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RESEARCH ARTICLE

REVISED Analysis of farmers' opinions and assessment of social acceptance and legitimacy in circular fertiliser adoption

[version 2; peer review: 5 approved with reservations, 1 not approved]

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Abstract

Background

The transition to a circular economy in agriculture requires the adoption of circular fertilisers, derived from secondary raw materials. Understanding the social acceptance and legitimacy of these products is essential for their successful implementation, yet both perspectives—especially legitimacy—remain understudied in this context.

Methods

This study is based on 360 surveys conducted with farmers across Europe to explore the conditions necessary for the proper adoption of circular fertilisers within the FER-PLAY project. The questionnaire included eight items addressing social acceptance dimensions and seven items related to legitimacy theory, enabling a qualitative analysis of attitudes, perceptions, and behaviors.

Results

Findings reveal that social acceptance is hindered by weak institutional capacity among policymakers, resulting in limited sociopolitical support. Market acceptance appears more favorable, provided that farmers' concerns and preferences are adequately addressed. Community acceptance remains neutral, with generally positive attitudes but limited engagement. From a legitimacy

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perspective, no strong pattern emerged regarding pragmatic legitimacy, while normative legitimacy showed signs of instability due to widespread distrust in political actors. In contrast, cognitive legitimacy displayed a promising trend, with circular fertilisers increasingly perceived as a natural and accepted solution.

Conclusion

The study highlights key challenges and opportunities in promoting circular fertilisers for the sampling size obtained in the FER-PLAY project.. Policy strategies should focus on strengthening institutional support, building trust in governance, and enhancing communication to reinforce both social acceptance and legitimacy. Addressing these social perceptions is crucial for enabling a broader and more sustainable uptake of circular fertilisers in European agriculture.

Keywords
Circular fertilisers, social acceptance, legitimacy, circular economy, surveys, farmers, organic farming, circular transition

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REVISED **Amendments from Version 1**

This revised version of the article incorporates several substantial improvements in response to the reviewers' comments. First, the statistical analysis has been significantly expanded. While the previous version relied primarily on descriptive statistics, the current manuscript now includes non-parametric inferential tests (Kruskal–Wallis with Dunn–Bonferroni post hoc comparisons), allowing for a more rigorous assessment of cross-country differences and trust patterns among stakeholder groups. Second, the discussion of sampling limitations has been strengthened. The revised text provides a clearer explanation of the geographic imbalance in the dataset and clarifies that findings should be interpreted as exploratory and not representative of the entire EU agricultural sector.

Collectively, these updates strengthen the analytical depth, methodological clarity, and interpretive nuance of the manuscript while maintaining consistency with the original study design.

Any further responses from the reviewers can be found at the end of the article

Introduction

The European Union (EU) defines the circular economy (CE) as "a model of production and consumption that involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended' (European Parliament, 2023). Using this CE strategy, waste can be reduced, creating further value for by-products and offering an alternative to the current linear economic model. The concept of CE has increased prominence in academy with more than 14,000 documents containing the term "circular economy" among 2020 and the end of 2021 according to a Scopus query; actually, in 2024, the scientific production reached more than 15,000 works according to an own Scopus query. Although CE research is thriving, its application in the industrial sector has not matched this trend. The Circle Economy Foundation published its annual report, entitled as "Circularity Gap Report 2024," posting the percentage of the total economy based on circular strategies (Circularity gap report, 2024): in 2023, the percentage was 7.2%, showing a downward trend, compared with 8.6% published in 2020 and 9.1% posted in 2018; about 21% lower in five years.

A key sector that creates an observable change in the CE percentage within the total economy is the agrarian sector. In the EU-27, the agricultural sector contributed 1.3% of the Gross Domestic Product (GDP) in 2023, half of which currently comes from France, Germany, Italy, and Spain (Eurostat, 2024a). This GDP value led to the idea that including circular strategies in this sector would provide perceptible insights. One way to apply these circular strategies in agriculture is the use of circular fertilisers (CFs), which can be defined as organic or recycled products derived from secondary raw materials (e.g., biomass or wastewater) used to improve soil health and promote plant growth in a sustainable manner by minimizing waste and utilizing renewable resources.

In practical terms, the CFs currently promoted and used in the EU encompass several well-established product groups derived from secondary raw materials. The most common examples include: i) composts and solid digestates produced from separately collected biowaste, ii) manures and other organic residues, iii) liquid digestates, phosphate and ammonium salts recovered from manure, iv) sewage sludge, v) ashes, and vi) biochar derived from biomass or waste streams (Hidalgo *et al.*, 2025; Huygens & Saveyn, 2018). Under the EU Fertilising Products Regulation, many of these CFs are placed on the market as organic fertilisers or soil improvers produced from specific Component Material Categories dedicated to secondary raw materials (ESPP, 2024).

Circular fertilisers present some advantages and disadvantages compared to synthetic fertilisers, as shown in Table 1.

Additionally, other divergence points can be extracted: i) discrepancies whether these products are cheaper (Case *et al.*, 2017) or expensive than the traditional ones (Cassou & Gerber, 2017); ii) byproduct surplus can be transported to nearby countries, but sometimes cannot, leading to an excess of nutrients in high livestock production regions (Leenstra *et al.*, 2014); and iii) some practitioners find CFs locally (Case *et al.*, 2017) and others have problems finding them (Willems *et al.*, 2016).

Therefore, a recurrent question for farmers is which kind of fertiliser should be used? Scientists advocate combining their use, some with an early maturity state, together with traditional fertilisers (Van Der Bom *et al.*, 2019). Long-term trials have yielded positive scientific insights into this strategy, indicating that this synergetic mix between circular and mineral products improves soil fertility compared to their isolated application, as reported by (Jate & Lammel, 2022) and Van der Bom *et al.* (2019). The strategy of mixing CFs and synthetic ones is in concordance with the aim of the EU farm-to-fork strategy to reduce the use of synthetic fertilisers by 20% by 2030.

Table 1. Advantages and disadvantages of the CFs compared to the synthetic ones.

	Advantages	Disadvantages	References
Circular fertilisers	General decreasing of GHG emissions	Necessity of taking into account the origin of the waste used as a by-product	Kyttä *et al*. (2021) Chojnacka *et al*. (2020) Gallego-Schmid *et al*. (2024) Rodríguez-Espinosa *et al*. (2023) Andrade *et al*. (2022) Smol (2021) Fernández-Gutiérrez *et al*. (2022) Tang *et al*. (2018)
	Improving soil health	Innovation in the product/ production	
	Enhancing nutrient cycling	Need of high skilled labour force	
	Reducing the dependence on external EU countries	Non a widely recognised tradition	
		Extra regulation	
Synthetic fertilisers	Traditionally produced	Do not accomplish the demand of fertilisers	
	Optimised synthetic pathways	Reduction of biodiversity, like negative impact of microorganism	
	Lower selling price per kg of effective nutrient	Dependence on external EU countries	
		Low nutrient release	
	High production yields	Price is rising	

In recent years, CFs have gained increased attention as a viable strategy to reduce reliance on synthetic fertilisers and enhance nutrient circularity in agriculture. Although comprehensive data on CF adoption are still emerging, several EU initiatives and research projects have highlighted their potential. In this context, circular alternatives could replace up to 3.77 million tonnes of conventional fertilisers by 2050, leading to an estimated 88% reduction in CO_2 emissions and 87% reduction in N_2O emissions, while potentially saving nearly 700 M€ annually by reducing dependence on imports (European Biogas Association, 2025). Despite these benefits, the current market uptake remains modest due to regulatory uncertainty, limited availability, and logistical barriers (Kurniawati *et al.*, 2023). Moreover, the EU reported a 15.9% decrease in mineral fertiliser use between 2017 and 2022, largely influenced by rising prices and geopolitical tensions, such as the war in Ukraine (Eurostat, 2024b), suggesting a shift in fertiliser dynamics that could favor the adoption of CFs. However, granular and harmonized data on CF usage across Member States are still lacking. The present study contributes to filling this knowledge gap by exploring not only farmers' attitudes towards CFs, but also the social and institutional dimensions underpinning their acceptance and legitimacy.

As previously discussed, CFs offer several advantages and can contribute to reducing reliance on synthetic fertilisers. However, many of these fertilisers remain unfamiliar to farmers and raise concerns and uncertainty. Therefore, it is crucial to assess what farmers think in order to understand their current attitudes, opinions, and knowledge. This preliminary study is important before introducing them to new information on the topic. For farmers, some pending barriers for willingness to change from a synthetic mineral to a circular one are i) the price, the most critical characteristic; ii) the necessity of a concentrated nutrient product; iii) the aim of extra-national regulation; iv) the willingness to participate in legislation processes; and v) unpleasant odor (Case *et al.*, 2017; Egan *et al.*, 2022; Smol, 2021; Tur-Cardona *et al.*, 2018). On the other hand, positive public perception is clear and strong: farmers support an increase in soil health (Case *et al.*, 2017) and support the CE (Romero-Luis *et al.*, 2023).

To address farmers' concerns regarding CFs, it is necessary to gather their opinions, which can be performed through surveys. This approach allowed us to evaluate

1) Social acceptance is defined as a trend at different levels of society (e.g., country, region, community, organizations) in different cognitive states (perception, opinion, attitudes, and behaviours) intertwined with a technology or technical system (Upham *et al*., 2015; Wolsink, 2010). Social acceptance has been frequently used in approaches to diverse technical and political issues, foresting particular fields such as waste and wastewater management (Achillas *et al.*, 2011; Devanadera *et al.*, 2024; Eskelinen et al., 2022), forestry resources (Eriksson *et al*., 2023; Shindler *et al*., 2002) and carbon capture and storage (Ha-Duong *et al.*, 2013; Witte, 2021) among others, such as renewable energy (Rojas-Peña *et al.*, 2024; Segreto *et al.*, 2020). This theory is used to evaluate the degree of achievement of sociological phenomena with its same name.

2) The legitimacy that respondents place on CFs. This is a widespread phenomenon in sociology, defined by scholars as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs and definitions" (Johnson *et al.*, 2006). Legitimacy does not study acceptance by targeting individual perceptions but addresses sectorial and societal rules, norms, and conventions (Markard *et al.*, 2016; Suchman, 1995). This concept has been applied to organizations (Scott, 2014; Suchman, 1995) and innovations (Binz & Truffer, 2017; Harris-Lovett *et al.*, 2015).

The combination of descriptive and theoretical analyses offers a comprehensive approach to survey data interpretation. On the one hand, a descriptive analysis provides an unbiased overview of the survey results, highlighting key patterns and trends, while social acceptance and legitimacy contribute to a deeper understanding of the underlying drivers and barriers. This dual approach integrates multiple dimensions of data and offers a cohesive perspective that enhances understanding and applicability. Balancing clarity and depth ensure that findings are accessible to general audiences while remaining relevant to academic and policy discussions, maximizing both their impact and practical value.

The use of social acceptance and legitimacy theories offers a comprehensive understanding of both individual behavioural inclinations and institutional trust dynamics. While social acceptance captures farmers' attitudes, opinions, and willingness to adopt CFs, legitimacy theory accounts for the systemic and normative alignment among stakeholders, policies, and practices. This dual lens is particularly appropriate in the case of CFs, which involve different technologies, public-private partnerships, and shifting regulatory frameworks. Such multidimensional innovations often require more than mere awareness to ensure adoption, as well as perceived appropriateness and alignment with broader societal norms.

The combined application of social acceptance and legitimacy theories is relatively unexplored within the European agrarian sector. Studies such as those carried out by Zeitlin *et al.* (2023) have addressed the relationship between the perceived legitimacy of decision-making procedures (procedure acceptance) and public acceptance of their outcomes in the pesticide sector in Europe.

To the best of our knowledge, this combination has not been discussed previously in the agricultural sector. The FER-PLAY project claims to promote CFs as a plausible option for the agrarian sector. For this purpose, the project mapped and assessed seven value chains of CFs made from secondary raw materials and highlighted their multiple benefits to foster wide-scale production and application. The project engages fertiliser producers, scholars, public administration, farmers, and farmer associations, coordinating and supporting the transition towards the studied products. For this purpose, the present study aims to understand the conditions necessary for the proper adoption of CFs. That is to say, the European farmers' attitudes collecting the participants' concerns, willingness, preferences, and perceptions regarding CFs are as follows:

Perform a quantitative assessment of the data extracted from the questionnaires.

- Compare the extracted results with previous data published by institutions.

- Do both sociological theories provide qualitative measurements of social acceptance and legitimacy?

- Carry out recommendations to fertiliser producers and policymakers based on these findings.

Materials and methods

The methodology followed for the preparation of this article began with an initial design and the spread of an online questionnaire survey. The collected data were then treated, allowing for the development of an appropriate discussion. Subsequently, social acceptance and legitimacy were assessed.

Online questionnaire survey

An online questionnaire survey was developed to address farmers. The survey was conducted with experts and stakeholders within the FER-PLAY project through co-creation meetings. In total, 35 questions were included in the questionnaire. The survey was conducted from June 2023 to June 2024. To reach as many end users as possible, the surveys were translated into Dutch, English, French, German, Italian, and Spanish. The survey was spread among the target audience via the FER-PLAY consortium contacts, working groups, events organized by the FER-PLAY partners, and the project website (https://fer-play.eu/). A total of 360 answers (sampling size) were collected from the farmers. Before survey completion, participants had to provide written consent for participation in the study by agreeing to the informed consent statement (which can be consulted in the Ethics and Consent Section, at the end of this manuscript).

Table 2. Respondents' profile achieved in the survey.

Academic level on agrarian fields	Yes	18.9 %
	No	81.1 %
Country	Germany	34.7 %
	Italy	24.2 %
	Spain	34.2 %
	Others	6.9 %
Gender	Male	61.0 %
	Female	39.0 %
Age	18–24	6.4 %
	25–34	44.7 %
	35–44	18.6 %
	45–54	15.8 %
	55–64	11.1 %
	> 65	3.1 %
Type of farming	Conventional	42.2 %
	Organic	42.2 %
	Transition	11.5 %
Fertiliser used	Compost	13.9 %
	Manure	33.1 %
	Mix circular	18.1 %
	Mix of circular and synthetic	26.4 %
	Mix synthetic	5.3 %
Activities carried	Arable	31.7 %
	Fruit	6.7 %
	Livestock	6.7 %
	Vegetable	3.9 %
	Vineyard	3.6 %
	Mix of the other ones	23.6 %
	Others	20.6 %
Size of the farm	< 20 Hectares	37.9 %
	20 < x < 400 Hectares	56.2 %
	> 400 Hectares	5.9 %

Table 2 shows the responses regarding the respondents' academic level in agrarian fields, nationality, gender, age, type of farming, type of fertiliser used, farming activities, and farm size. These nominal data are cardinal for a proper understanding of the results from the present study and for the formulation of recommendations to the stakeholders involved.

Despite efforts to disseminate the survey across multiple European countries, the majority of the responses came from Germany, Italy, and Spain. This distribution reflects the presence of active agrarian stakeholders and project partners from the FER-PLAY consortium in these countries, which has facilitated broader outreach and engagement with local farming communities. Additionally, these three countries represent some of the largest agricultural producers in the EU, making them particularly relevant for understanding trends in CF adoption.

The number of responses obtained from other EU Member States was too low to allow statistically meaningful comparisons. As a result, the inferential analyses and cross-country comparisons presented in this article are restricted

to Germany, Italy and Spain (93.1% of the total). Consequently, the findings should be interpreted as exploratory and cannot be considered representative of the EU agricultural sector as a whole.

Data processing

Data analysis was performed using Microsoft Excel Professional Plus 2016 (version 2411) to eliminate repetitions. First, the number of unanswered questions per questionnaire was calculated and divided by the total number of questions. Questionnaires with more than 30% of the unanswered items were deleted.

To translate respondents' opinions on these topics into quantitative data, five-point Likert-type questions and yes/no questions were used.

Descriptive analysis of the responses

Queries from the questionnaire were split into different groups according to the topic covered. In this way, a clear and concise descriptive analysis was conducted, providing different perspectives on the same subject. Consequently, the questionnaire was clustered into the following topics: (1) willingness to use CFs, (2) economic circumstances, (3) not in the backyard (NIMBY) effect, and (4) knowledge and trustworthiness. This cluster is shown in Supplementary Table 1 (Albaladejo Rodilla, 2025).

Assessment of the social acceptance and the legitimacy of the CFs

Two approaches were employed for this assessment: social acceptance theory and legitimacy theory. In the present study, based on the survey results, specific questions were posed to evaluate the dimensions of both approaches. Each approach encompasses three dimensions that are further divided into subsections. Table 3 presents the dimensions and questions related to social acceptance, as proposed by various authors (Dickson *et al.*, 2022; Rutherford *et al.*, 2018; Sovacool & Lakshmi Ratan, 2012). Similarly, Table 4 illustrates the dimensions and questions for the legitimacy theory, as outlined by Harris-Lovett *et al.* (2015).

Seven questions were posed to address the sections related to social acceptance and the other six questions were proposed to assess the social legitimacy of CFs. The questions are collected in Table 3 and Table 4 and aimed to provide insights into the necessary conditions for the proper adoption of circular alternatives in the European agrarian sector.

Table 3. Sections and subsections selected to assess social acceptance of CF, next to the definition of each one and a question designed to carry out qualitative assessment of this subsection.

Section	Subsection	Definition	Posed question
Socio political	Strong institutional capacity.	The capacity of countries to maintain ministries or specific departments that provide support with specific programmes of research and development dedicated to CFs	What are the perceptions of farmers about political institutions?
	Political commitment	Capability of public institutions to make circular fertilisers a highly visible topic	Are the communication channels among farmers an institution beneficial?
Market	Competitive properties of the new products	Circular fertiliser producers satisfy consumers' necessities successfully, with the local stock always available.	Are farmers' concerns and preferences addressed by the market?
	Mechanisms for information and feedback.	Effective mechanisms of information and feedback to build trust, inform stakeholders about product benefits and address concerns or misconceptions	Are farmers' communication channels with the CF stakeholders reliable?
	Access to subsidies	End uses can be applied to funds or tax reduction fees for products produced with CFs.	Do the farmers feel the necessity of subsidizing these products?
Community	Use	Circular fertilisers are perceived as useful?	Will farmers purchase local CFs in their business?
	Recognition of externalities or positive public image	Circular fertilisers have a good public image.	Do farmers perceive these products as goods?

Table 4. Sections and subsections of legitimacy selected to assess social acceptance, next to the definition of each one and a question designed to carry out the qualitative assessment of this subsection.

Section	Subsection	Definition	Posed question
Pragmatic	Exchange	Users directly perceive benefits.	Are CFs ready to foster soil quality or other farmers' concerns as sustainability, cost, etc.?
	Dispositional	Evaluate the degree of honesty and fairness in related organisations.	Are public administration, NGOs and farmers' associations perceived as trustworthy?
Cognitive	Comprehensive	Understanding and awareness of how a solution works and its purpose in addressing societal needs.	Do CFs offer an easy transition?
	Taken-for-granted	Perception that this solution is inevitable and therefore it is not questioned	How are the CFs perceived in terms of environment improvement?
Normative	Procedural	Fairness and inclusiveness of the processes used to implement or regulate the product	How can public administrations involve stakeholders on the CFs use?
	Structural	Studies whether value chain actors can bring into the table consistent know-how. The existence of quality controls, toxicological essays, or business models of CFs is crucial for adding fairness to circular alternatives.	Can farmers' concerns be solved by the current status of the CFs?

To assess social acceptance theory, Wüstenhagen *et al.* (Wüstenhagen *et al.*, 2007) proposed fragmentation in three dimensions, contributing to the clarification of the literature: i) socio-political, ii) market, and iii) community. Simultaneously, these dimensions can be divided into subcategories (Table 3). The sections and subsections of legitimacy and social acceptance vary among fields. Suchman's comprehensive work (Suchman, 1995) postulates three sections: i) pragmatic, ii) cognitive, and iii) normative. The sections, subsections, and posed questions related to legitimacy are listed in Table 4.

Kruskal-Wallis H test

Following Eiselen and Van Huyssteen (2023), a non-parametric method suitable for Likert-scale data was carried out. A Kruskal–Wallis H test was applied to compare trust levels across Italy, Germany and Spain, the three countries with sufficient sample size for inferential analysis. Standard tie correction was implemented to adjust the test statistic for the presence of tied ranks. When the omnibus test indicated significant differences, Dunn's post hoc test was used to conduct pairwise comparisons, employing tie-corrected standard errors to obtain accurate Z-statistics. To control the familywise error rate arising from multiple comparisons, Bonferroni correction was applied ($\alpha = 0.05$), and only adjusted p-values meeting this threshold were considered statistically significant.

Results and discussion

In the present study, the profile of respondents was different from the actual average found in the agrarian sector in terms of gender, type of farming activities, and fertiliser produced, among others (Eurostat, 2020). Although the sample achieved in the survey's collection does not fit the European agrarian sector, it is interesting to conduct a qualitative discussion. It is remarkable to consider this fact to make comparisons. The most common nationalities were Germany (34.7%), Spain (34.2%), and Italy (24.2%). The remaining 6.9% of the remaining countries have accumulated. Thus, specific conclusions and recommendations were considered for the three main countries.

Descriptive analysis of the responses

Willingness of using CFs

After obtaining an overview of the participants' profiles, they were asked other interesting questions. In this way, the willingness of using CFs was evaluated by the respondents' preferences and the circumstances (economic and production) under which they would use a CF. Respondents scored seven factors individually according to their preferences when choosing a fertiliser (Table 5).

Table 5. Factors scored according to their relevance for selecting a fertiliser by end-users.

	Non important	Slightly important	Moderately important	Very important	Extremely important
Form	7.5%	18.1%	28.9%	33.6%	10.6%
Ease of use	0.3%	5.1%	22.8%	53.4%	18.4%
Currently used machinery	2.5%	12.0%	30.0%	43.7%	11.8%
Nutrient content/ composition	0.3%	2.2%	23.5%	35.8%	38.3%
Cost	0.0%	3.4%	21.2%	36.6%	38.9%
Environmental aspects	0.3%	7.5%	31.3%	35.8%	24.7%
Production sustainability	0.8%	7.0%	24.4%	44.7%	22.8%

The maximum concern was linked to the **costs** (75.5% agreed that this topic is very or extremely important), **nutrients and composition** associated with fertilisers (74.1% of respondents answered very or extremely important), in agreement with similar studies conducted in 2019 (Case *et al.*, 2017; Egan *et al.*, 2022; Laborda *et al.*, 2023; Smol, 2021). Referring to economic concerns, these data indicate that subsidies must be economically appealing to attract new adopters to these new products, even if the farmer knows the CF, as shown in a study on manure tacking case (Hou *et al.*, 2018). Up to this point, the estimations suggest that the price for a CF at the 30–46% discount compared to the price of an equivalent mineral fertiliser would maximize the market share of the product (Moshkin *et al.*, 2023). Subsidies must cover this price.

Ease of use was also rated as a cardinal preference point. Yield is an endpoint, and farmers seem to be concerned about the middle stages of their processes. For this reason, 71.3% of the farmers rated it as very or extremely important to receive clear ease of use from fertiliser-producing companies.

The **production sustainability** and **environmental aspects of** the products were rated as middle importance factors, according to 67.7% and 60.7%, highlighting them as very or extremely important. Farmers claim proper sustainability and environmental regulation for the products they consume. The analysis of circular products from waste products will satisfy these requirements. This might result in a perception of safety among farmers when they buy CFs from waste by-products. These waste sources tend to accumulate large amounts of microplastics, which is one of the reasons for the poor reputation of these fertilisers (Estoppey *et al.*, 2024). In 2019, Regulations (EC) No. 1069/2009 and (EC) No 1107/2009 started setting new rules (*European Parliament*, 2019). However, currently, the imposition of performing quality tests on these products is still under construction.

The less important factors were the **form** of the product (44.8% rated as important or very important) and whether they could use their **currently used machinery** with the new product (55.5% of important or very important answers). This indicates that a fraction of respondents was not too worried about how to spread the fertiliser over the field. These findings are noteworthy because sociological studies point out that farmers make rational decisions about fertiliser use, striving to maximize utility. This means that farmers' choices are strongly linked to their perceptions of utility (Daadi & Latacz-Lohmann, 2021; Garmendia-Lemus *et al.*, 2024).

Economic circumstances

The importance of **local production** (Figure 1A) and the **easiness of finding CF locally** (Figure 1B) are shown. Finally, the **probability of participants to switch their current fertiliser to a circular one** is also displayed (Table 6). Figure 1A shows that the local production of a CF is important for 59.2% of the surveyed people. However, it is not easy to find it, as observed in Figure 1B, where 66.7% considered no easy (10.3%), slightly easy (15.6%), or moderately easy (40.8%) access to these fertilisers. This highlights the need for logistic impediments to increase the use of CFs. This finding is not serendipitous, and older studies have identified this problem (Case *et al.*, 2017).

The Krukal-Wallis test about how important it is for farmers that a CF is locally produced revealed a strong and highly significant country effect (Hadj = 85.5 and $p < 0.001$), with a relatively large effect size ($\varepsilon^2 = 0.26$). This suggests that the country of residence, among the three studied countries, substantially shapes how much value farmers place on local production. Mean ranks showed that German farmers attach the greatest importance to local production, closely followed

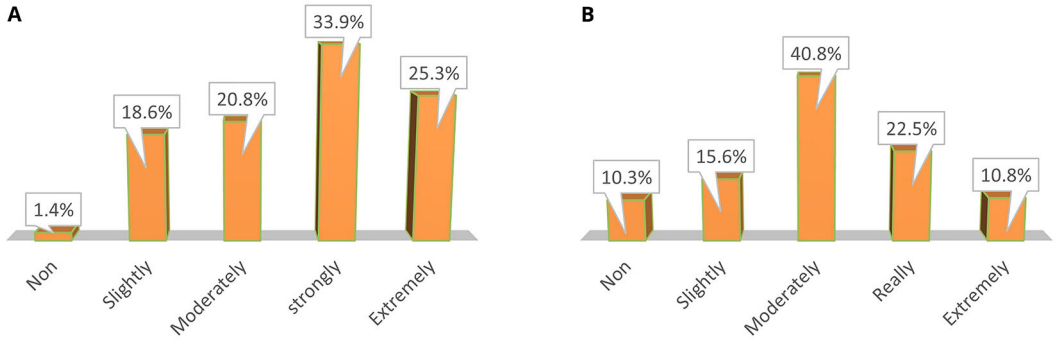

Figure 1. Farmers' concern about the availability of CFs: A) importance of producing them in surrounding areas, and B) the ease of finding CFs locally.

Table 6. Key conditions and probability to change from a mineral to a CF.

Key conditions	Not willing to substitute	1.0%
	I already use them	15.0%
	Subsidized or free of charge	34.0%
	Cheaper	34.0%
	Same price	13.0%
	Slightly expensive	3.0%
Probability	No likelihood	6.5%
	Slightly likelihood	20.0%
	Moderately likelihood	41.5%
	Strongly likelihood	24.0%
	Extremely likelihood	8.0%

by Italian farmers, whereas Spanish farmers again stand out with clearly lower scores. Dunn's post hoc tests with Bonferroni correction confirmed that both Germany and Italy differ very significantly from Spain, with farmers in these two countries attributing much higher importance to local production of CFs. In contrast, the Italy–Germany comparison was not statistically significant, suggesting that these two countries show similarly high levels of concern on this aspect.

On the other hand, the analysis about how easy it is to find CFs locally revealed a small but statistically significant country effect (Hadj = 7.77 and p = 0.02). Mean ranks suggest that Italian farmers perceive CFs as more easily available than their German counterparts, while Spanish farmers occupy an intermediate position. Dunn's post hoc tests with Bonferroni correction showed that only the Italy–Germany contrast remained significant, whereas Spain did not differ significantly compared to Italy and Germany. Taken together, these results indicate that perceived local availability of CFs varies across countries, but the magnitude of these differences is modest.

However, local access to these fertilisers is not the only obstacle. As previously mentioned, cost is one of the key factors in selecting one fertiliser (Table 5). In this way, another economic question was asked to **know likely a farmer would change a traditional fertiliser by a circular one** (Table 6). Farmers would likely use a CF instead of a mineral fertiliser if the former is **subsidized/free of charges** or **cheaper** than the latter (68% of the total). This percentage increases to 81% when the **price is not higher than the mineral fertilisers**. Therefore, achieving a circular economy within the agricultural sector is extremely important.

Finally, a question was asked to determine the real **willingness to use CFs** was performed. As shown in Table 6, 68% of the participants were moderately (41.5%), slightly (20%), or non-predisposed (6.5%) to switch from a mineral fertiliser to a CF. These results suggest that farmers may select CFs only if the price and local availability compete against mineral fertilisers.

The statistical analysis about farmers' likelihood of switching from their current fertiliser to a circular alternative showed a statistically significant but small country effect (Hadj = 9.5, p = 0.009; $\varepsilon^2 = 0.028$). Mean ranks indicate that Italy and Germany exhibited nearly identical levels of willingness to switch. In contrast, Spain scored notably lower, suggesting, by comparison, a reduced intention to adopt CFs among Spanish farmers.

Dunn's post hoc tests revealed a significant difference between Germany and Spain after Bonferroni correction (p = 0.017), while the Italy–Germany comparison was non-significant. The Italy–Spain contrast can be considered as borderline significant (p = 0.049). Overall, these results indicate that the most pronounced separation occurs between Germany and Spain.

Not in my backyard effect

After evaluating the importance of the **local production** and an **easy access** to CFs, another interesting parameter was analysed the NIMBY (Not In My Back Yard) effect. This effect assesses the willingness of a local community to allow a facility settlement in its surroundings, showing positive behavior towards a certain type of industry (Case *et al.*, 2017). To contrast this behavioral attitude, two extra questions were assessed to shed light on the opinions of CFs and circular economy among respondents.

Referring to this topic, 60.9% of the participants were not worried about having a production plant of CF near their area, knowing that they came from secondary raw materials (Figure 2A). For those who answered yes (141 people), the survey included a question to determine the minimum distance at which the facility settlement would be accepted (Figure 2B). A total of 55% (77 people in this group) ranged from 2 km to 15 km. Therefore, it may be considered that the surveyed people were not against the implementation of CF plants in their surroundings. This would reduce the logistic impediment of import-fertilizing products. To have a larger acceptability, an intermediate solution could be analyzed; the implementation of a CF facility should not be further than 15 km. In this way, the acceptability would rise to 82.2%, and the logistics costs might not significantly increase.

To continue analyzing their possible attitudes and support, two questions were asked. They answered based on their agreement with the following two statements: 1) the inconvenience that CF production could cause, and 2) if it is offset by the benefits of circularity that they provide (Table 7).

Both questions show non-well-defined opinions, being the most repeated answer to the neutral one: "moderately agree." Nevertheless, the plots exhibit slightly more followers than refusers, showing a positive attitude towards CFs.

Therefore, it is important to ensure the reliability of business models. Life cycle impact assessments of CFs are scarce, removing legitimacy from the circular benefits that they can provide. If circular products can provide fair information and details about their production processes and the advantages they procure, new adopters can be engaged.

Referring to the first question (Table 7, Question a), this statement still had many undecided voters. On the one hand, the *extremely agree* selections were slightly higher than *non-agree* ones. On the other hand, the *slightly agree* selections were similar to the *really agree* ones. According to the results, the circular economy might not be a clear alternative to the traditional agricultural system.

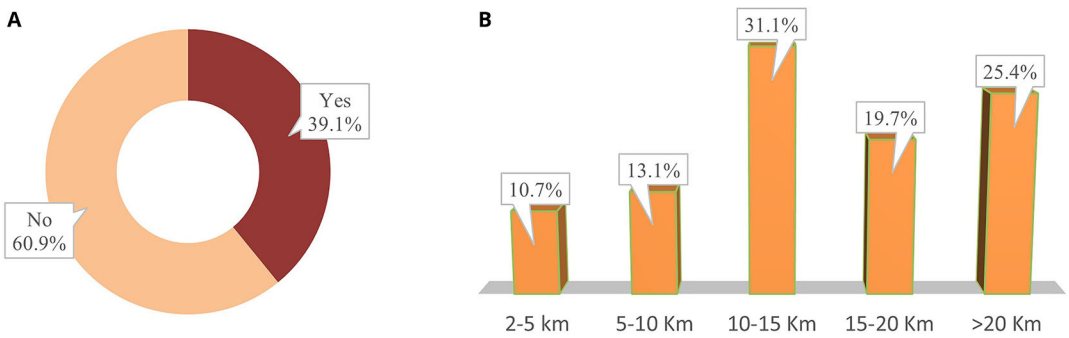

Figure 2. Results obtained of participants about their A) concerns about having a CF factory less than two kilometres from their home and their B) desirable distance to have a CF production nearby.

Table 7. Degree of agreement with the idea that a) the inconvenience that CF production is offset by the benefits they provide and b) supporting CFs due to the circular advantages they provide.

	a) The inconvenience that circular fertiliser production is offset by the benefits they provide	b) Supporting circular fertilisers due to the circular advantages they provide
Non important	1.2%	2.8%
Slightly important	22.5%	12.0%
Moderately important	39.6%	39.8%
Really important	20.4%	27.5%
Extremely important	16.2%	17.9%

Knowledge and trustworthiness

In this section, farmers' trustworthiness and their perceptions of the legislation are presented. This behavior is key to understanding the current state of European farms. The lack of reliable information for stakeholders is the most typical barrier to market acceptance (Simpson, 2017).

In the present study, the **lack of awareness regarding fertilisers' legislation** is reflected in 48.9% of farmers who declare check updates less than once per year. Among the contestants, 35% consulted the national legislation annually, 30% checked regional legislation, and 11% checked European legislation. Only 11% of the respondents checked the three legislation levels. These data indicate that those farmers might not perceive checking legislation as useful, especially in Europe.

One of the most important aspects extracted from the survey was **trustworthiness**. Respondents were invited to answer on a five-point Likert scale the trustworthiness of eight key value-chain actors: specialized press, neighboring farmer, farmers' association, fertiliser producers, salespersons, environmental non-governmental organization (NGOs), technical advisors and public authorities (Table 8). By evaluating the reliance of end users on their environment, miscellaneous ideas were extracted.

1. In general, farmers have moderate trustworthiness in their neighbors (52%), fluctuating notably among countries and types of farming.

2. Farmers' associations were trustworthy sources; 34.7% of respondents ensured that those groups were very or extremely trustworthy. The answers still varied notably between countries and farming types.

3. The most fixed and reliable sources were technical advisors; 44.3% of respondents found them very or extremely reliable. However, salespersons and NGOs were the most discredited, with 42% of farmers who did not or slightly trusted them.

4. Based on consortium knowledge, fertiliser producers already detect that farmers do not trust sales representatives. To solve this problem, the fertiliser industry is hiring external technical advisors.

5. The fact that NGOs are underrated in this classification may be explained by the perception of stakeholders that these organizations are disconnected from the real farmers' necessities.

6. Public authorities have a bad reputation, disrupting key conflicting voting processes during election periods. These institutions are becoming involved in coordinating and supporting action projects, working among real user problems, and reaching reliability among them.

In order to complement the descriptive patterns observed in Table 8 and to determine whether the differences in trust across Italy, Germany and Spain are statistically meaningful for the eight stakeholder groups, the Kruskal-Wallis H test was carried out. For seven of the eight stakeholder groups, the Kruskal–Wallis H test indicated significant country effects at $\alpha = 0.05$ among Italy, Germany and Spain. The only exception was the stakeholder specialised press (Hadj = 5.32, p-value = 0.07), where no statistically reliable differences in trust between Italy, Germany and Spain were detected.

Table 8. Degree of trustworthiness among: specialised press, neighbour farmers, farmers association, fertiliser producers, salespersons, environmental non-governmental organizations, technical advisors and public authorities.

	Non-trustworthy	Slightly trustworthy	Moderate trustworthy	Very trustworthy	Extremely trustworthy
Specialised press	7.2%	15.3%	43.6%	31.7%	1.9%
Neighbour farmers	7.3%	19.6%	52.%	15.9%	5.3%
Farmers associations	5.3%	20.8%	38.9%	21.4%	13.3%
Fertiliser producers	8.9%	21.1%	43.9%	23.1%	2.5%
Salespersons	11.4%	30.1%	49.3%	8.4%	0.3%
Environmental NGOs	15.9%	19.8%	50.7%	11.4%	2.2%
Technical advisors	0.8%	10.6%	44.3%	30.3%	14%
Public authorities	6.2%	22.1%	40.8%	27.9%	3.1%

Effect sizes (ε^2) ranged from small to large: they were smallest for specialised press ($\varepsilon^2 = 0.016$) and modest for technical advisor and neighbouring farmer ($\varepsilon^2 = 0.03$ and 0.02, respectively), while clearly larger effects were observed for fertiliser producers ($\varepsilon^2 = 0.14$), salesperson and farmers association ($\varepsilon^2 = 0.23$ and 0.22), and moderate ones for environmental NGOs and public authorities ($\varepsilon^2 = 0.04$–0.05).

Dunn's post hoc tests with Bonferroni correction (three pairwise comparisons per stakeholder; adjusted $\alpha = 0.05/3$) showed that for fertiliser producers in Spain had markedly higher mean ranks than both Italy and Germany; the Italy–Germany contrast was only borderline after correction ($p = 0.05$). For technical advisors, only the Germany–Spain comparison remained significant, indicating a moderate separation between these two countries, with Italy in an intermediate position. In line with the test results, none of the pairwise contrasts for specialised press survived Bonferroni adjustment.

For neighbouring farmers, the test suggested a small but significant effect; however, all pairwise comparisons were either non-significant or borderline once Bonferroni correction was applied, so these differences should be interpreted with caution. In contrast, salespersons showed very strong and consistent country differences: all three pairwise comparisons were highly significant after adjustment, with Germany displaying the lowest mean ranks and Spain the highest. A similar pattern emerged for farmers associations, where Germany's mean rank was substantially lower than that of both Italy and Spain, and both Germany–Italy and Germany–Spain comparisons were highly significant. For environmental NGOs, Spain exhibited significantly higher trust than both Italy and Germany, whereas Italy and Germany did not differ from each other after correction. Finally, for public authorities, Germany showed significantly higher mean ranks than both Italy and Spain, which did not differ significantly between themselves.

Overall, these results indicate that the effect of country of residence on trust is stakeholder-specific, ranging from negligible (specialised press) to large (e.g. salespersons, farmers associations), and that many of the strongest contrasts involve Germany versus Spain and/or Italy, rather than systematic differences between Italy and Spain.

Evaluation of results according to the social acceptance and legitimacy theories

Both concepts are essential for the success of new technologies such as CFs. They operate on different levels: social acceptance focuses more on the practical realities of adoption, while legitimacy concerns the societal justification for innovation.

Social acceptance

As mentioned in previous sections, social acceptance is a widely recognized concept that reflects a societal trend across various levels, such as national, regional, community, and organizational. It encompasses different cognitive dimensions, including perception, opinion, attitudes, and behaviors, all of which are closely intertwined with a specific technology or technical system (Upham *et al.*, 2015; Wolsink, 2010). In the present section, the three main dimensions of social acceptance theory are covered: socio-political, market, and community. The questions necessary to conduct this assessment are presented in Supplementary Table 2.

Socio-political acceptance

Socio-political acceptance refers to the endorsement, support, or resistance of technologies or projects at the macro-level by key stakeholders such as governments, NGOs, and the general public. Within this dimension, strong institutional capacity and political commitment were addressed from the farmers' perspective.

a) Strong institutional capacity

Strong institutional capacity can be indirectly evaluated under the FER-PLAY context by the question: *What are the perceptions of farmers about political institutions?*

The findings indicate a negative trend in social acceptance of political institutions. A significant proportion of farmers lacked trust in public administration: 28% expressed mistrust, while 41% remained neutral. This ambivalence contributes to a general sense of unreliability and the weak legitimacy surrounding these institutions. Although there are some strategies (e.g., farm-to-fork and zero pollution action plans) to limit chemical products in crops to achieve a circular economy, mistrust in political institutions might hamper the adoption of CFs in European crops. To address this issue, political institutions should involve active stakeholders in the debate, instead of implementing these strategies without a social consensus. Additionally, it may be useful if political entities can adapt policies to local realities, which may increase farmers' trust.

b) Political commitment

The authors wanted to assess the question: *Are the communication channels among farmers and institutions beneficial?* In the FER-PLAY context, political commitment refers to political institutions' willingness and active efforts to foster the implementation of CFs. Political commitment was partially mentioned in the previous section. The European Commission is focused on reducing dependence on mineral and fossil resources and driving the use of organic resources. Kurniawati *et al.* (2023) reported a complete list of policies linked to fertilisers in the European Union.

In this way, the effective implementation of CFs as a real option goes through the knowledge of these regulations and their updates, such as the new categories: product function category (PFC) and component material category (CMC). However, only 10.9% of the respondents were aware of the current legislation regarding fertilisers at the European, national, and regional levels, 9.1% at the national and regional levels, and 4.6% at the European and national levels. Most participants were aware only at the national or regional level (34.6% and 30.3%, respectively). Furthermore, 49% of participants reviewed the legislation (at any level) at least once per year.

This can be caused by policymakers' inability to establish effective communication channels, which may stem from a prevailing atmosphere of distrust among stakeholders, as reported by Mariano Zapata (LinkedIn, 2024) and WWF (2024).

Therefore, European projects play a crucial role as intermediaries among the value chain actors. These initiatives represent a promising starting point for fostering a positive dynamic within the socio-political dimension, especially by increasing the visibility of relevant topics and bridging communication gaps.

Market

This subsection addresses three interesting aspects linked to social acceptance: i) competitive properties of new products, ii) mechanisms of information and feedback, and iii) access to subsidies.

a) Competitive properties of the new products

The competitive properties of new products are highly relevant within the market dimension of social acceptance theory, as a product must be perceived as competitive in terms of price, performance, quality, and added value compared to existing alternatives to gain acceptance by stakeholders. In this way, it is necessary to show farmers' concerns and preferences to assess whether *farmer's concerns and preferences are addressed by the market.*

According to Egan *et al.* (2022), one of the key challenges is the high cost and availability of organic fertilisers. This is in line with the results obtained, where the main competitive property considered by the respondents was cost (75.4%),

followed by nutrient composition (74%). Moreover, most respondents (75.8%) would be willing to switch from a mineral fertiliser to a CF if the latter is subsidized, cheaper, or the same price as the former. On the other hand, the availability of CFs at a local level was also evaluated. According to participants, the local production of CFs was strongly or extremely important (59.2%). However, it is easy or extremely easy to find local CFs in 33.3% of cases. The country-level differences in local availability were already statistically analysed in Section 3.1.2.

As previously mentioned, the composition of CFs is another property that should be considered together with the cost. According to The CFs present lower concentrations of nutrients than mineral ones; up to 20 times lower according to the International Fertiliser Association (IFA, 2024). A potential short-term solution may be the use of minerals and CFs. Some studies have reported that the combination significantly improved the total and available content of macronutrients and, at the same time, reduced costs (Luo *et al.*, 2024; Mi *et al.*, 2022).

b) Mechanisms of information and feedback

Effective mechanisms of information and feedback build trust, inform stakeholders about product benefits, and address concerns and misconceptions. These factors are crucial in fostering market acceptance. Thus, it is necessary to address the question: *Are farmers' communication channels with the CF stakeholders reliable?*

To evaluate the present characteristics, it is important to assess farmers' trust in different information sources. The most trustworthy stakeholders were technical advisors, farmers' associations, and specialized press (44.3%, 34.8%, and 33.7% rated them as very or extremely reliable, respectively), whereas the lowest rating was for environmental NGOs and salespersons (13.6% and 8.9% considered very or extremely trustworthy, respectively). Public authorities and fertiliser producers were considered very or extremely reliable at 31% and 25.7%, respectively. However, a similar percentage considered them to be non-reliable or slightly reliable. Detailed statistical differences in trust levels across countries can be found in Section 3.1.4.

The evaluation of the information and feedback mechanisms highlights the significant role of trust in fostering market acceptance. Farmers tend to rely more on technical advisors, farmers' associations, and specialized presses for information, reflecting the credibility and reliability of these channels. Conversely, limited trust in environmental NGOs and salespersons indicates a gap in their perceived legitimacy or alignment with farmers' interests. The mixed perception of public authorities and fertiliser producers underscores the importance of improving transparency and tailored communication to strengthen trust. Enhancing the reliability and effectiveness of communication channels is essential for aligning stakeholders and addressing broader goals of market acceptance in the context of sustainable agricultural practices.

It is also interesting to mention another point that influenced this section. The fertiliser Product Regulation (FPR) 2019/1009, intended to promote organic and waste-based fertilisers, has been partially implemented despite promises since 2016. This may be perceived as a lack of commitment to fulfilling promises and reducing farmers' trust. As of 2024, delays persist owing to the absence of notified bodies and harmonized testing methods. To address this, the EU supports "living labs," where pilot farms test new products publicly, combining results with techno-economic and toxicological analyses (BioSOILUTIONS, 2024; ICOSHELL, 2024) Obtaining feedback from the pilot farms test into regulatory adjustments can enhance trust among stakeholders, which can be essential for closing the communication loop.

c) Access to subsidies

Although subsidies can be considered in the social-political section, they are included in the market because access to subsidies is directly related to stakeholders' interactions with the product in terms of economic viability, competitiveness, and adoption drivers. That is, if farmers perceive subsidies as essential, this signals a barrier to market acceptance, tying subsidies to the market dimension. Hence, the following question was addressed: *do the farmers feel the necessity of subsidising these products?*

fertiliser prices have been increasing worldwide since the end of 2021. In this context, the value of organic fertilisers has changed from the farmers' perspective (Daadi & Latacz-Lohmann, 2021). In this way, the results of the survey clearly showed that farmers perceived the necessity of subsidies to switch from a mineral fertiliser to a circular one: 43.6% of the participants would switch only if the CF was subsidized or cheaper than the mineral fertiliser. This may be related to only 36.6%, considering that the benefits of CFs outweigh the inconveniences.

The Common Agricultural Policy (CAP) involves several proposals to address circular solutions for farms. In total, €387 billion of funding has been allocated to the CAP as part of the EU's long-term budget, which is the multiannual financial framework (2021–2027) (Eurostat, 2023). Even in the above-mentioned living labs, the EU subsidizes part of the detrimental effects of the harvest, if any. To strengthen market acceptance, it is essential to ensure that subsidy programs are complemented by alternative economic incentives, such as innovation grants or tax relief for early adopters of CFs. Additionally, robust quality control mechanisms must accompany funding decisions to mitigate the risks associated with production facility relocation. Clear and transparent criteria for stakeholder selection can enhance the perceived fairness and effectiveness of subsidies, further driving their acceptance and integration into the market.

Community

Within the community dimension, the use and recognition of externalities and positive public images are discussed.

a) Use

Community use is central to this dimension because it reflects the direct impact of a solution, which is key to gaining local acceptance. For this reason, the posed question *will farmers purchase local CFs in their business?* was addressed.

To answer this question, farmers' perceptions were first shown. Farmers considered very or extremely important that fertilisers were sustainable and environmentally friendly (66.9% in combination). Moreover, 72.5% of respondents believed that CFs improved soil health. The statistical assessment is shown in Section 3.2.2.1 a).

However, two other important factors must be evaluated: cost and availability/accessibility limitations. Although it seems that farmers were interested in CFs, only 3.6% of the participants would be willing to pay a bit more for a CF, and 10.3% would use a CF if the cost was the same as a mineral option. On the other hand, only 33.3% easily found local CFs, and 36.6% considered that the benefits outweigh the disadvantages. This might explain why only 32% of the participants were predisposed to switch from a mineral fertiliser to a CF. Additionally, farmers tend to use fertilisers with texture and characteristics similar to mineral options (Tur-Cardona *et al.*, 2018), which may hamper the adoption of CFs. To address this fact, extra efforts in fostering properties and parameters desired by farmers must be made, besides spreading the obtained results from living labs, as mentioned in the mechanisms of information and feedback section. The combination of demonstration programs, incentives (as mentioned in the subsidies section), and partnerships with local suppliers could foster a more favourable perception of CFs and accelerate their integration into farming practices.

b) Recognition of externalities or positive public image

In the context of community acceptance, recognizing the broader environmental and social benefits of CFs is key to fostering positive perceptions. As key stakeholders in agricultural sustainability, farmers play a crucial role in determining the success of these products. Their attitudes are shaped not only by their direct impact on their farming practices but also by their understanding of the larger environmental benefits. This raises the following question: *Do farmers perceive these products as goods?*

The perception of CFs at the local level revealed mixed attitudes: 32% of farmers viewed CFs positively and 26% opposed them, whereas the remaining 42% expressed indifference (moderate agreement). Farmers' concerns about soil health and the environmental impact of mineral fertilisers drive a slightly proactive attitude towards circular products. These concerns stem from tangible, local-level impacts, such as degraded soil quality, which directly affect their livelihoods. However, while some farmers recognize the potential benefits of CFs, many remain unconvinced or indifferent. This indifference may be due to the lack of clear communication or direct evidence of the benefits of CFs in their specific contexts.

In summary, although farmers' recognition of externalities remains limited, targeted improvements in information dissemination, political support, and engagement can shift perceptions. Addressing farmers' indifference and leveraging their environmental concerns through effective feedback mechanisms and localized outreach initiatives will be essential for enhancing community acceptance.

Legitimacy

As previously mentioned, legitimacy explains how innovations, policies, and organizations gain societal approval by aligning with norms, values, and expectations. Therefore, the present section discusses the three primary forms of

legitimacy (pragmatic, cognitive, and moral) within the FER-PLAY project concept. The questions necessary to conduct this assessment are presented in Supplementary Table 2.

Pragmatic

The pragmatic form is based on audience self-interest and their perception of tangible benefits, such as economic advantages, efficient resource use, and direct practical value to end users.

a) Exchange

Exchange legitimacy is based on the perceived direct benefits stakeholders receive from the initiative, such as cost savings or increased crop yields in the FER-PLAY project context. In this way, the question arose: *Are CFs ready to foster soil quality or other farmers' concerns as sustainability, cost, etc.?*

One of the main concerns among farmers is the cost, nutrient content and ease of use (75.4%, 74.1% and 71.3% considered it as very/extremely important, respectively) of the CFs. Other preoccupations were process sustainability (67.7%), environmental aspects (60.7%), and the necessity of new machinery and product formats (55.5%).

One of the most important factors affecting CFs is how they are perceived in the context of soil health. In this case, the majority of the respondents (72.5%) considered that CFs improve soil health. Concerning the statistical Kruskal-Wallis test, there is a very strong and highly significant country effect (Hadj = 106.8 and $p < 0.001$). The associated effect size ($\varepsilon^2 = 0.32$) indicates that country of residence explains a substantial share of the variability in perceived soil-health benefits. Mean ranks showed a clear gradient: German farmers expressed the strongest belief in the positive impact of CFs on soil health, followed by Italian farmers. Spanish farmers were markedly more sceptical compared to the other countries.

Dunn's post hoc tests with Bonferroni correction confirmed that both Germany and Italy differ very significantly from Spain, with farmers in these two countries showing much higher confidence that CFs will improve soil health. In contrast, the difference between Germany and Italy was not statistically significant after correction, suggesting broadly similar levels of optimism in these two countries.

With the ongoing status of technology in the fertiliser sector, circular alternatives are ready to solve the detriment in soil quality. Although their performance is lower in general, scientists already postulate that the correct mindset is to mix circular and mineral products, as long-term trials show with manure (Jate & Lammel, 2022). With this mix, farmers can achieve proper yields in addition to other qualities, such as soil-improving qualities.

However, it is necessary to discuss whether farmers are ready to switch from a mineral fertiliser to a CF. Thus, 42% of the patients were moderately predisposed to do so. This might be linked to the ease of finding them at the local level, as 40.8% answered that it was moderately easy. Additionally, 39.6% of respondents considered that the inconveniences caused by the production of CFs were offset by their benefits. Therefore, these issues must be addressed to accelerate the implementation of CFs in European soils. The statistical assessment about farmers' predisposition to switch to CFs and the ease of finding them was previously discussed.

b) Dispositional

Disposition is linked to trust in the intentions, values, and goodwill of an entity promoting the initiative. For instance, if stakeholders accept a solution, they believe that policymakers or developers are acting in their best interests. Thus, a question was posed in the FER-PLAY context: *Are public administrations, NGOs and farmers' associations perceived as trustworthy?*

The survey's results showed that respondents had more extreme trust in farmers' associations than in public authorities (34.8% and 31%, respectively), whereas only 13.6% thought NGOs were extremely trustworthy. In contrast, it is interesting to mention that the three groups were perceived as moderately trustworthy: 50.7% (NGOs), 40.8% (public authorities), and 39% (farmers' associations). The Kruskal-Wallis test was discussed in Section 3.1.4.

Cognitive

Cognitive legitimacy occurs when technology, policy, or practice is seen as inevitable or aligned with societal expectations. It is often linked to widespread awareness and understanding of the initiative's role in solving existing problems such as the transition to circular economies.

a) Comprehensive

The comprehensive view is derived from the understanding and awareness of how a solution works and its purpose in addressing societal needs. In this context, the following question was posed: *Do CFs offer an easy transition?*

Currently, there are very few long trials on CFs. Scientists strive to test as many new CFs as possible. Toxicological assessments, detection of specific chemical compounds (such as certain types of microplastics), and other tests are being conducted. Therefore, it could be said that the transition is not currently easy, as some issues linked to CFs need to be studied in depth.

Furthermore, the transition could not be effective if a wide majority of the participants (60%) did not know if there was any limitation on the availability/accessibility of CFs in their areas, whereas 17% answered that there were limitations. In line with this, only 33.3% of the participants answered that it was really or extremely easy to find CF locally. Hence, it is required that the stakeholders driving CFs implementation act to reverse this situation.

Additionally, a test was added to the survey to evaluate participants' knowledge of CFs. This may show that the transition from traditional fertilisers to CFs can be realistic in the mid-term. The use of CFs may require additional training as the nutrient composition varies; they can require specific storage conditions and regulatory and certification requirements (IFFCO Nano Urea, 2024; Javatpoint, 2024; Tur-Cardona *et al.*, 2018). However, only 33.2% of the participants knew that CFs may require additional training.

On the other hand, 52.4% of the participants knew that CFs have lower nutrient content compared to the mineral ones and, thus, the use of CFs would not be correctly applied by about 50% of them. Moreover, 54.8% of respondents did not know that CFs have some limitations depending on the soil and crop. Nevertheless, circular alternatives to mineral fertilisers offer a variety of improvements (Barzee *et al.*, 2019; Egan *et al.*, 2022; O'Donnell *et al.*, 2022). These enhancements have turned into solutions to the current farming problems.

b) Taken-for-granted

This form of legitimacy arises when a solution becomes normalized and is no longer questioned, because it is seen as a standard or inevitable solution. For instance, within the FER-PLAY context, CFs could be perceived as the default option in agriculture owing to its widespread use. In this way, the posed question to answer was: *how are the CFs perceived in terms of environment improvement?*

Among respondents, 41.8% were concerned about the environmental impact of fertilisers, 66.9% considered very/extremely important that the fertiliser be sustainable and environmentally friendly, and, as previously mentioned, 72.5% thought that the soil health improved by using CFs. Additionally, 36.8% of respondents considered that the inconveniences linked to CFs production were offset by its benefits. Therefore, it seems that the use of fertilisers from secondary raw materials could be a default option in the mid-term.

To complement this section, the Kruskal-Wallis test was performed. In this way, the analysis revealed significant cross-country differences in concern about the environmental impact of fertilisers ($H_{adj} = 19.08$ and $p < 0.001$). Dunn's post hoc tests confirmed a strong and statistically robust difference between Italy and Spain after Bonferroni correction; whereas, the contrast between Germany and Spain was borderline. Finally, mentioning that the Italy–Germany comparison showed only a trend but was not statistically significant. Taken together, these findings suggest that Italian respondents are notably more concerned about the environmental impact of fertilisers compared with Spanish respondents, whereas Germany occupies an intermediate position without clearly differing from either country under conservative post hoc criteria. This indicates that country-level differences exist but are not uniform, with the most pronounced gap observed between Italy and Spain.

On the other hand, analysing how important it is for farmers that fertilisers are sustainable and environmentally friendly, the Kruskal–Wallis test indicated a very strong and highly significant country effect (Hadj = 93.6 and $p < 0.001$). The adjusted epsilon-square was around 0.28, pointing to a large influence of country of residence on the perceived importance of fertiliser sustainability. Mean ranks showed that Italy and Germany place similarly high importance on sustainability; whereas, Spain scores much lower. Dunn's post hoc tests with Bonferroni correction confirmed this pattern: Italy–Spain and Germany–Spain differences were both highly significant, indicating that Spanish respondents attach substantially less importance to sustainable and environmentally friendly fertilisers than their Italian and German counterparts. In contrast, the Italy–Germany comparison was not significant after correction, suggesting that farmers in these two countries are similarly aligned in giving high priority to sustainability attributes.

Normative

The normative section is related to moral legitimacy, which is based on the perception that the initiative is "the right thing to do" according to shared values, ethics, and cultural standards. It emphasizes fairness, justice, and long-term benefits over immediate personal gains.

a) Procedural

Procedural legitimacy is based on the fairness and inclusiveness of processes used to implement or regulate a product. For instance, farmers are more likely to accept policies on CFs if they are actively involved in the decision-making processes. Taking into account the survey performed in the course of the FER-PLAY project, the posed question aligned with procedural legitimacy was: *how can public administrations involve stakeholders on the CFs use?*

First, it is important to highlight that farmers' trust in public administrations is notably low, with 68.8% considering them either untrustworthy or moderately trustworthy. Improving the public image of these institutions is essential to fostering stakeholder engagement. Additionally, administrations should establish stronger communication channels with farmers to assess their understanding of current fertiliser legislation and provide targeted support to enhance their involvement. Notably, only 11% of the respondents were familiar with the legislation at the European, national, and regional levels, and only 9% were aware of it at the national and regional levels.

From an economic perspective, public administrations need to evaluate and address the cost of CFs if they want to be effectively implemented. On the one hand, 82.1% of the participants were moderately or extremely concerned about the cost of fertilisers (27.9% and 54.2%, respectively). In this way, 28.9% would be willing to use CFs if they were subsidized or cheaper than the conventional ones, 14.7% if these were subsidized, 13.9% if they were cheaper than the conventional fertilisers, and 10.3% if they presented the same price. In total, 67.7% would be willing to use CFs if the price was at least the same as that of conventional fertilisers. Only 3.6% of contestants would be willing to change if the circular alternative included a slightly more expensive price. Therefore, public administrations and policymakers should keep in touch with these concerns if they want an effective implementation of the circular economy in the agricultural sector. Moreover, considering that one of the most important EU strategies is to reach a real circular economy, the points related to the price and availability of CFs are highly recommended for further policy discussions involving the affected stakeholders. It is crucial to keep addressing farmers with easy reports and documents that disseminate reliable information to engage in more legitimacy in order to reduce, for example, the lack of knowledge about the decision-making process, as reported by Egan *et al.* (2022).

The Kruskal-Wallis test applied on the concern about cost of fertilisers results indicated a highly significant country effect (Hadj = 60.44, $p < 0.001$). Mean ranks revealed a clear pattern: Italian respondents reported the highest concern, whereas Germany and Spain formed a much lower and more homogeneous group. Dunn's post hoc tests with Bonferroni correction confirmed that Italy differs very strongly from both Germany and Spain, with both pairwise comparisons remaining highly significant after adjustment. By contrast, the Germany–Spain comparison was non-significant, indicating that these two countries do not differ meaningfully in their perceived concern about fertiliser costs.

b) Structural

Structural legitimacy relates to whether the private or public entity promoting the initiative is seen as capable, credible, and aligned with societal values. In this sense, the following question was posed: *can farmers' concerns be solved by the current status of the CFs?*

Structural legitimacy combines the results of different questions. On one hand, the factors considered by the participants were relevant, as previously mentioned. The cost was at the top of the factors, in addition to the nutrient content (75.4% and 74%, respectively). In this way, CFs can be cheaper than mineral CFs if they are locally produced as additional transport, processing, etc. can increase their costs (Kurniawati *et al.*, 2023). This is directly linked to the fact that 67.7% of the respondents mentioned that it is non-, slightly-, or moderately easy to find local CFs. Moreover, as mentioned in the procedural legitimacy section, only 3.6% of the participants would be willing to change if the circular alternative included a slightly more expensive price. The Kruskal-Wallis test about the how easy it is to find CFs was discussed in Section 3.1.2.

In terms of nutrient content, CFs presented some advantages, such as the improvement of soil health, as perceived by 72.5% of the participants. However, some CFs have a lower nutrient density, which translates to a larger application requirement. This might explain why 68% of participants were non-, slightly-, or moderately predisposed to switch to a CF, and 63% considered that the inconveniences caused by CFs production do not, slightly, or moderately compensate for their benefits.

Additionally, it is mandatory to mention the participants' trustworthiness in those stakeholders driving the implementation of CFs: 86.4% and 69% considered non-trustworthy, slightly trustworthy, and public administration, respectively. By contrast, technical advisors were considered very or extremely trustworthy by 44.3% of the participants. These advisors may be a good driving force to improve the current CFs situation.

Conclusions

The main goal of the present study was to analyze the survey results of CFs obtained in the course of the FER-PLAY project from different viewpoints for the effective adoption of CFs in European agriculture. On the one hand, a descriptive analysis was carried out, where economic concerns, particularly the price and availability of CFs, emerged as the primary factors influencing the willingness to adopt them. Subsidies and local production were identified as key elements in increasing adoption. The NIMBY effect was assessed, showing that the majority of farmers were open to having CF production plants nearby, suggesting that local production could help alleviate logistical barriers. Furthermore, the analysis of farmers' trust in various sources of information revealed that technical advisors were the most trusted, while NGOs and salespersons faced skepticism.

On the other hand, a qualitative assessment was performed by two sociological theories: the social acceptance and legitimacy. Social acceptance assessment revealed that adopting CFs within European agriculture requires building trust in institutions, fostering communication, improving product competitiveness, and aligning policies with farmers' needs. Integrated efforts, including demonstration programs and economic incentives, can help overcome these barriers, accelerate adoption, and promote sustainable farming practices. To strengthen legitimacy, it is essential to integrate strategies that address economic concerns, enhance accessibility, build trust, and provide clear evidence-based information about CFs. By prioritizing these areas, policymakers and stakeholders can align the adoption of CFs with societal expectations, ensuring their successful integration into sustainable agricultural practices.

Beyond the descriptive and theoretical contributions of this study, the results have a broader significance for the future of sustainable agriculture in Europe. The findings suggest that the successful integration of CFs will depend not only on their agronomic performance or cost competitiveness but also on building trust in institutions, enhancing access to local products, and fostering targeted communication strategies. Technical advisors and farmers' associations, identified as the most trusted actors, should play a central role in disseminating information and supporting behavioral change. Furthermore, the low procedural and structural legitimacy of CFs signals the need for transparent, inclusive, and farmer-driven policy processes. As the EU intensifies its efforts towards a circular economy and climate-resilient food systems, these social and institutional factors must be addressed to avoid resistance and foster widespread adoption. Ultimately, this study highlights that promoting CFs is not only a technological or environmental challenge but also a deeply social one that requires coordinated efforts across policy, research, and practice to align innovation with farmers' expectations and societal values.

Ultimately, this study highlights that promoting CFs is not only a technological or environmental challenge but also a deeply social one requiring coordinated efforts across policy, research and practice. Complementing these broader insights, the statistical comparison conducted for the three countries with sufficiently large sample sizes (Italy, Germany and Spain) further illustrates how acceptance and legitimacy vary across contexts. The Kruskal–Wallis tests revealed clear and consistent cross-country patterns. Italy and Germany showed markedly higher levels of environmental concern and stronger sustainability values than Spain, which consistently ranked lowest on these dimensions. Perceptions related to product benefits and local anchoring followed the same structure: Italian and German farmers expressed greater

confidence in the soil-health benefits of CFs and placed higher importance on local production compared with Spanish ones. For market-oriented considerations, differences were smaller but still evident. Spain reported lower perceived local availability and a substantially lower willingness to switch to circular fertilisers, whereas Italy and Germany displayed comparable and generally higher levels of adoption intention. Overall, these findings show that acceptance and legitimacy vary considerably across national contexts, highlighting the need for tailored strategies that address the specific motivations and barriers present in each country.

Finally, it is worth noting that the survey design did not include open-ended questions, which limits the depth of qualitative interpretation. Future studies should incorporate open-text responses and thematic coding to enhance interpretive validity, as well as ensure a more balanced sample across European countries to improve representativeness.

Ethics and consent

To prepare this manuscript, the results of an online questionnaire survey voluntarily answered by farmers were used. Before completion, participants had to agree to the following informed consent statement: *The collected answers, besides analysed and managed data will be performed according to the European General Data Protection Regulation (2016/679/EU) and ethical requirements. Answers will be totally anonymous, and no results can be connected to individual persons. All of this will be overseen by the FER-PLAY Open Science and Data Manager. By participating, you accept these conditions.* This survey was part of the FER-PLAY Horizon Europe project and was approved by the Internal Project Ethics Committee on 02/05/2023, with the FP23_01 ethical approval number.

Data availability

Authors agree to make freely available all of the data and materials supporting the results or analyses in our manuscript, under Creative Commons Attribution 4.0 International License (CC-BY 4.0). Datasets, together with the original survey, can be accessed on Zenodo through the following persistent identifier:

https://doi.org/10.5281/zenodo.15064468 (Albaladejo Rodilla, 2025).

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?

Xinping Pei
The Hong Kong Polytechnic University, Hong Kong, China

This study addresses a policy-relevant question on the social acceptance and legitimacy of circular fertilisers in the EU, and provides rich descriptive evidence on farmers' perceptions across several EU countries.

I have the following suggestions to strengthen the manuscript:
1. Please clarify the statistical hypothesis for the Kruskal-Wallis H test in the Introduction.
2. Regression analysis is recommended to examine how farmers' characteristics influence social acceptance and legitimacy.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and does the work have academic merit?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Environmental Science and Social Science

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 12 May 2026

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El Mehdi Eddarai
Mohammed V University in Rabat, Rabat, Morocco

This study examines farmers' perceptions, social acceptance, and the legitimacy of circular fertilizers (CFs) in Europe, based on responses to a survey of 360 participants from several European Union countries, mainly Germany, Spain, and Italy. It combines descriptive statistics and sociological frameworks related to social acceptance and legitimacy to analyze barriers to adoption and conditions conducive to the implementation of CFs in agriculture. Moreover, the authors provides useful exploratory insights into farmers' attitudes toward CFs and contributes to the growing literature on socio-institutional dimensions of circular economy implementation in agriculture.

The manuscript would be strength substantially by addressing the conceptual precision and moderating some interpretations.
The statistical analysis remains largely descriptive:
1. Provide exact sample sizes per country in inferential analyses.
2. Provide clearer interpretation of sizes effect .
3. The analyses mainly compare countries but do not sufficiently explore interactions between variables such as age, farming type, organic vs conventional farming, farm size, or current fertiliser practices.

Decision : Approved with reservation.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and does the work have academic merit?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: 1. ANALYTICAL CHEMISTRY

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 06 May 2026

https://doi.org/10.21956/openreseurope.23996.r73594

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Tonni Agustiono Kurniawan
Xiamen University, Fujian, China

The manuscript attempts to address an important sustainability topic—farmer acceptance of circular fertilizers—but in its current form it fails to meet the minimum standards of analytical rigor, conceptual clarity, methodological transparency, and scientific contribution required for publication in a peer-reviewed journal.
1. Conceptual vagueness and weak theoretical framing
The central constructs—“social acceptance,” “legitimacy,” and “circular fertilizer adoption”—are introduced in a generic and interchangeable manner without clear operational definitions. The manuscript does not distinguish between cognitive acceptance, behavioral intention, institutional legitimacy, or socio-political acceptance. As a result, the conceptual framework is shallow and non-operational, making it impossible to assess what is actually being measured or analyzed.
Moreover, “circular fertilizer adoption” is treated as a monolithic concept without distinguishing between types of circular fertilizers (organic waste-derived, biochar-based, nutrient-recovered products), each of which has distinct adoption barriers. This oversimplification undermines analytical depth.
2. Methodological insufficiency and lack of reproducibility
The methodological section lacks essential scientific detail. There is no clear explanation of:

- sampling strategy (random, purposive, stratified, or convenience)
- sample size justification or statistical power analysis

- survey instrument design or validation procedure
- reliability testing (e.g., Cronbach's alpha, construct validity)
- analytical methods used for assessing "acceptance" and "legitimacy"

Without these, the study cannot be replicated or verified, which is a fundamental requirement for publication.
Furthermore, the treatment of "farmers' opinions" appears purely descriptive and anecdotal, with no robust statistical modeling or inferential analysis. This reduces the work to a qualitative opinion summary rather than a scientific assessment.
3. Weak analytical depth and absence of causal reasoning
The manuscript largely reports perceptions without explaining underlying causal mechanisms. For example, it does not investigate:

- why farmers accept or reject circular fertilizers
- how economic constraints, risk perception, or institutional trust shape decisions
- how information asymmetry or extension services influence adoption

There is also no attempt to model adoption behavior using established frameworks such as the Theory of Planned Behavior, Technology Acceptance Model, or Diffusion of Innovations theory. This results in a descriptive account rather than an explanatory or predictive analysis.
4. Overgeneralization and lack of contextual grounding
The findings are presented in overly broad terms that are not adequately grounded in specific geographic, socio-economic, or agronomic contexts. Farmers are treated as a homogeneous group, ignoring heterogeneity in land size, income level, education, market access, and crop type. This lack of contextual segmentation significantly weakens the policy relevance of the study, as adoption of circular fertilizers is highly context-dependent.
5. Lack of novelty and incremental contribution
The topic of fertilizer adoption and farmer perception has been extensively studied in agricultural economics and sustainability science. However, the manuscript does not clearly articulate what is novel in its approach, dataset, or analytical framework.
It appears to replicate well-established findings (e.g., cost, awareness, and risk perception influence adoption) without offering new theoretical insight, methodological innovation, or empirical evidence that advances the field.
6. Poor integration with circular economy literature
Although the study claims relevance to "circular fertiliser adoption," it does not meaningfully engage with circular economy principles such as nutrient cycling efficiency, system-level sustainability, or resource loop closure. The discussion remains at the level of individual perception rather than system transformation.
This disconnect between micro-level opinions and macro-level circular economy frameworks significantly reduces the academic value of the work.
Final Verdict: Rejection Justification
The manuscript is **not suitable for indexing in its current form** due to the following critical deficiencies:

1. Lack of clear theoretical and conceptual framework
2. Methodological under-specification and non-reproducibility
3. Absence of rigorous analytical or statistical modeling
4. Overly descriptive rather than explanatory approach
5. Limited novelty and incremental contribution

6. Weak integration with circular economy and sustainability theory

Overall assessment
While the topic is relevant and potentially valuable for sustainability transitions in agriculture, the current manuscript represents an **exploratory opinion-based report rather than a scientifically robust research study**. Substantial redesign of the conceptual framework, methodology, and analytical depth would be required before reconsideration for publication.

Is the work clearly and accurately presented and does it cite the current literature?
No

Is the study design appropriate and does the work have academic merit?
No

Are sufficient details of methods and analysis provided to allow replication by others?
No

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
No

Are the conclusions drawn adequately supported by the results?
No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: circular economy and climate change

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Reviewer Report 22 April 2026

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Yuanita Handayati
Institut Teknologi Bandung, Bandung, Indonesia

The paper would benefit from a more coherent writing flow, particularly by strengthening the explanation of the research gap and the study's novelty so that its contribution becomes more

explicit from the introduction onward. It is also important to maintain consistency in the use of terms throughout the manuscript, especially in describing the research approach and key concepts, and to ensure stronger alignment between the introduction and the conclusion so that the final section clearly reflects the study's original focus, framing, and contribution.

Introduction:

1. Clarify the research gap and problem statement more explicitly. It is not enough to simply say that it has "not been discussed"; it should be specified at what level it remains underexplored, by whom, and what the implications are for CF policy development and adoption. Remove wording like "To the best of our knowledge".
2. Improve the flow and keep the introduction consistently focused on farmers' acceptance of circular fertilisers. Avoid sections that feel disconnected from the main focus.
3. Provide literature to support paragraph 2 and 3 page 5

Methodology:

1. Clarify the consistency between qualitative and quantitative wording;
2. Adjust the study aim and claims in the introduction so they match the actual sample, which is exploratory and concentrated in Germany, Italy, and Spain
3. On descriptive analysis, it would be better to clarify which items were measured using Likert scales and which used binary responses. Provide justification for the factors.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and does the work have academic merit?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Operation, supply chain management, circular economy, logistic and transportation

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have

significant reservations, as outlined above.

Version 1

Reviewer Report 08 October 2025

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Abhinav Katiyar
Indian Institute of Management (IIM), Mumbai, Maharashtra, India

This study examines the social acceptability and legitimacy of circular fertilizers (CFs) among European farmers. Through two theoretical lenses—legitimacy theory and social acceptability theory—it analyzes the factors impacting the willingness to use CFs, or fertilizers derived from secondary source materials, using 360 survey results from six EU nations.

Area of Concern Suggestion
Analysis of Statistics: No inferential or multivariate tests were included; only descriptive analysis was presented. Incorporate regression or correlation analysis to measure relationships (e.g., between readiness to adopt and trust).
Bias in Sampling Results may be skewed by the overrepresentation of Germany, Spain, and Italy (about 93% of the total). Describe the limitations of geographic imbalance and provide clarification on representativeness.
Limitations of Software Analytical depth is limited when Excel is the only tool used. For more thorough inferential and factor analysis, future research should use specialized software (such as SPSS or R).
Qualitative Depth: Although the theoretical analysis (legitimacy vs. acceptance) is interpretive, it lacks open-ended questions or quotes from participants. To improve interpretative validity, incorporate content analysis or qualitative coding.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and does the work have academic merit?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: LCA, CE, SCM, Fertilizers

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 25 June 2025

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Helen C. S. Amorim
University of Arkansas Fayetteville, Fayetteville, Arkansas, USA

Summary:
This study employs two approaches (social acceptance and legitimacy) to investigate the willingness of farmers to use CF/status of CF utilization in the EU/perception of farmers regarding CF. While the survey brings some interesting points, the paper does not apply a formal statistics analysis. This needs to be improved to enhance the scientific soundness of the paper; otherwise, it is just a report.

Introduction
1. More details on circular fertilizers are needed - perhaps provide a list of the most common "circular fertilizers" being used in EU;
2. On social acceptance (page 3, paragraph 8): please include more recent references about the use of social acceptance in different field of studies;
3. Avoid the repeated use of expressions like 'as previously discussed', 'on the other hand', or 'to the best of our knowledge';
4. Please briefly describe the FER-PLAY project for your readers;

Materials and Methods
5. More details on the data processing are needed. For example, how were the data analyzed? Average, median values? Or only qualitative responses were provided?

Results and Discussion
6. The group responding the survey is not representative of the EU agricultural sector. I am curious about how the authors will expand these results.

Figure 1 needs more detail on the caption.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and does the work have academic merit?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
No

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular economy, waste management, insect frass, conservation agriculture, soil health

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.