VERIFICATION OF THE PRACTICES OF THE EUROPEAN UNION REGULATORY FRAMEWORK AND COMPARATIVE ANALYSIS WITH THE CAPABILITIES AND REQUIREMENTS OF GOOD PRACTICES IN PRECISION SEEDING IN BRAZIL.

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ABSTRACT

Global digital and precision agriculture is undergoing a period of technological and regulatory transition; the recent approval of the free trade agreement between Mercosur and the European Union inaugurates a new era for Brazilian agribusiness. Given the growing global demand for operational efficiency, Brazilian technology for active seed metering and high-speed delivery emerges as a high-value-added solution. However, the commercialization of these components in the European market requires technical harmonization between Brazilian practices and the bloc's certification requirements. This study aims to examine the European Union's regulatory framework standards applicable to agricultural machinery and conduct a comparative analysis with the technical capabilities of Brazilian active seed delivery technologies, considering that the European market hosts major precision seeding players such as Amazone, Horsch, and Väderstad, among others. The objective was to identify the requirements necessary for high-speed seeding technology developed in Brazil to be integrated and marketed in machines within the European market in the near future. The research utilized a qualitative-comparative approach, analyzing the guidelines of the "Farm to Fork" strategy—which aims to achieve climate neutrality for the European Union by 2050—and CE Marking requirements in relation to the testing protocols and best seeding practices of the Brazilian Commission for Precision Agriculture (CBAP). Parameters of functional safety, industrial cybersecurity (essential for electronic planters), and data reporting capacity for traceability required by the EU Deforestation Regulation (EUDR) were evaluated. The results indicate that Brazilian active seeding systems exhibit superior performance in soil conditions with mulch cover (crop residue), aligning with the European goal of reducing erosion and soil conservation through atmospheric CO_2 sequestration, thereby improving soil health and fertility, increasing water retention, erosion resistance, and biodiversity, which brings economic and environmental benefits. It is concluded that Brazilian high-speed seeding technology possesses the mechanical and electronic maturity to compete in Europe, provided it is integrated with data auditing protocols that allow European farmers to verify input application

precision. Convergence with EU standards not only facilitates the export of components but also elevates the standards of transparency and efficiency in precision seeding within the domestic market.

Keywords: High-speed Seeding; Precision Agriculture; CE Marking.

RESUMO

A agricultura digital e de precisão global atravessa um período de transição tecnológica e regulatória, a recente aprovação do acordo de livre comércio entre o Mercosul e a União Europeia inaugura uma nova etapa para o agronegócio brasileiro. Diante da crescente demanda mundial por eficiência operacional, a tecnologia brasileira de dosagem ativa de sementes e condução em altas velocidades surge como uma solução de alto valor agregado. No entanto, a comercialização desses componentes no mercado europeu exige a harmonização técnica entre as práticas brasileiras e os requisitos de certificação do bloco. Este trabalho visa verificar os padrões do arcabouço regulatório da União Europeia aplicáveis a máquinas agrícolas e realizar uma análise comparativa com as capacidades técnicas das tecnologias brasileiras de condução ativa de sementes, visto que o mercado europeu possui grandes players em semeadura de precisão, como Amazone, Horsch, Väderstad, entre outros. Objetivou-se identificar os requisitos necessários para que a tecnologia de semeadura em alta velocidade desenvolvida no Brasil seja integrada e comercializada em máquinas no mercado europeu em um futuro próximo. A pesquisa utilizou uma abordagem qualitativo-comparativa, analisando as diretrizes da Estratégia "Do Prado ao Prato" (From Farm to Fork), cujo objetivo é alcançar a neutralidade climática para a União Europeia até 2050, e os requisitos da Marcação CE em relação aos protocolos de teste e boas práticas de semeadura da Comissão Brasileira de Agricultura de Precisão (CBAP). Foram avaliados parâmetros de segurança funcional, cibersegurança industrial (essencial para semeadoras eletrônicas) e a capacidade de reporte de dados para rastreabilidade exigida pelo Regulamento da UE para Produtos Livres de Desmatamento (EUDR). Os resultados indicam que os sistemas brasileiros de semeadura ativa exibem desempenho superior em condições de solo com cobertura morta (palhada), alinhando-se à meta europeia de redução da erosão e conservação do solo através da remoção de CO_2 da atmosfera, melhorando a saúde e a fertilidade do solo, aumentando a retenção de água, a resistência à erosão e a biodiversidade, o que traz benefícios econômicos e ambientais. Conclui-se que a tecnologia brasileira de semeadura em alta velocidade possui maturidade mecânica e eletrônica para competir na Europa, desde que integrada a protocolos de auditoria de dados que permitam aos agricultores europeus verificar a precisão na aplicação de insumos. A convergência com os padrões da UE não apenas facilita a exportação de componentes, mas também eleva o padrão de transparência e eficiência da semeadura de precisão no mercado nacional.

Palavras Chaves: Semeadura em alta velocidade; Agricultura de Precisão; Marcação CE.

INTRODUCTION

The global agricultural revolution is driven by the urgent need to reconcile increased productivity with environmental sustainability, optimizing and preserving production environments. At the epicenter of this transformation lies Precision Agriculture (PA), which focuses on developing high-precision machinery to meet emerging market demands through management systems that utilize digital technologies to monitor and optimize agricultural production at an unprecedented level of detail. According to Molin et al. (2015), precision agriculture in Brazil has evolved from a phase focused solely on soil fertility to a systemic approach, encompassing intelligent mechanization and on-board electronics, where increasingly precise machines aligned with advanced technology are developed to perform more accurate and efficient operations.

The development of pneumatic meters and active seed guidance systems was driven by the necessity of operating across vast territorial expanses under the No-Till System (NTS), which demands millimeter precision in seed distribution within shorter timeframes. As noted by Casão Junior et al. (2012), maintaining crop residue (straw) on the soil surface requires highly efficient cutting and seed deposition mechanisms to prevent clogging (hairpinning) and ensure uniform seeding depth. This technological level has demonstrated high precision in sowing quality, particularly in no-till systems challenged by high-density surface residue, becoming a hallmark of Brazilian agricultural technology.

The European Union (EU) has spearheaded the global movement toward a carbon-neutral economy through the European Green Deal. The "Farm to Fork" strategy establishes rigorous targets for reducing chemical input usage and promoting soil conservation practices (EUROPEAN COMMISSION, 2020). This scenario creates a unique opportunity for international technologies that can assist European farmers in achieving these goals.

European regulations for agricultural machinery focus intensely on operator safety and environmental protection. The Machinery Directive 2006/42/EC establishes essential health and safety requirements for placing products on the market. More recently, the focus has expanded to "industrial cybersecurity," as modern planters are complex cyber-physical systems. Furthermore, the "Farm to Fork" strategy requires agricultural technologies to contribute to climate neutrality. As highlighted by Von der Leyen (2019), technology must serve as the bridge between economic competitiveness and the preservation of the European continent's natural capital.

Brazil, as a world leader in no-till seeding technology and high-speed sowing, develops critical components for active guidance and seed metering that surpass many global standards in terms of robustness and efficiency in soils with heavy cover crop residue. However, entering the European market is not merely an engineering challenge but a regulatory one. Compliance with CE Marking, functional safety (ISO 25119), and the new EU Deforestation Regulation (EUDR) represent technical barriers that must be thoroughly understood and overcome.

This article aims, therefore, to conduct a profound comparative analysis between the EU regulatory framework and the technical capabilities of Brazilian technologies, delineating the path for technological integration into the European market, where global leaders such as Amazone, Horsch, and Väderstad operate.

MATERIALS AND METHODS

The present study employed a qualitative and exploratory research methodology based on comparative documentary analysis. The process was organized into three primary stages:

1. Regulatory Survey: The core regulatory standards of the European Union were compiled, including the Machinery Directive (2006/42/EC), the ISO standards for electronic communication (ISOBUS - ISO 11783), and functional safety requirements (ISO 25119).

2. Analysis of Brazilian Protocols: A review was conducted of seeding machinery testing protocols and best practice guidelines issued by the Brazilian Commission for Precision Agriculture (CBAP) and the Ministry of Agriculture and Livestock (MAPA).

3. Comparative Analysis: A cross-referencing of data was performed between European certification requirements and the technical performance specifications of Brazilian active guidance technologies. The analysis focused on parameters such as deposition precision, operational speed, electronic safety, and the capacity for data log generation for traceability in compliance with the EU Deforestation Regulation (EUDR).

RESULTS AND DISCUSSION

The results demonstrate that Brazilian seeding technology featuring high-speed active seed delivery—commercially known as Selenium NEO by manufacturer J. Assy—possesses an intrinsic alignment with the EU's sustainability objectives. While the European market has traditionally operated with conventional tillage, the transition toward conservation methods (such as mulch farming) renders the Brazilian expertise in no-till systems extremely valuable. Since this developed technology is specifically engineered for no-till environments, it aligns with the "Farm to Fork" strategy by contributing to the European goals of erosion reduction and soil conservation through atmospheric CO_2 sequestration. Furthermore, it enhances soil health, fertility, water retention, erosion resistance, and biodiversity, yielding significant economic, environmental, and sustainable benefits.

The capacity of Brazilian systems, such as the Selenium NEO technology, to maintain singulation and spacing precision even at speeds exceeding 10 km/h in terrains with high biomass loads contributes directly to erosion control and carbon sequestration. The preservation of soil structure, facilitated by these systems, meets the criteria for enhancing biodiversity and fertility advocated by the European Commission (2020).

Despite mechanical and agronomic superiority under specific conditions, the analysis identified gaps regarding technical documentation and electronic safety. CE Marking requires each electronic component of the planter to undergo rigorous electromagnetic compatibility (EMC) testing and risk analysis for software failures that could result in physical harm.

Brazilian manufacturers must invest in the certification of their electronic control systems under the ISO 25119 standard. ISOBUS interoperability is another critical factor; although widely utilized in Brazil and integrated into most current precision machinery technologies, formal certification by the AEF (Agricultural Industry Electronics Foundation) is mandatory for acceptance by major European OEMs such as Amazone and Horsch.

The EU Deforestation Regulation (EUDR) mandates that agricultural products marketed in Europe must not originate from deforested areas. For agricultural machinery, this translates into the requirement for data reporting systems capable of georeferencing every seed and input applied within each worked field plot.

Brazilian active seed delivery technology, such as the Selenium NEO, already generates substantial volumes of Big Data. The identified challenge lies in the standardization of this data into audit protocols that allow European farmers to verify input application precision before regulatory bodies.

Comparison with brands such as Väderstad and Horsch revealed that Brazilian pneumatic metering technologies with active delivery present competitive advantages in terms of adaptability to diverse seed types, planting systems, and soil moisture conditions. However, European players lead in User Interface (UX) design and integration with European Farm Management Information Systems (FMIS).

CONCLUSION

Brazilian high-speed seeding technology has reached a level of maturity that positions it as a formidable competitor in the global market. The comparative analysis indicates that its agronomic advantages—specifically its performance in soils with mulch cover (crop residue) and its efficiency at high operational speeds—are perfectly compatible with the European Union's 2050 sustainability targets.

However, effective commercialization within the European bloc requires:

1. Formal compliance with functional safety and cybersecurity requirements (ISO 25119).

2. Attainment of the CE Marking through rigorous technical auditing processes.

3. Integration of data systems that ensure full operational traceability, aligning with the EUDR (EU Deforestation Regulation).

It is concluded that convergence with EU standards will enhance the level of transparency and efficiency in Brazilian precision agriculture, facilitating the export of high-value-added components—such as pneumatic seed metering mechanisms with active delivery systems—and strengthening Brazil's position as an innovation hub for high-precision machinery developed for precision agriculture.
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