of teaching, extension, and research as key elements of a more inclusive and context-responsive education.

This doctoral research analyzes foundational documents from Agronomy (or Agricultural Engineering) undergraduate programs across Brazil. The initial phase consisted of cataloging available documents from institutional websites. It is noteworthy that many universities provide only curricular matrices, while others do not publicly disclose any course information. This stage aimed to support a second phase, involving an individual analysis of each document to verify whether agroecology is explicitly or implicitly incorporated into the training of future agronomists.

The study covered the full set of available documents that guide the courses for Agronomy programs in Brazil. To manage this volume of data, extraction criteria were previously validated through a pilot study, ensuring the representativeness of variables such as geographic region, funding type, and course schedule. The systematization followed a rigorous protocol to identify institutional profiles and curricular structures.

In the first stage of analysis, an exploratory search was conducted within the PPCs using terms that, although not explicitly referring to “agroecology,” could indicate its implicit presence. The selected keywords included “organic,” “bioinput,” “biodynamic,” “permaculture,” and “regenerative,” chosen due to their conceptual proximity to agroecological practices. According to Altieri (2009), agroecology should be understood not merely as a set of techniques, but as a paradigm integrating traditional and scientific knowledge across ecological, economic, social, and cultural dimensions. Similarly, Abreu *et*

al. (2012) highlight the intersection between organic agriculture and agroecology as a hybrid field combining scientific, practical, and socio-political elements.

In a second stage, a mapping of additional keywords related to sustainability and agroecology was conducted. The terms “agroecology,” “sustainability,” “certifica” (as an indirect reference to certification processes, particularly agroecological ones), and “climatic” (including variations such as climate and climate change) were analyzed. After the pilot study, it was observed that some initial terms were not consistently identified; therefore, the final analytical framework focused on the terms “agroecology,” “sustainability,” “certifica,” and “bioinput.”

In addition to keyword analysis, the study also investigated direct references to key authors in the field of agroecology and socio-environmental studies, considered central to the epistemological construction of this approach. The following authors were examined: Miguel Altieri (“Altieri”), Stephen Gliessman (“Gliessman”), Francisco Caporal (“Caporal”), Ana Primavesi (“Primavesi,” specifically in relation to agroecology rather than soil science disciplines), Eduardo Sevilla Guzmán (“Guzmán”), and José Antônio Costabeber (“Costabeber”). The following section presents and discusses the results obtained from the qualitative analysis of the examined documents.

4 RESULTS AND DISCUSSION

The analysis of the 287 institutional documents identified, composed predominantly of Course Pedagogical Projects (PPCs) and, to a lesser extent, curricular matrices, reveals a national process of institutionalization of agroecology and sustainability within Brazilian higher education, particularly in the fields of Agricultural Sciences, Rural Education, and related areas. The predominance of PPCs in the empirical corpus reinforces their role as key mediators between educational policies, institutional projects, and concrete training practices, as they systematically express the epistemological, pedagogical, and political-institutional foundations of academic programs.

As discussed by Saviani (2011) and Libâneo (2017), the pedagogical project constitutes a privileged space for articulating conceptions of education and the social commitments assumed by institutions. In this sense, the analyzed PPCs should not be understood merely as technical-administrative instruments, but as political-pedagogical artifacts in which disputes over models of science, development, and society–nature relations are materialized.

Initially, it is noteworthy that, of the 287 documents analyzed, 195 correspond to Course Pedagogical Projects (PPCs) and 92 to curricular matrices, highlighting the predominance of PPCs as the main documentary source of the study. Regionally, the documents are distributed as follows: 82 from the Southeast, 78 from the South, 51 from the Midwest, 43 from the Northeast, and 33 from the North, indicating a greater concentration in the South and Southeast regions, historically more consolidated in terms of Agronomy program offerings.

Regarding the validity period of the documents, 96 PPCs/matrices are up to 3 years old, 40 are between 4 and 6 years old, 39 between 7 and 10 years, and 39 are over 10 years old, revealing the coexistence of recent documents and significantly outdated curricula, which directly impacts the updating of content related to agroecology, sustainability, and climate change. Additionally, it was not possible to identify the publication year of 73 PPCs/matrices.

In terms of institutional funding, 124 documents are from federal public institutions, 38 from state public institutions, 2 from municipal public institutions, and 123 from private institutions, demonstrating a strong presence of both the federal public system and the private sector in the analyzed agronomic training.

Regarding the schedule and modality of program delivery, full-time in-person programs predominate (157), followed by evening in-person programs (59), distance education (22), morning in-person programs (11), and alternating regimes (3). This pattern confirms the centrality of the full-time in-person model in agronomic education, with still limited participation of alternative modalities such as distance learning and alternation. It is also noted that 35 PPCs/matrices did not clearly specify their modality and schedule. Furthermore, the number of analyzed documents is lower than the number of active programs in Brazil, an issue discussed below.

4.1 AVAILABILITY OF PPCS AND INSTITUTIONAL TRANSPARENCY

It was observed that, of the 492 Agronomy programs identified in official databases, only 287 Course Pedagogical Projects (PPCs) or equivalent documents, containing curricular matrices and course descriptions, are publicly available online. This indicates that approximately 42% of programs do not have accessible PPCs, which, beyond being a quantitative finding, also constitutes a qualitative indicator that warrants critical analysis.

The unavailability of essential academic information, such as PPCs, raises concerns about institutional practices related to transparency and access to information, which are

fundamental principles of public administration in Brazil, as established by Law No. 12,527/2011, the Access to Information Law (LAI). According to this law, public bodies and entities must ensure the fundamental right of access to information by promoting the disclosure of documents and data of collective interest, especially those related to public education.

From a critical perspective, Freire (1996) emphasized that democratic education presupposes access to knowledge and formative processes as a condition for the development of autonomous and critical subjects. In this sense, when documents such as PPCs are not publicly available, there is not only a restriction of bureaucratic information, but also a limitation on access to socially produced knowledge, directly impacting the principles of emancipatory education.

From a legal and normative standpoint, both the National Education Plan (PNE 2014–2024) and the National Curriculum Guidelines (DCNs) for undergraduate programs reinforce that higher education must align with principles of transparency, social responsibility, and sustainable development (Brazil, 2014; Brazil, 2006). Furthermore, the 1988 Federal Constitution, in Article 37, establishes the publicity of administrative acts as a fundamental principle of public administration, essential for ensuring citizenship and social control.

This scenario of limited availability of PPCs compromises not only academic research that seeks to analyze the alignment of programs with contemporary demands, such as agroecology, sustainability, and climate change, but also weakens mechanisms for monitoring by civil society, students, social movements, and professional councils.

According to Demo (2000), the construction of citizenship occurs, among other aspects, through the appropriation of knowledge, which requires unrestricted access to public information, especially in the field of education, which is foundational for socially and environmentally responsible development.

Therefore, the preliminary data point not only to a methodological limitation but also to an ethical and political challenge related to the necessary democratization of educational processes, which includes free access to pedagogical projects that guide the training of professionals who will directly act in the transformation of Brazil's agricultural, rural, and environmental sectors.

4.2 INTEGRATION OF AGROECOLOGY INTO CURRICULA: HETEROGENEITY AND STRUCTURAL LIMITS

The analysis of PPCs from different higher education institutions in Brazil reveals a heterogeneous landscape regarding the integration of agroecology, sustainability, and climate change into the training of future agronomy professionals. It is important to reiterate that this study, based on documentary analysis of PPCs, aims to understand how these themes are incorporated into curricula and pedagogical proposals.

The results indicate that agroecology frequently appears as a guiding axis of training in the analyzed documents. However, qualitative analysis reveals significant heterogeneity in the epistemological depth attributed to the concept. In some PPCs, agroecology is conceived as a critical scientific paradigm, aligned with contemporary literature that defines it as science, practice, and social movement (Gliessman, 2018; Wezel *et al.*, 2020).

From this perspective, agroecology is understood as a process of paradigmatic transition that goes beyond the technical-productive dimension and explicitly incorporates social, cultural, political, and territorial dimensions. Gliessman (2018) argues that agroecology implies the reconfiguration of food and production systems based on principles of social justice and ecological sustainability, assigning higher education a strategic role in building alternatives to the hegemonic agro-industrial model.

However, the results also show that, in a significant portion of the documents, agroecology is appropriated in an instrumental way, predominantly associated with sustainable practices, environmental impact mitigation, or alternative techniques. This trend indicates a partial dilution of the critical character of agroecology, bringing it closer to sustainability discourses compatible with the logic of ecological modernization. This finding aligns with critiques by Caporal and Costabeber (2004), reinforced by Guzmán (2018), who warn about the risks of depoliticizing agroecology when it is reduced to a technical repertoire.

The data demonstrate that, among the analyzed courses, agroecology appears in diverse ways, including mandatory, optional, or elective courses, as well as punctual mentions in syllabi, objectives, or graduate profiles. Despite being present in several documents, agroecology does not, in most cases, function as a structuring axis of training, but rather as a peripheral content. This scenario reveals that, although the importance of the theme is acknowledged, its effective curricular integration remains limited, reinforcing the persistence of conventional agricultural paradigms (Altieri, 2009; Gliessman, 2014).

This result reveals the coexistence, within curricula, of distinct educational projects: on one hand, an adaptive project aimed at reconciling the dominant production model with environmental demands; on the other, an emancipatory project that understands agroecology as a structural critique of agribusiness, the commodification of nature, and socio-territorial inequalities.

4.3 CERTIFICATION AND BIOINPUTS: INSTITUTIONALIZATION, MARKET DYNAMICS, AND THE TECHNIFICATION OF AGROECOLOGY

The analysis of the occurrence of the category's “certification” and “bioinputs” in PPCs and curricular matrices reveals key elements for understanding contemporary processes of agroecology institutionalization in higher education. Although both categories appear less frequently than terms such as sustainability and agroecology, their presence is qualitatively significant, as it directly relates to the interfaces between regulation, market, public policies, and agroecological practices.

The presence of the “certification” category in the analyzed documents indicates that some courses incorporate, albeit in a limited way, the debate on certification of organic and agroecological products. However, qualitative analysis suggests that certification is mostly treated from a normative and procedural perspective, associated with compliance with legal requirements, insertion into differentiated markets, and adaptation to formal control systems.

This approach tends to emphasize certification as a technical-administrative tool, to the detriment of its political and social dimensions. This finding aligns with critiques by Renard (2005), Locanto and Fouilleux (2019), who argue that certification systems may reinforce processes of standardization, bureaucratization, and commodification of agroecological production, especially when primarily guided by market logics.

Within the field of agroecology, authors such as Guzmán (2018) and Wezel *et al.* (2020) highlight that certification, when disconnected from territorial and organizational processes, may contribute to the co-optation of agroecology by the dominant agri-food system. Guzmán (2018) argues that the institutionalization of agroecology through market mechanisms tends to displace its transformative character, reducing it to a productive niche compatible with green capitalism.

On the other hand, the literature also highlights alternative experiences such as Participatory Guarantee Systems (PGS), which seek to articulate certification, social control, collective organization, and the territorial construction of trust (Brandenburg; Billaud, 2020).

However, the analysis of PPCs indicates that these approaches appear in a limited or insufficiently developed manner, suggesting that certification is more often treated as an external requirement than as an educational, political, and organizational process.

From a training perspective, this result is significant, as it points to the risk of educating professionals with a technicist understanding of certification, centered on norms and audits, without adequate critical reflection on its social, economic, and territorial implications. This gap compromises the formative potential of agroecology as a counter-hegemonic project, as argued by Gliessman (2018) and Leff (2015).

The category of bioinputs also appears only sporadically in the analyzed documents, generally associated with replacing chemical inputs with biologically derived products, such as biofertilizers, biostimulants, and biological control agents. Qualitative analysis indicates that, in most cases, bioinputs are approached from a technological and productivist logic, emphasizing their agronomic efficiency and their potential to reduce environmental impacts.

This approach reflects a broader movement of incorporating bioinputs into public policies and agribusiness strategies, particularly in the context of so-called “low-carbon agriculture” and green technological transition (Pereira and Silva, 2020; MAPA, 2023). However, several authors warn that the centrality given to bioinputs may lead to a technification of agroecology, shifting the focus from ecological, territorial, and social processes to predominantly technological solutions.

Altieri and Nicholls (2020) emphasize that agroecology cannot be reduced to the substitution of inputs, even biological ones, as this maintains the logic of external dependency and the industrial rationality of agriculture. According to the authors, replacing chemical inputs with biological ones, without structural changes in agroecosystem design, tends to reproduce the same logic of the conventional model, albeit with a “green” appearance.

Similarly, Gliessman (2018) argues that agroecological transition should prioritize the redesign of production systems based on diversity, ecological cycles, and farmers' autonomy, rather than merely replacing inputs. An excessive emphasis on bioinputs, when disconnected from these principles, may contribute to maintaining technological dependency and the commodification of knowledge.

The presence of the categories “certification” and “bioinputs” in PPCs clearly highlights the tension identified throughout the analysis between two educational projects: (i) an adaptive project, which seeks to align agroecology with market, regulatory, and technological

innovation demands; and (ii) an emancipatory project, which understands agroecology as a process of structural transformation of agri-food systems and society–nature relations.

From a higher education perspective, this tension has direct implications for student training. When certification and bioinputs are approached predominantly through a technical and normative lens, there is a risk of training professionals oriented toward compliance management and process optimization, rather than toward critical, territorially grounded, and politically engaged formation, as advocated in the literature on rural education and agroecology (Caldart, 2019).

Thus, the results suggest that these themes should be addressed more deeply in PPCs, explicitly incorporating discussions on: the limits of certification as a market mechanism; the role of Participatory Guarantee Systems; the risks of agroecology technification through bioinputs; and the centrality of autonomy, agroecological redesign, and socio-territorial organization.

Such analytical expansion is essential to prevent agroecological training from being progressively captured by a logic of green adaptation of the dominant model, thereby undermining its critical and transformative potential, as warned by Wezel *et al.* (2020), Altieri and Nicholls (2020), and Leff (2015).

4.4 INTERDISCIPLINARITY, CURRICULAR FRAGMENTATION, AND ENVIRONMENTAL RATIONALITY

Although interdisciplinarity is widely mentioned in PPCs as a pedagogical principle, the analysis of curricular matrices reveals the persistence of a strongly disciplinary and fragmented organization. This result confirms the literature pointing to the difficulty higher education institutions face in effectively operationalizing interdisciplinary and transdisciplinary approaches, even when these are discursively recognized as necessary (Morin, 2011).

The concentration of agroecological content within specific disciplines, without effective transversal integration across other curricular components, highlights structural limits to the consolidation of a systemic form of education. This fragmentation compromises the integrated understanding of agroecosystems and socio-environmental dynamics, a central aspect of contemporary agroecological training, as argued by Wezel *et al.* (2020).

From the perspective of environmental rationality, Leff (2015) argues that overcoming the socio-environmental crisis requires transforming the epistemological foundations of knowledge, which implies breaking with the fragmented logic that separates nature, society,

ethics, and politics. The results indicate that, despite recognition of this complexity in institutional discourse, curricula still largely operate under a modern rationality centered on the compartmentalization of knowledge.

4.5 WORKLOAD, CURRICULAR UPDATING, AND CONTEMPORARY CHALLENGES

Quantitative results indicate a high average workload for the courses (mean ≈ 4,041 hours), suggesting favorable institutional conditions for the development of more integrated and in-depth training processes. However, the average duration of validity of the documents reveals challenges related to curricular updating, especially in light of recent debates on the climate crisis, agroecological transition, food sovereignty, and socio-environmental justice.

Caporal *et al.* (2006) emphasize that agroecological training requires dynamic curricula that are continuously revised and territorially grounded, capable of incorporating new issues and theoretical-political advances in the field. The temporal lag identified in part of the PPCs may contribute to maintaining curricula that do not fully engage with the increasing complexity of contemporary challenges.

4.6 AGROECOLOGY AS A STRUCTURING AXIS: INTERPRETATIVE SYNTHESIS

In summary, the data reveal a fragmented, instrumental, and decontextualized presence of concepts associated with agroecology. Rather than constituting a structuring axis of the curriculum, these concepts appear mostly in a dispersed, technical, and limited manner, often restricted to specific curricular components or occasional mentions in PPCs, without organic articulation with other areas of training.

This configuration shows that, in a large portion of the analyzed programs, agroecology is incorporated more as an additional content or discursive device than as an epistemological framework guiding training. This finding corroborates literature that problematizes the institutionalization of agroecology in higher education, which often results in its partial appropriation, weakening its critical and transformative potential (Guzmán, 2018; Wezel *et al.,* 2020).

As argued by Gliessman (2018), agroecology as a paradigm implies not only the inclusion of new disciplines or content, but a profound reorganization of curricular structures, pedagogical methodologies, and conceptions of science that guide training. When curricula maintain a fragmented and disciplinary logic, agroecology tends to be reduced to alternative

practices or “green” techniques, reproducing, under a new guise, the productivist rationality of the conventional model.

This process can be interpreted, in light of Leff (2015), as an expression of the persistence of dominant economic and technoscientific rationality, which subordinates ecological, social, and ethical principles to demands for efficiency and competitiveness. In this perspective, the occasional presence of agroecology in PPCs does not necessarily represent a paradigmatic rupture, but may function as a mechanism of “green” adaptation of the curriculum, aligning it with contemporary sustainability discourses without altering its structural foundations.

Furthermore, the observed fragmentation compromises the articulation between agroecology, territory, and social subjects, an essential element for critical training in the fields of Agricultural Sciences and Rural Education. As highlighted by Caldart (2019), agroecology as an educational project must be rooted in territories, social practices, and processes of collective organization, requiring curricula that integrate ecological, social, political, and cultural dimensions in a transversal manner.

Thus, the analyzed data reinforce the need for effective integration of agroecology as a structuring axis of training, overcoming its current condition as peripheral or technical content. Such integration requires not only expanding the nominal presence of the term in PPCs, but also transforming the epistemological foundations of the curriculum, adopting participatory methodologies, and valuing the dialogue of knowledge, as advocated by Altieri and Nicholls (2020), Wezel *et al.* (2020), and Gliessman (2018).

Therefore, the analysis supports the argument that the central challenge lies not merely in “including” agroecology in the curriculum, but in reconfiguring the educational project so that agroecology moves from a marginal position to one that structurally and transversally guides conceptions of science, development, education, and society–nature relations within agronomic training.

4.7 MOBILIZED THEORETICAL FRAMEWORKS: CITATION PATTERNS AND EPISTEMOLOGICAL IMPLICATIONS

Finally, the analysis of the occurrence of authors such as Altieri, Gliessman, Caporal, Primavesi, Guzmán, and Costabeber in PPCs and curricular matrices constitutes a relevant indicator of the epistemological frameworks that explicitly or implicitly guide training in agroecology and related fields. These authors are widely recognized as foundational

references in the agroecological field, both in its scientific and political-pedagogical dimensions. Therefore, their presence (or absence) in institutional documents provides important insights into the degree of alignment of curricula with the critical agroecological paradigm.

The results indicate a higher incidence of the names Stephen Gliessman and Francisco Caporal, suggesting that these authors occupy central positions as references in the analyzed documents. The recurring presence of Gliessman points to the valorization of agroecology as an applied scientific field, particularly regarding ecological principles of agroecosystems, sustainable management, and the technical foundations of agroecological transition (Gliessman, 2018).

However, the way Gliessman is mobilized in PPCs, as evidenced by the broader qualitative analysis, tends to privilege its technical-ecological dimension, often detached from its more recent contributions on food systems, social justice, and structural transformation. This reinforces the already identified trend of agroecology's technification, in which ecological principles are incorporated without adequate articulation with the political and social dimensions of the paradigm.

The recurrence of caporal, in turn, indicates the strong influence of the Brazilian tradition of critical rural extension and public policies oriented toward agroecology. Caporal is often associated with institutional approaches, agroecological extension methodologies (ATER), and productive transition processes. However, similarly to what was observed with Gliessman, the analysis suggests that his contributions are often appropriated in an operational manner, emphasizing instruments, policies, and practices without equivalent depth in his critique of the dominant rural development model (Caporal and Costabeber, 2004; Caporal *et al.,* 2020).

The relatively limited presence of Miguel Altieri is a qualitatively significant finding, given that Altieri is one of the main formulators of the agroecological paradigm in its critical, political, and Latin American dimension. Altieri and Nicholls (2020) emphasize agroecology as a project of resistance to agribusiness, productive homogenization, and technological dependency.

The low incidence of Altieri suggests a possible weakening of the political-structural dimension of agroecology in curricula, reinforcing the hypothesis that the paradigm has been progressively reconfigured as a technical approach to sustainability, rather than as a counter-hegemonic framework. This result aligns with the observed trend of fragmentation and

instrumentalization of agroecology, as well as with the centrality of authors more closely associated with the institutional operationalization of the field.

The occurrence of ana maria Primavesi indicates recognition of her fundamental contribution to the ecological understanding of soil and critique of conventional management. However, the analysis suggests that Primavesi is often mobilized in a sectoral manner, mainly associated with soil biology and ecological fertility.

This partial appropriation tends to reduce the breadth of her contribution, which goes beyond technical aspects to include a profound critique of the mechanistic rationality of modern agriculture (Primavesi, 2016). The limitation of Primavesi's presence to soil-related content reinforces, once again, the compartmentalization of agroecological references, rather than promoting an integrated approach.

The low incidence of Eduardo Sevilla Guzmán and José Antônio Costabeber is particularly relevant analytically, as both are central authors in framing agroecology as a sociopolitical project linked to peasant struggles, food sovereignty, and critique of capitalist development in rural contexts.

Guzmán (2018) is widely recognized for his contribution to political agroecology and critical rural sociology, emphasizing agroecology as a strategy of resistance and social transformation. Similarly, Costabeber has played a central role in consolidating agroecology in Brazil, articulating technical, political, and educational dimensions.

The limited recurrence of these authors suggests that the political, historical, and socio-territorial dimensions of agroecology occupy a secondary position in the analyzed PPCs. This finding reinforces the interpretation that curricula tend to prioritize an agroecology compatible with processes of institutionalization, regulation, and market integration, rather than one linked to structural transformation and social justice projects.

Taken together, the results regarding the occurrence of authors reveal an epistemological pattern consistent with the broader findings of the study: agroecology is predominantly appropriated through frameworks that favor its technical and institutional operationalization, while authors more closely associated with structural critique, political agroecology, and socio-territorial struggles occupy a less central role.

This pattern reinforces the hypothesis that the analyzed training is predominantly oriented toward an adaptive agroecology, aimed at improving the environmental performance of the existing model, rather than an emancipatory agroecology committed to transforming

agri-food systems and power relations in rural contexts, as advocated by Aaltieri and Nicholls (2020), Guzmán (2018), and Wezel *et al.* (2020).

From a higher education perspective, these findings are particularly relevant, as they indicate that curricula tend to produce professionals with strong technical-ecological expertise, but with limited depth in the political, historical, and territorial dimensions of agroecology. This configuration constrains the critical formative potential and reinforces the need to rebalance the theoretical frameworks mobilized, incorporating more systematically authors and approaches that emphasize agroecology as a scientific, political, and educational project of social transformation.

4.8 FINAL ANALYTICAL CONSIDERATIONS OF THE ARTICLE RESULTS

The results presented and discussed in this chapter demonstrate that the training of agronomy engineers in Brazilian higher education, with regard to the incorporation of Agroecology, is shaped by structural tensions between distinct educational projects. Although the Course Pedagogical Projects and curriculum matrices reveal the formal presence of Agroecology, sustainability, and related themes, their integration occurs predominantly in a fragmented, instrumental, and peripheral manner, not constituting, in most cases, a structuring epistemological axis of professional training.

The integrated analysis of quantitative and qualitative data indicates that Agroecology has been incorporated mainly as a technical complement to conventional agronomic training, rather than as a framework capable of reorienting, in a transversal manner, the conceptions of science, technology, rural development, and society–nature relations that underpin the professional practice of agronomy engineers. This configuration contributes to the maintenance of a productivist rationality, even when framed within sustainability discourses, thereby limiting the critical formative potential of Agroecology as an alternative paradigm.

The centrality given to technical-operational approaches, expressed, for instance, in how categories such as certification and bioinputs are addressed in the PPCs, reinforces a logic of “green adaptation” in training. This approach is oriented toward environmental compliance management, participation in differentiated markets, and the incorporation of technological innovations, without substantially questioning the foundations of the dominant agro-industrial model. Such a training pattern tends to prioritize competencies related to productive efficiency and regulatory compliance, to the detriment of a formation oriented

toward critical reading of territories, socio-territorial inequalities, and the socio-environmental implications of production systems.

The persistence of a fragmented curricular organization, even in the presence of discursive recognition of interdisciplinarity, reinforces the continuity of a modern epistemological matrix centered on the compartmentalization of knowledge. This structure limits the capacity of future agronomists to understand agroecosystems as complex systems in which ecological, social, economic, cultural, and political dimensions are inseparably intertwined. As a result, training tends to reproduce a technicist view of agronomic practice, with limited space for dialogue of knowledges, territorial knowledge construction, and integration between academic science and traditional knowledge.

From an institutional perspective, the low public availability of PPCs and curricular documents reveals weaknesses in transparency and access to information processes, directly affecting the possibility of critical monitoring of agronomic training by society, students, and social movements. This limitation compromises not only academic research but also the democratic character of constructing educational projects, restricting public debate on the directions of professional training in a strategic sector for the country's rural and environmental development.

The analysis of the theoretical references mobilized in the PPCs reinforces this diagnosis, highlighting the predominance of authors associated with the technical and institutional operationalization of Agroecology, to the detriment of frameworks more closely linked to political agroecology, structural critique, and socio-territorial struggles. This epistemological pattern contributes to the training of agronomists with strong technical-ecological expertise, but with less depth in the historical, political, and territorial dimensions of agrarian issues and agroecological transition.

In summary, the results support the thesis that the main challenge in agronomy training within the context of Agroecology lies not merely in the quantitative expansion of disciplines or content, but in the profound reconfiguration of the educational project. This implies enabling Agroecology to guide, in a transversal and epistemologically consistent manner, the conceptions of science, curriculum, professional practice, and rural development. Such reconfiguration requires shifting Agroecology from a peripheral position to a structuring role in education, articulating technical competencies with critical training, territorial commitment, socio-environmental ethics, and the capacity for transformative action in the face of the contemporary socioecological crisis.

5 CONCLUSIONS

This research systematically analyzed Course Pedagogical Projects (PPCs) and curricular documents of Agronomy programs in Brazilian higher education, with the aim of understanding how Agroecology, sustainability, and related themes have been incorporated into the training of future agronomy engineers. The documentary analysis, combining quantitative and qualitative approaches, made it possible to identify patterns, limitations, and contradictions in the processes of institutionalizing Agroecology within curricula, thus contributing to the academic debate on professional education, curriculum, and agroecological transition.

The results show that, although Agroecology is formally present in a significant portion of the analyzed PPCs, its inclusion occurs predominantly in a fragmented, instrumental, and peripheral manner, not constituting, in most cases, a structuring axis of the educational project. This configuration indicates that Agroecology has been incorporated mainly as a technical complement to conventional agronomic training, without systematically promoting a reconfiguration of the conceptions of science, technology, rural development, and society–nature relations that guide the professional practice of agronomy engineers.

The research also revealed that curricular organization remains strongly marked by disciplinary fragmentation, despite the discursive recognition of interdisciplinarity and the complexity of socio-environmental problems. This structure limits the training of professionals capable of understanding and intervening in agroecosystems from a systemic, integrated, and territorialized perspective, reinforcing the persistence of a technicist and productivist rationality in agronomic education.

Regarding the specific categories analyzed, such as certification and bioinputs, the results indicate that these themes are predominantly addressed through a normative and technological lens, associated with environmental compliance management and input substitution. This occurs to the detriment of critical approaches that problematize their limits, sociopolitical implications, and relationship with farmers' autonomy and territorial processes of agroecological transition. This finding reinforces the interpretation that the analyzed training tends to privilege an adaptive form of Agroecology, aimed at reconciling the dominant production model with environmental requirements, rather than an emancipatory Agroecology committed to the structural transformation of agri-food systems.

Additionally, the analysis of the theoretical references mobilized in the PPCs revealed an epistemological pattern that prioritizes authors and approaches linked to the technical and

institutional operationalization of Agroecology, while frameworks associated with political agroecology, structural critique, and socio-territorial struggles occupy a secondary position. This pattern contributes to the training of professionals with solid technical-ecological expertise, but with less depth in the historical, political, and territorial dimensions of agrarian issues and agroecological transition.

From an institutional perspective, the limited public availability of PPCs and curricular documents constitutes a relevant finding, as it reveals weaknesses in transparency and access to information processes, with direct implications for social oversight, academic research, and the democratic character of constructing educational projects. This scenario highlights the need to strengthen institutional practices of transparency and public access to pedagogical projects, in line with the principles of public administration and the democratization of knowledge.

In terms of contributions, this thesis demonstrates that consolidating Agroecology as a structuring axis in the training of agronomy engineers requires more than the quantitative expansion of disciplines or specific content. It demands a profound reconfiguration of the educational project, involving transformations in the epistemological foundations of the curriculum, pedagogical organization, teaching methodologies, and the relationship between universities, territories, and social actors. Such reconfiguration implies the transversal integration of technical, ecological, social, political, and cultural dimensions, fostering a form of education oriented toward critical analysis of agrarian reality, socio-environmental commitment, and transformative professional practice.

Finally, the research points to the need for further studies that combine documentary analysis with empirical investigations into pedagogical practices, perceptions of faculty and students, and the impacts of training on graduates' professional performance. Such studies may contribute to a more comprehensive understanding of how curricula are materialized in the daily life of academic programs and to what extent they effectively support the training of agronomists committed to agroecological transition processes, socio-environmental justice, and sustainable territorial development.

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