



SoildiverAgro

Soil biodiversity enhancement in European agroecosystems to promote their stability and resilience by external inputs reduction and crop performance increase

D6.4. FARMERS' ADOPTION OF SUSTAINABLE SOIL MANAGEMENT PRACTICES

Universidad de Vigo
 Universidad Politécnica de Cartagena
 symbiom. LEARNING FROM NATURE
 FEUGA FUNDACIÓN EMPRESA - UNIVERSIDAD GALILEA
 UNIVERSITY OF COPENHAGEN
 ILVO Flanders' research institute for agriculture, fisheries and food
 PROEFSTATION VOOR DE GRONDTEELT
 RUBÉN RODRÍGUEZ GÓMEZ
 Tyynelän tila
 PETLA
 Luke LUONNONVARAKESKUS
 Kelpiän tila - auringonvalosta iloa ja hyötyä
 THÜNEN
 inorde Instituto Obrero de Desarrollo Científico y Tecnológico Fundación de Galicia
 ASAJA Región de Murcia
 Eesti Maaülikool EMU Estonian University of Life Sciences
 fyneco Vegeta Technology
 contactica innovation
 FlächenAgentur Rheinland GmbH
 inagro INSTITUTO GALLEGO DE INVESTIGACIÓN E INNOVACIÓN AGROPECUARIA
 POMONA
 Mullakaitse

D6.4 FARMERS' ADOPTION OF SUSTAINABLE SOIL MANAGEMENT PRACTICES

Summary

Change in the current farming practices is crucial for improving soil conditions and the ecosystem services. Beyond economic and environmental aspects, the adoption of new management practices by farmers depends on several social and psychological factors at the farm level. The objective of this deliverable is to obtain a better understanding of decision-making by farmers when it comes to the adoption of sustainable soil management practices. In this deliverable, we apply the theory of planned behavior. We present barriers and drivers for different sustainable soil management practices taking into account the context of the five pedoclimatic regions included in our study. Furthermore, we present an econometric analysis of farmers compensation requests.

The survey results from the regions showed that the most commonly used indicators to evaluate soil quality were soil structure, pH levels, and water retention capacity. Generally, 46% of respondents rated soil quality as rather good, while 38% rated it as neither good nor bad. Popular practices to improve soil quality included incorporating crop residue and implementing long rotation periods, with strong interest in less frequent ploughing and reducing tillage depth. Attitudes towards improving soil quality were positive, and the intention to invest in soil quality was strongly linked to past behavior and moral obligation.

Varying levels of intention were shown related to regional practices, being highest in Atlantic Spain (crop diversification) and in Finland (plant cover, shallow tillage). The importance of attitude and past behavior in explaining intention to apply the practices were consistent across the regions, with the most positive attitudes in Mediterranean Spain towards biostimulants and biofertilizers, and the most negative in Germany towards underseeding.

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Natural Resources Institute Finland (Luke)	Eija Pouta (Luke) Jo Bijttebier (ILVO) Olha Aleksandrova (EMU) Annika Tienhaara (Luke) Martin Banse (TI) Javier Calatarava (UCO) Simon Lox (ILVO) David Martínez-Granados (UCLM) Anne Pöder (EMU) Miguel Rodriguez Mendez (Uvigo)

Marina Gomez Rodriguez (Uvigo)
 Paul Swagemakers (UCM)
 Omid Zamani (TI)

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1 Introduction

In the EU Soil Deal for Europe (EC 2021), healthy soils are acknowledged as the foundation of our food systems. *'Soil is the foundation of our food systems. It provides clean water and habitats for biodiversity while contributing to climate resilience. It supports our cultural heritage and landscapes and is the basis of our economy and prosperity.'*

In Soildiveragro, we specifically focus on soil biodiversity. Soil biodiversity is recognized as crucial in guaranteeing the functioning of soil and as a provider of several ecosystem services. Soil biodiversity, together with their abiotic and biotic interactions, determines the multi-functionality of soils: complex soil food webs recycle nutrients, decompose organic matter, sequester carbon, regulate and filtrate water, provide habitat support, raw and food materials, remediate contaminants, and increase the genetic pools (Wagg et al., 2014).

However, according to EU Soil Observatory (EUSO 2025) dashboard, more than 60% of EU soils are considered unhealthy due to current management practices, pollution, urbanisation and the effects of climate change. As a direct consequence, soil biodiversity is also threatened by multiple stresses including intensive agriculture, deforestation, urbanisation, loss of organic matter, soil compaction and sealing, soil acidification and nutrient imbalances, pollution, salinisation and sodification, fire, erosion and landslides, climate change and invasive species (FAO, 2015). Previous studies have claimed that soil biodiversity is under pressure in 56% of the total European land, with 14% being at high risk (Gardi et al., 2013) and another study found 40% of 14 Member States (MS) (EU + UK) under a moderate-high to high potential risk (Orgiazzi et al., 2016).

Over the last decades, agriculture in Europe has intensified significantly to meet the demands of the increasing human population. As a result, a variety of agricultural management processes have been imposed on the soil ecosystem, including external inputs such as pesticides, fertilizers, herbicides, and tillage. These practices distort the natural balance of the soil ecosystem and may compromise the output of other environmental services (Kibblewhite et al. 2008), which, to a large extent, results in the loss of other ecosystem functions and thus renders the soil unhealthy.

Change in the current farming practices is crucial for improving soil conditions and the ecosystem services. The main objective of SoildiverAgro is the adoption of new management practices and cropping systems that enhance soil genetic and functional biodiversity to reduce the use of external inputs while increasing crop production and quality, delivering ecosystem services and enhancing EU agricultural stability and resilience. New management practices with realistic potential for meeting end users' needs through soil biodiversity enhancement were tested in the case studies' on-field experiments within WP5. These innovative agricultural practices are in generally based on the principles of minimizing soil disturbances, keeping the soil covered, maximizing plant diversity, and maximizing the period of living root growth, considering the soil's natural characteristics such as texture, natural drainage class, and slope (Woodyard and Kladviko, 2017). Managing soil for improved health demands a long-term commitment to using combinations of soil-enhancing practices.

However, before large-scale adoption of new management practices and cropping systems that aim to enhance soil genetic and functional biodiversity, an environmental and socio-economic analysis is needed to guarantee the real benefits of managing soil organisms for farmers and

society. The main aim of WP6 is therefore to assess the environmental, economic and social costs and benefits of proposed management practices and cropping systems that might positively affect soil biodiversity. However, beyond economic and environmental aspects, earlier studies have shown that the adoption of new management practices additionally depends on several social and psychological factors at the farm level.

The objective of this deliverable is to gain more insight into decision-making by farmers when it comes to the adoption of sustainable soil management practices. This deliverable summarizes the methodologies and results of activities carried out within task 6.2.3. with the overall objective of identifying barriers and drivers of a diversity of cropping systems and management practices in five pedoclimatic regions.

Before we introduce our methodology and results, we start with introducing the theoretical framework that guides our methodological approach. We will also give a short overview of earlier studies with respect to the adoption of sustainable soil management by farmers, to justify some methodological choices. In the following, we will present the methodology. In the results section, we present barriers and drivers for different sustainable soil management practices in the context of the 5 pedoclimatic regions included in our study. Finally, we will conclude with overall recommendations for further promoting the adoption of practices that enhance soil biodiversity.

2 Theoretical framework and previous literature for understanding farmers' adoption of sustainable soil management practices

2.1 Behavioural approaches and theory of planned behaviour

Many different models and approaches exist to study behavioural change. Some models focus on understanding internal antecedents of behaviour such as values, attitudes and intentions. Others focus more on external factors like incentives, norms and institutional constraints. Some models focus on assessment of internal aspects of individual decisions but fail to fully address the importance of contextual or situational variables and vice versa (Jackson et al., 2005). Making sense of behaviour inevitably requires a multi-dimensional view which incorporates both internal and external elements. In this respect, we believe that behavioural sciences can make a relevant contribution to exploring changes in agricultural practices since it approaches behavioural change from an interdisciplinary perspective. Behavioural science is the branch of science concerned with the study of human behaviour, encompassing fields such as sociology, psychology and economics. Applied behavioural science focuses on developing interventions for behavioural change by understanding how decision-making is affected by various factors, including internal as external factors.

Several frameworks and models have been developed to contribute to applied behavioural sciences. In this deliverable, we will use the Theory of Planned behaviour (TPB). The theory was established in the late 1980s and early 1990s, and has been successfully used in various fields for examining factors that influence individual behaviour. TPB is recognized as a practical and empirically supported framework that provides clear guidelines for quantifying social-psychological variables and developing theoretical models. This framework states that individual human behaviour depends on an individual's intention to perform the behaviour (itself influenced by beliefs, habits, etc.) in addition to perceived behavioural control (how difficult one believes a task to be) and social norms. This framework is used as it acknowledges the fact that decision-making does not occur in a vacuum but rather in a social, technological, legal and psychological context.

Evaluating farmers' behaviour towards sustainable soil management practices through the TPB lens can uncover the motivating factors and obstacles that affect their decision making. At the heart of TPB is the idea that a person's likelihood to engage in a behaviour is linked to their intention to perform that behaviour (Ajzen and Fishbein, 1980; Ajzen, 1987; Ajzen, 1991). This intention is shaped by three key influences: their personal attitude toward the behaviour, the perceived social expectations (or subjective norms) from influential people around them, and their own belief in their capability to perform the behaviour (known as perceived behavioural control). Attitude emerges from the farmer's belief that certain practices lead to specific results. This belief is influenced by the importance the farmer places on each result. Subjective norm is

shaped by the farmer's perception of the expectations of others, known as referents, regarding whether the farmer should engage in the behaviour. It also depends on the farmer's willingness to adhere to these perceived expectations. Perceptions of behavioural control are formed by the farmer's belief in the presence of factors that either ease or hinder the behaviour. These factors are considered alongside the anticipated effect they would have if they were to occur. Together, these underlying subjective beliefs act as cognitive motivators or deterrents, influencing the farmer's intention to adopt a practice by either encouraging or dissuading them.

These aspects collectively guide a farmer's decision-making process regarding whether to embrace a particular agricultural method, weighing the perceived benefits or drawbacks (attitude), the perceived encouragement or pressure from their community (subjective norm), and their confidence in their ability to successfully implement the practice (perceived behavioural control) (Figure 1).

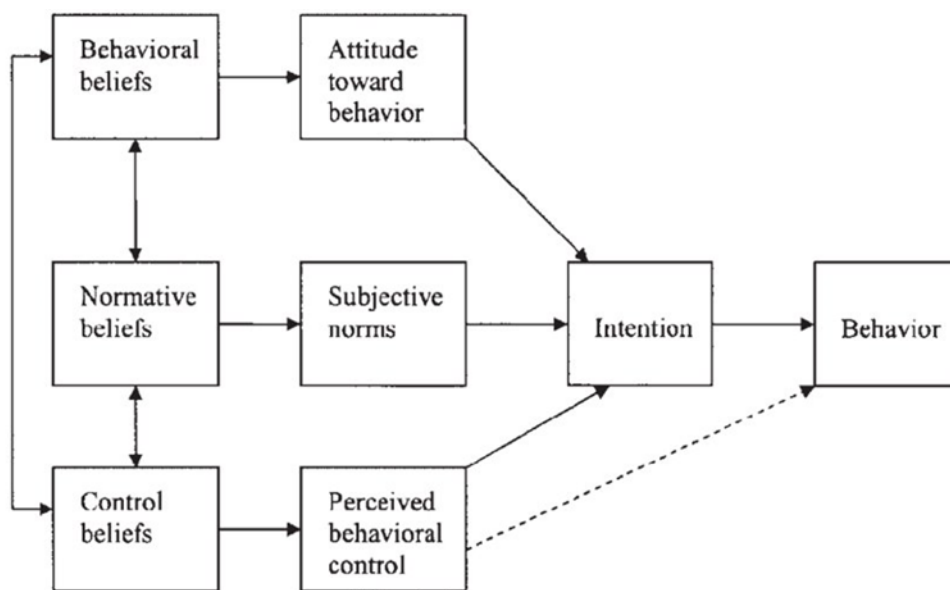


Figure 1. Theory of planned behavior

2.2 Previous studies on the adoption of sustainable soil management practices

A meta-analysis by Wauters and Matthijs (2014) revealed that most TPB studies on soil conservation practices originated from the USA, Canada, or Australia. However, also in Europe, several studies have been done during the last decades to understand the adoption of soil conservation practices more deeply. We focus on those that have applied the theory of planned behaviour to gain insight into barriers and drivers for the adoption of sustainable soil management practices. Several studies showed that farmers' intentions to adopt sustainable agricultural practices are influenced both by their positive attitudes towards the environment, perceived social pressures, and their sense of control over the actions (Adnan et al., 2017; Arbuckle and Roesch-McNally, 2015; Hijbeek et al., 2018). For example, farmers' intentions to

use cover crops or to increase soil organic matter are influenced by their environmental attitudes, social pressures, and perceived control over their actions (Arbuckle and Roesch-McNally, 2015; Hijbeek et al., 2018). These studies focus on testing the validity of the TPB framework for the adoption of a particular agricultural practice, meaning that it generates knowledge on the influence of attitude, subjective norm and perceived behavioural control on the intention to adopt the measure.

While concluding that attitude, subjective norm, and perceived behavioural control affect intentions and behaviour is helpful, it is not sufficient for developing effective interventions in extension, communication, policy, and research, as it does not provide information on how to change attitude. To address this issue, some studies have focused on eliciting the subjective beliefs that form the basis of attitudes, norms, and perceived control (Beedell and Rehman, 1999; Fielding et al., 2005; Wauters and Mathijs, 2013; Werner et al., 2017; Bijttebier et al., 2018). These beliefs are thought to provide the cognitive and affective foundation for attitudes, norms, and control perceptions. As an example, farmers with positive intentions are more likely to view favourable outcomes as probable and feel more pressure by their social environment, including key referents such as agricultural organizations, neighbours, and government (Werner et al., 2017). Bijttebier et al. (2018) emphasizes the context specificity of these subjective beliefs. They applied the TPB in four countries to understand adoption of non-inversion tillage. Context specificity consists of biophysical, economic and social characteristics but also regulatory and institutional conditions in a region. This is confirmed also by the study of Schneider et al. (2010), showing differences within a country, by illustrating the importance of culture in the adoption of conservation tillage in Switzerland. So, it is difficult to draw generalized conclusions on how to approach and stimulate adoption in different contexts. In this deliverable, we therefore develop case study specific questionnaires to draw conclusions on the adoption of specific practices, taking into context specificities.

The studies above show that most studies focus on the adoption of very specific soil management practices. These studies are motivated by the position that soils across Europe are unhealthy and on the positive contribution of these practices to soil health and soil quality. This position is shared by the community of soil scientists and policy makers. However, to what extent is that position also shared within farmers' community? To what extent are they concerned about soil biodiversity and soil quality in general? To what extent are they convinced and feel the urgency to take action to improve soil quality of agricultural land? Is improving soil quality compatible with other goals, values and norms that drive farmers' action and behaviour? Ingram et al. (2010) have shown that farmers and scientists/advisors use different methods and language to describe soil properties and attribute different meaning to what they see. They operate in different contexts, pursuing different goals. Differing perceptions are directed and shaped by their respective aims, methods and context of work. Farmers and researchers have different conceptions of soil, they attribute different meaning to the same activities, and use different words and language to describe the same features. With these insights in mind, it is interesting to explore how farmers define soil quality, what they consider as good quality, what kind of indicators they use to assess this, and how convinced they are of their contribution as individual farmers in addressing soil related challenges.

Therefore, we conclude that besides it is important to know drivers and barriers towards adoption of specific management practices, it is equally important to understand farmers' perspectives, attitude, and knowledge regarding soil quality and soil management in a more

general way relative to other environmental issues and other farm related challenges and aspects.

2.3 Complementing the Theory of planned behaviour in the soil management context

Although the TPB has been used as theoretical model to predict human behaviour, also in the context of the adoption of sustainable farming practices, the TPB does not provide a complete explanation of intention or behavior. In other words, social norm, attitude and perceived behavioural control do not provide a full explanation of intention or behaviour. Two studies, in the context of soil conservation practices in Europe, reported a predictive ability of the model up to 70% (Wauters et al., 2010; Werner et al., 2017). This limited predictive power is probably one of the most commonly discussed critiques on the model. However, according to Ajzen (1991), the theory is in principle open to the inclusion of additional explanatory variables, as long as they can be shown to have a significant and distinct contribution. This has prompted researchers to add additional constructs and test whether they increase predictive power of intention and/or behavior. In Botetzagias et al. (2015), a small overview is given. They indicate that moral norms, situational factors and past behavior are the ones most commonly used and generally perceived as enhancing the predictive ability of the standard constructs of the TPB. Other studies also included self-identity, perception of mass media, environmental knowledge and perceived habit (or lack of it) of sustainable practices.

Some of these constructs were tested in the context of pro environmental behaviour. There has been increasing evidence on the additional predictive power of moral norms in explaining the variance in pro-environmental behaviour, which should not surprise as moral and normative considerations are inherent in any discussion of pro-environmental behaviour (Bamber and Moser, 2007). Moral norms are 'personal feelings of moral obligation of responsibility to perform a certain behavior'.

Also, in the context of perceived behavioural control, several studies support the dimensionalisation of the construct into two components, internal and external control, to provide a better understanding of the complex nature of the perceived behavioural control (PBC) construct (Conner & Armitage, 1998). They distinguish between a behaviour that may be perceived as being within an individual's control based on factors that are either internally or externally oriented. A behavior may be internally controllable when an individual perceives that he or she possesses control over personal resources, such as requisite skills, confidence, and ability, to perform the behavior (Armitage & Conner 1999). A behavior may also be externally controllable when it is perceived as easy to perform; that is, when it is relatively free of external or extrinsic influences that can act as a barrier toward behavioral performance. Jackson et al. (2005) also criticized the assumption that many behaviours are carried out without any conscious deliberation at all. As individuals, we often seem to act instinctively, automatically, out of routine or habit, in spite of our best intentions to act otherwise. They state that habits and routines play a vital role in the cognitive effort to function effectively. This explains the efforts of some researchers to also add 'past behaviour'.

Moral norms, past behaviour, external and internal control are therefore added to the basic constructs of the TPB and tested in our study as potential predictors of farmers' intention and behaviour to invest in soil quality measures.

2.4 Economic approach: Farmers stated preferences for soil management in economic terms

Farmers' intention to apply soil friendly practices can also be enhanced with economic support. Then farmers intention is viewed as a decision-making problem to choose new management practices with significant positive externalities. As rational economic agents, farmers' choice of new practice is a decision made by comparing the costs and benefits of the old and new management practice to maximize profit (Yu et al., 2017). Traditional farming practices may result in water body contamination with pharmaceuticals, affecting farmers' profits (Bbxa et al., 2021). When famers can perceive the harm that traditional farming practices may cause to harvest quality, they are inclined to adopt soil friendly practices driven by economic rationality (Chen et al., 2023).

Previous literature exploring farmers' willingness to improve soil quality highlights a multifaceted interplay of economic, social, and environmental factors. Studies indicate that farmers' willingness often hinges on their awareness of the long-term benefits of soil health, such as increased crop yields, reduced input costs, and enhanced sustainability (Dessart et al., 2019). Socioeconomic factors, including education levels, farm size, and access to subsidies or incentives, also significantly influence decisions (D'Souza et al., 1993). Additionally, external pressures such as regulatory policies and market demands for sustainably produced goods play critical roles (Schröder et al., 2018). Furthermore, access to extension services and participatory training has been shown to enhance farmers' willingness by bridging knowledge gaps and fostering collaborative learning environments (Knowler & Bradshaw, 2007). Empirical studies highlight that environmental awareness, and the recognition of ecosystem services are strong motivators for adopting sustainable soil management. For example, farmers who understand the benefits of improved soil health, such as increased productivity and resilience to climate change, are more likely to adopt conservation practices (Dessart et al., 2019). In contrast, those lacking such awareness may remain hesitant, emphasizing the need for targeted outreach and education efforts. Furthermore, the adoption of soil-friendly practices is often region-specific, shaped by local environmental challenges, regulatory pressures, and market demands for sustainably produced goods (Prokopy et al., 2008).

The concept of willingness to accept (WTA) compensation has been applied to measure the strength of farmers preferences for implementing soil conservation practices. In previous studies, the factors influencing preferences and WTA compensation for chemical fertilizer reduction and conservation technologies have generally been categorised into: socio demographics, farm characteristics, and environmental and political factors (Aihale et al., 2020; Liu et al., 2023). The financial incentives, such as subsidies or compensation schemes, significantly enhance farmers' interest in adopting sustainable practices, particularly when the perceived risks and upfront costs of new technologies are high (Li et al., 2018).

3 Methods and data

3.1 Survey data

This study applied the Theory of Planned Behavior (TPB) to assess farmers' behavioral intentions, attitudes, subjective norms, and perceived behavioral control concerning soil management practices across different regions. The survey included both common practices in all regions as well as region specific management practices. The criteria for selecting region specific management practices focused on identifying practices that could be clearly described in a survey and easily understood by respondents. These practices had to be suitable for large-scale implementation and not too novel, ensuring that they were already familiar to some adopters. The selected region-specific management practices and their descriptions are in Table 1.

Table 1. Management practices in each region.

Country	Management practice	Definition
Belgium	Non-inversion tillage	Non-inversion tillage means not using a plow to turn the soil for at least a year.
Estonia	Direct seeding (no till)	A tillage method where land is not plowed, minimizing soil disturbance. Seeds are sown directly, which reduces soil erosion and improves soil quality.
Finland	Cultivation with plant cover	A practice where the soil is lightly tilled in spring (8-10 cm depth) and covered with plants or plant residues, enhancing soil protection.
Germany	Undersowing	Sowing a second crop with or after the main crop, which improves soil quality.
Spain (Atlantic)	Crop diversification	Growing different species (e.g., potatoes and vegetables) either simultaneously or in rotation, improving soil quality.
Spain (Mediterranean)	Biostimulants/ Biofertilizers	Use of bio-based products to enhance plant growth and soil health.

Semi-structured interviews were used to help identify commonly held beliefs, key outcomes, referents, and control factors for each practice among farmers. Based on these insights, a survey questionnaire was designed to capture farmers' beliefs on the likelihood of outcome to take place and the perceived importance of outcomes, the influence of social referents, and control factors affecting adoption of the management practice.

The survey questionnaire began by collecting background information on the farmer and farm characteristics. It then moved on to questions related to soil management, including how farmers assess soil quality on their farms, the indicators they use, and their perceptions and experiences with different soil management practices. This section also measured the key

components of the TPB, such as intention, attitude, subjective norms, and perceived behavioural control regarding investments in soil quality overall (Table 2).

The second part of the survey focused on region-specific management practices, asking whether farmers currently apply these practices and their intentions to adopt them in the future. For those not interested in adopting a specific practice, additional questions explored whether they might reconsider if compensation were provided, along with their compensation requests. In this section, the components of TPB were measured for region specific management practices. In addition, behavioural, normative and control beliefs as well as their importance were measured (Table 2).

Table 2. Measures for TPB, a) general intention to invest in soil quality and b) regional measures.

Concept	Scale	Measure
a) general intention to invest in soil quality		
Intention	1-13	Number of currently used or intended practices from the list of 13 practices and their perceived impact on soil quality
Attitude	1 not at all necessary – 5 very necessary	Investing in good soil quality on my farm is..
Subjective norm	1 completely disagree – 5 completely agree	People who are important to me in farming issues think I should invest in having good soil quality on my farm
		People whose opinion I value think I should invest in having good soil quality
Perceived behavioral control	1 completely disagree – 5 completely agree	I am confident that I am able to maintain soil in good quality
		I believe I have the ability to improve quality of my soil
		Having soils of good quality on my farm is entirely up to me
		Improving soil quality is beyond my control
Moral obligation	1 completely disagree – 5 completely agree	I feel a strong obligation investing in good soil quality on my farm
		I would feel guilty if I didn't focus on the good to the quality of the soil on my farm.
		Investing in solutions to environmental problems is in line with my values and beliefs.
b) regional measures, management practice marked as MP		
Intention	1 no 2 maybe 3 yes	I have the intention to apply MP on at least one parcel next season
	1 no 2 maybe 3 yes	It is in my plan for the near future to apply MP on at least one parcel
Attitude	1 not at all useful – 5 very useful	I think that applying MP on my farm is...
Subjective norm	1 completely disagree – 5 completely agree	People who are important to me think I should apply MP
		People whose opinion I value think I should apply MP
Perceived behavioral control	1 completely disagree – 5 completely agree	To me, MP is very difficult to apply
		Whether I apply MP or not is totally up to me.
		The decision to apply MP or not is totally under my own control.

Behavioral beliefs	1 not at all important – 5 extremely important	How important you consider the following topics (regional)?
	1 very unlikely – 5 very likely	How likely MP would cause following outcomes (regional) on your farm?
Normative beliefs	1 completely disagree – 5 completely agree	I feel that X (regional) think I should apply MP
	1 not at all important – 5 extremely important	How important do you perceive the opinion/advise of the following persons or institutions (regional) while deciding about the use of MP?
Control beliefs	1 completely disagree – 5 completely agree	Do you agree or disagree with the following statements? (regional statement of controlling aspects)
	1 strongly hinders adaptation – 5 strongly supports adaptation	How do you perceive the following factors in decision to use MP? (regional)

The survey was conducted using Webropol online survey platform across the five regions, targeting a sample size large enough for statistical modelling (N > 300 per region) and focusing on areas where the selected practices were viable. The survey was translated into the local language of each target region.

The aim was to have enough data for statistical modelling from each of the six regions. The approaches were different because the opportunities to reach the farmers varied between regions. E-mail invitations were preferred for inviting farmers to respond to the survey, but also other methods for contacting respondents had to be used in some of the regions as contact information for farmers was not available. In these cases, survey links were distributed through farmers' organizations, newsletters and agricultural press.

- **Belgium:** The Agency for Agriculture and Fisheries, part of the Government of Flanders has extensive identification data on all Flemish farmers. Contact details were requested from the Agency for Agriculture and Fisheries in Flanders, in accordance with the protocol for providing personal data to ILVO by the agency. The selected contact details were passed on to the data manager of the social sciences unit at ILVO, who sent the survey to 243 organic farms and 1694 non-organic farms. The link to the survey was additionally published in several newsletters and agricultural press.
- The sample for the **Estonian** survey was formed on the basis of the list of agricultural producers, who applied for CAP single area payment in 2022. EMU applied for the access to the contact details through the Agricultural Registers and Information Board (ARIB) that is the agency for agricultural supports in Estonia. After the removal of duplicates, the list contained 6433 unique contacts to whom the email invitation was sent. All contacted farmers were sent one email reminder one week after initial invitation. 286 producers answered the questionnaire; but after the removal of responses that did not tick the consent form, 273 responses remained in the analysis.
- In **Finland** e-mail addresses were drawn from the register of the Finnish Food Authority. In 2021, the primary farmers of spring cereals in Finland were categorized based on their farming methods and the status of their organic certification. There were a total of 2,000 email addresses collected, divided as follows: Conventional farming: 1,500 email addresses and Organic farming: 500 email addresses. E-mail invitations and reminders were sent to sampled farmers.
- In **Germany**, panel data company Product + Markt was used for data collection.

- In **Atlantic Spain**, due to confidentiality concerns arising from national data protection law, there was no direct access to most farmers' emails. As a result, the Atlantic Spain survey relied on the collaboration of entities such as research centers, farmers' associations, and local development groups to distribute the survey among their contacts. In addition, several agricultural newspapers and the social media accounts of some of the participating organizations published the link to the survey.
- In **Mediterranean Spain**, the link with the survey questionnaire was sent by e-mail and/or WhatsApp to about 500 potential respondents through both farmers' unions collaborating in SoildiverAgro and several agricultural technical advisory enterprises that collaborate with UPCT. Consequently, UPCT did not have direct access to farmers' contact details. A reminder message was sent to initially contacted farmers several weeks after the first message.

The survey questionnaire was pilot tested with a small group of farmers from Belgium, Estonia, Finland, and Spain (Atlantic and Mediterranean South regions). Based on the feedback received during this testing phase, minor adjustments were made to the questionnaire, resulting in a slight reduction in the length of the survey. Final data was collected from March to October 2023. Participants in different phases of data collection for each region are presented in Table 3. The timing of data collection varied by region to avoid the busiest farming seasons, aiming for minimal disruption to the farmers' schedules. The descriptive statistics of final farmer data in each region are shown in Table 4.

Table 3. Participants in different phases of data collection.

	Belgium	Estonia	Finland	Germany	Spain (Atlantic)	Spain (Mediterranean)
Farmers interviewed in focus groups	11	7	7	7	7	7
Farmers participated in pilot	2	7	7	-	8	3
Sampled farmers for the survey	1937	6433	1926			≈500
Started answering	229	480	517		189	305
Dropouts	92	195	124		122	81
Response rate	6.7%	4,23%	18.5%		21%*	44%
Completed the survey questionnaire	137	285	393	200	67	224
Final number of observations from those gave consent	131	273	357	200	62*	218

*Total number of Galician potato farmers with crop area more than 1 ha is 315. Response rate calculated from this total population.

Table 4. Summary statistics of respondents' characteristics.

Variables	Categories	Finland	Estonia	Belgium	Germany	Atlantic Spain	Mediterranean Spain
Gender	"1" - male	90%	82%	91%	92%	73%	79%
	"0" - other	10%	18%	9%	8%	27%	21%
Age	continuous mean	55.3	52.77	52.72	48.94	42.94	45.88
Education	"1" high education	35%	48%	47%	51%	48%	17%
	"0" other	65%	52%	53%	49%	52%	83%
Organic farms	1-yes 0-other	29%	37%	28%	9%	21%	21%
Land	Continuous (ha) mean	77.67	351.13	45.36	290.13	29.58	31.60
Farmer ownership	"1" full time farmer	75%	61%	73%	91%	58%	54%
	"0" other	25%	39%	27%	9%	62%	46%
N		357	273	131	200	62	218

3.2 Statistical methods

In this deliverable, we mainly use **descriptive analysis** to report the survey results. To gain a deeper understanding of the factors influencing landowners' intentions to 1) apply soil management practices in general and 2) the region-specific practices, we build **structural equation models (SEM)** based on TPB. The aim was to understand how different components of TPB affect the intention. This was chosen as the best method for analyzing the relationships between the variables, since it allows the entire model to be evaluated while accounting for both direct and indirect effects.

As background information for modelling, the correlation matrix between the measured variables used in SEM was calculated by using Pearson's correlation coefficients. The full information maximum likelihood (FIML) estimation method was used in the analysis to account for the respondents who had a few missing answers. Modification indices, such as Lagrange's multiplier test, were used to improve the model.

The model's goodness-of-fit was evaluated using the root mean square error of approximation (RMSEA) and the standardized root mean square residual (SRMR), where values below 0.08 were interpreted as acceptable. Furthermore, values over 0.90 for the comparative fit index (CFI) indicated a reasonable fit and values greater than 0.95 indicated a good fit (Hu and Bentler, 1999). We conducted the statistical analyses using SAS Enterprise Guide 7.15 (SAS Institute, Inc., Cary, NC, United States).

To analyze farmers' decision making from economic point of view the **hurdle models** were used. The most common is the double hurdle model as proposed by Cragg (1971) and Heckman (1979). The triple hurdle model expands on the double hurdle model by including a third decision-making stage (Famulusi et al., 2023).

Starting with all sample observation, the first stage uses an ordered logistic regression to determine whether an individual is interested in applying soil-friendly practices. In the second stage, the model evaluates the decision to apply these practices specifically if compensation is offered. The second stage uses a probit model to analyze this adoption decision. The third stage involves the regression model to obtain farmers WTA and its determinants. The dependent variable for WTA compensation model is the compensation amount that farmers would accept if compensated. In the survey, the compensation options ranged from minimum of 40 €/ha/year to maximum of more than 800 €/ha/year. .

The decisions made at each stage may be conditional on the outcomes of the previous stage, and there is a risk that unobserved factors affecting one stage could bias estimated in the next stage. We used the standard method to correct for selection bias by calculating and including the Inverse Mills Ratio (IMR). This accounts for the correlation between the errors in the selection process and those in the outcome equation. (Ma et al., 2012). To address the issue of missing values in our sample for WTA compensation (in the context of dependent variable for the third hurdle estimation), we follow approach by Zhong et al. (2018) and replace missing values with the observed mean of corresponding subsample.

4 Results

4.1 Farmers assessment of soil quality in general and interest to improve it

The survey assessed *the indicators utilized by farmers* to evaluate the soil quality (Figure 2). Among all the indicators, the most selected across the entire sample included soil structure, pH levels, and water retention capacity. In Belgium, the primary indicator was the quantity of organic matter, although pH and soil structure were also highly used. In Estonia, crop yield stood out as a key indicator, alongside soil structure and pH monitoring. In Finland and Germany, the indicators mirrored the typical distribution observed across all countries emphasizing soil structure, pH levels, and water retention capacity. In Finland, also water absorption into the ground emerged as a crucial indicator. In Mediterranean Spain, a diverse array of indicators was highly utilized, with particular emphasis on soil structure, water retention capacity, and nitrogen content. In Atlantic Spain, pH level was prominent indicator, alongside crop yield.

Farmers were asked about how they perceived the current average soil quality on their farms using the indicators they employed for evaluation (Figure 3). Across all the regions, soil quality was generally regarded as rather good, with 46% of respondents selecting this option, while 38% evaluated it as neither good nor bad. In Belgium, over half of the respondents viewed the soil quality on their farms as rather good. Conversely, in Estonia, the predominant category chosen was neither good nor bad. In Finland, the most frequently selected category was rather good, similar to Germany. In Mediterranean Spain, farmers often selected very good or rather good, whereas in Atlantic Spain, rather good and neither good nor bad were the most commonly chosen categories.

The difference in perceived quality between organic and conventional farmers was tested. In most regions, no statistically significant difference was found (Table 5). However, in Belgium, organic farmers perceived the quality to be better than non-organic farmers. Among organic farmers, 22% considered the quality to be very good. In Mediterranean Spain, the perceptions were strongly in the opposite direction, with over half of the conventional farmers perceiving the quality as very good, while none of the organic farmers did.

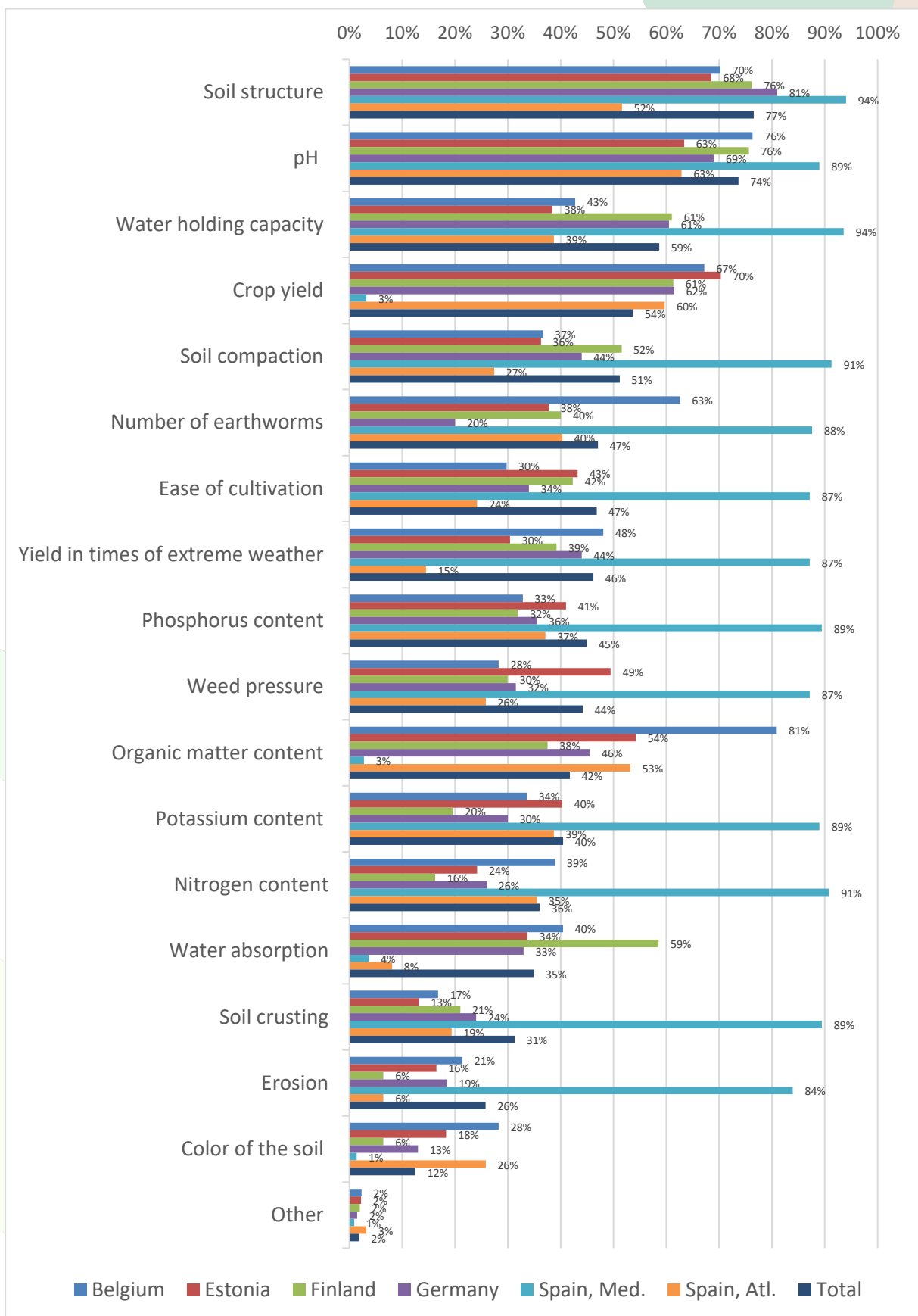


Figure 2. Use of indicators to evaluate soil quality, share of appliers in %. Survey question: What indicators do you use to evaluate soil quality on your farm?

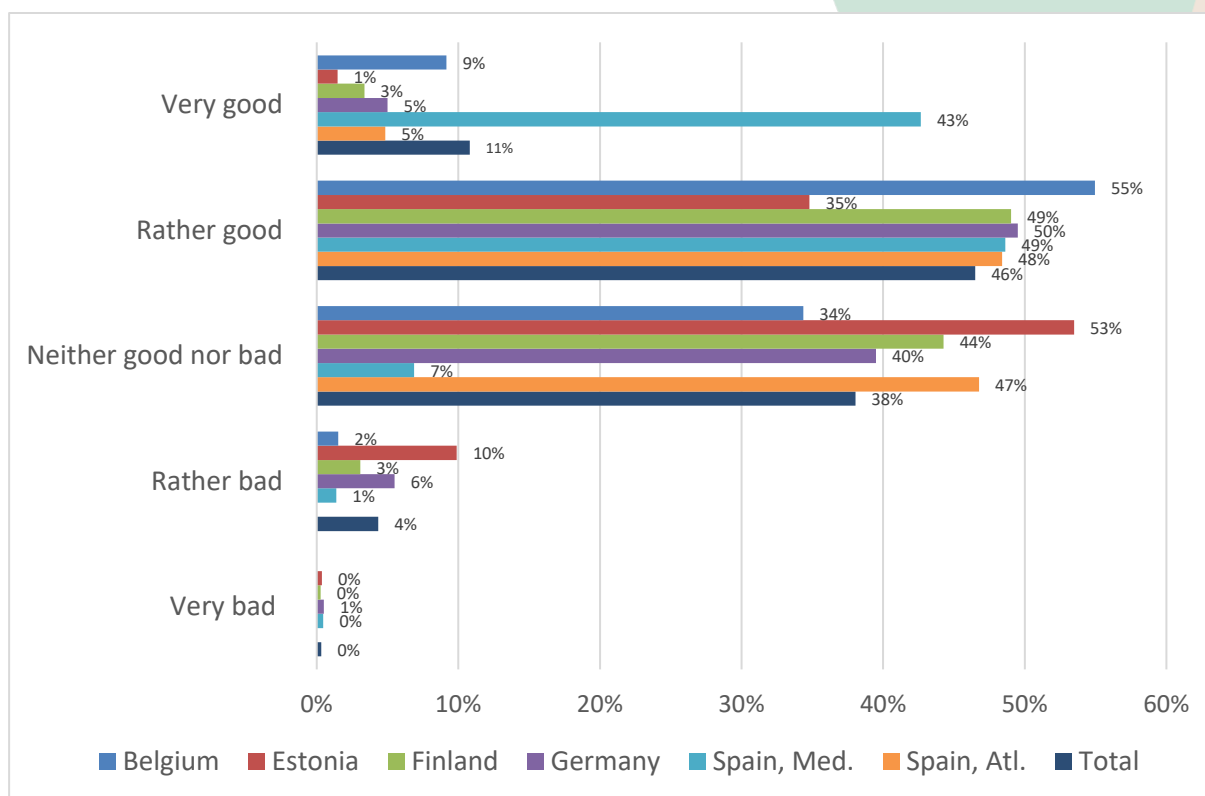


Figure 3. Farmers' evaluation of the average soil quality on their farm.

Table 5. Farmers' evaluation of the average soil quality on organic and non-organic farms.

		Very good	Rather good	Neither good nor bad	Rather bad	Very bad	Chi-square p-value
Belgium	organic	21.6 %	51.4 %	24.3 %	2.7 %	0.0 %	0.013
	non-organic	4.3 %	56.4 %	38.3 %	1.1 %	0.0 %	
Estonia	organic	1.0 %	26.0 %	61.0 %	12.0 %	0.0 %	0.153
	non-organic	1.7 %	39.9 %	49.1 %	8.7 %	0.6 %	
Finland	organic	4.9 %	44.7 %	48.5 %	1.9 %	0.0 %	0.535
	non-organic	2.8 %	50.8 %	42.5 %	3.5 %	0.4 %	
Germany	organic	5.9 %	52.9 %	35.3 %	5.9 %	0.0 %	0.993
	non-organic	4.9 %	49.2 %	39.9 %	5.5 %	0.5 %	
Spain Med.	organic	0.0 %	86.7 %	11.1 %	0.0 %	2.2 %	<0.001
	non-organic	53.8 %	38.7 %	5.8 %	1.7 %	0.0 %	
Spain Atl.	organic	0.0 %	38.5 %	61.5 %	0.0 %	0.0 %	0.387
	non-organic	6.1 %	51.0 %	42.9 %	0.0 %	0.0 %	

To assess farmers' current and potential adoption of soil management practices, 13 practices were presented in the survey. Farmers were asked to indicate whether they currently use each practice or intend to use it in the future (Figure 4). Among the 13 practices assessed, the most popular were incorporating crop residue (79%) and implementing long rotation periods in cultivation (74%). Additionally, over 70% of farmers expressed interest in less frequent ploughing and reducing tillage depth. Agroforestry was the least favoured practice. Typically, 40% to 70% of farmers were currently applying the practice, while fewer than 10% of farmers were not currently applying it but intended to do so in the future.

Analysing each region separately revealed distinct preferences. In Belgium, cover crops (that are mandatory) and incorporating crop residue were particularly applied by farmers. Belgian farmers also showed high interest in catch crops and long rotation periods. Estonian farmers prioritized the incorporation of crop residue, with additional interest in longer rotation periods. In Finland, reduced tillage depth and less frequent ploughing were the top choices, alongside an interest in long rotation periods. German farmers showed significant interest in incorporating crop residue, with nearly all farmers either already applying or intending to adopt this practice. Additionally, they expressed interest in intercropping, catch crops, and several other practices, with over 50% of farmers indicating their intent to adopt nine practices in total. Mediterranean farmers from Spain exhibited even greater interest in a wide variety of soil management practices, with nearly all proposed practices being selected by 90% of farmers. In the Atlantic Spain region, more than half of the responding farmers expressed interest in nine practices, with less frequent ploughing being the most popular among the listed practices.

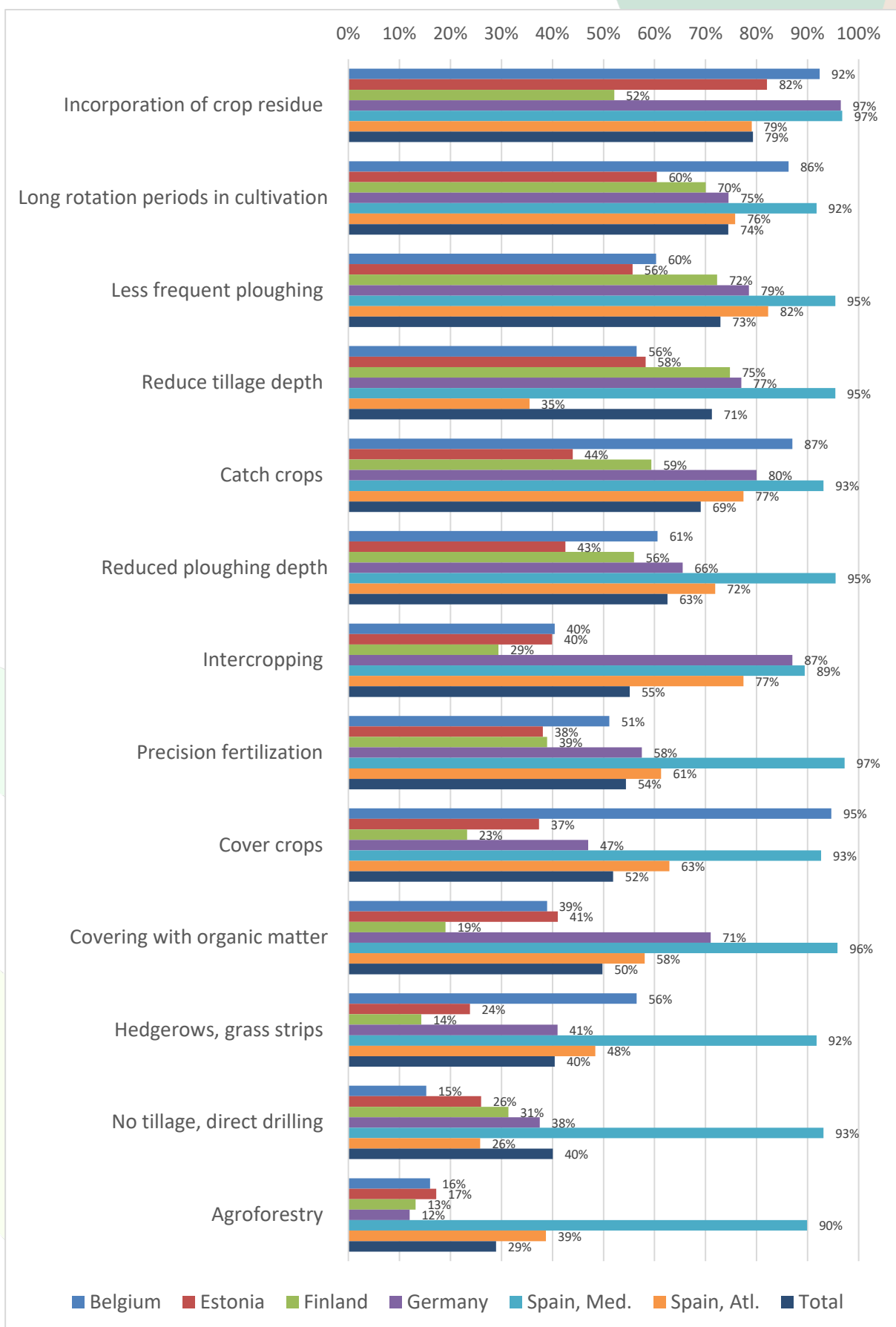


Figure 4. Share of farmers intending to use different management practices (present applicators and future intenders).

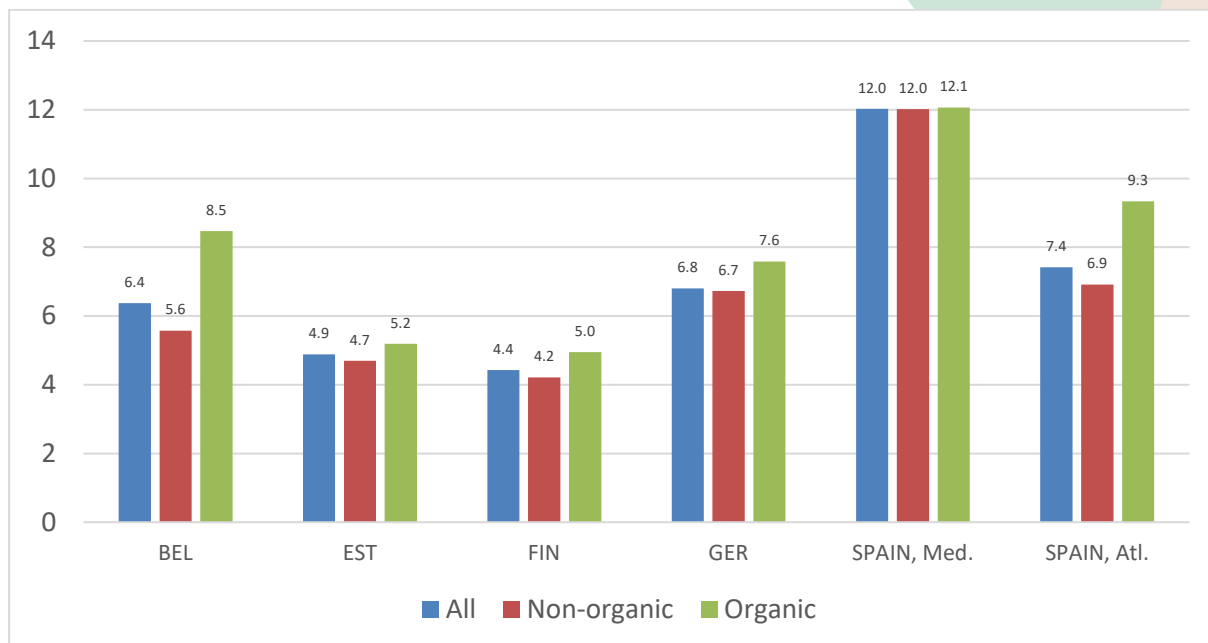


Figure 5. Comparison of organic and non-organic farmers with respect to the number of practices intended to be used.

We analysed the difference between non-organic and organic farmers in the intention to use several management practices in the near future. In Belgium, Finland and Atlantic Spain the average number of practices was significantly higher in organic production than in non-organic (Figure 5). Individual practices that were significantly more commonly used by organic farming ($p < 0.01$) include direct seeding, precision fertilization, longer rotation periods, the use of cover crops, and agroforestry.

We also measured farmers' perceptions of the possible impacts of different practices (Figure 6). Especially covering field with organic matter, intercropping and cover crops were seen as practices that contribute to good soil quality. In Belgium, also long rotation periods in cultivation incorporation of crop residue in soil were seen useful. In Estonia farmers had very positive perceptions of cover and catch crops and precision fertilization. Finland's evaluations were in line with the average of all countries but were somewhat less optimistic, similar to Germany. In Germany, the highest evaluation was given to long rotation periods, as was also the case in Atlantic Spain. In Mediterranean Spain, farmers' perceptions were very positive towards all the practices.

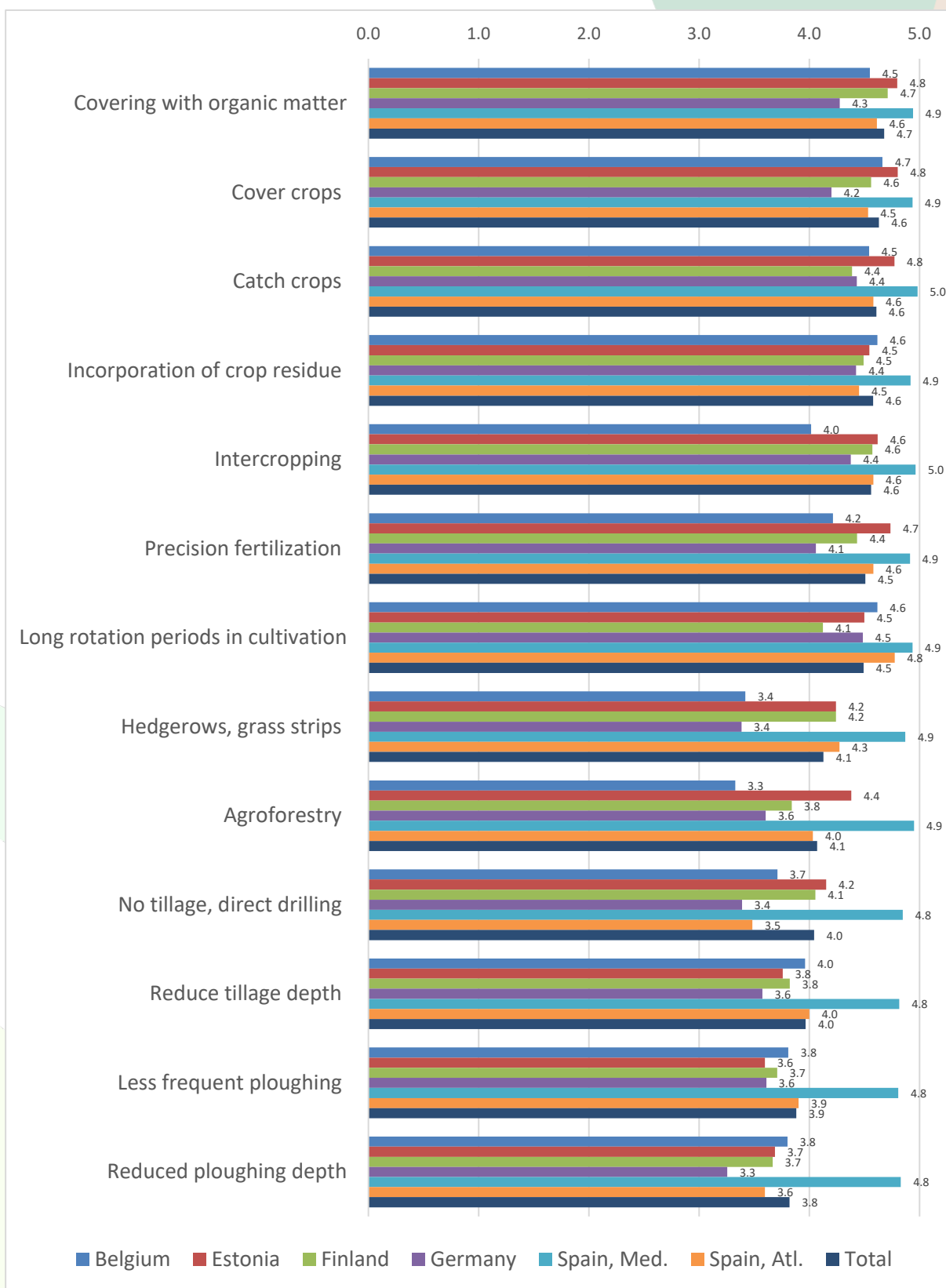


Figure 6. Farmers' beliefs regarding how management practices contribute to improving or maintaining soil quality (1 strong negative contribution... 3 no contribution... 5 strong positive contribution,).

According to TPB, attitudes and social norms as well as perceived behavioural controls impact on the intention to commit a behaviour. In our data, attitudes towards improving soil quality were very positive on a scale from one to five, the mean being 4.4 (Figure 7). Attitudes were most positive in Mediterranean Spain followed by Belgium and Atlantic Spain. The attitude scores were lowest in Finland, but still rather positive as the mean was over the value of four. Social norms, i.e. people's perception that people important for them would like them to invest in soil quality, were somewhat lower than the value of attitudes, as the mean over all regions was 3.8. Social norms were highest in Atlantic Spain and Mediterranean Spain. Perceived behavioural control, i.e. the perception that it is easy for farmers to impact on the soil quality, was rated approximately at 4. It was highest in Belgium with average of 4.2. As an extension to TPB, we also analysed the impact of moral obligation for soil quality improvements. The moral obligation was also perceived on high level, around 4, being highest in Mediterranean and Atlantic Spain as well as Belgium.

While comparing organic farmers and non-organic farmers, we found that all attitudes, social norms, perceived behavioural controls and moral obligations were higher among organic farmers compared to non-organic farmers (Figure 8). This implies that organic farmers perceive more encouraging factors towards using management practices that would improve soil quality.

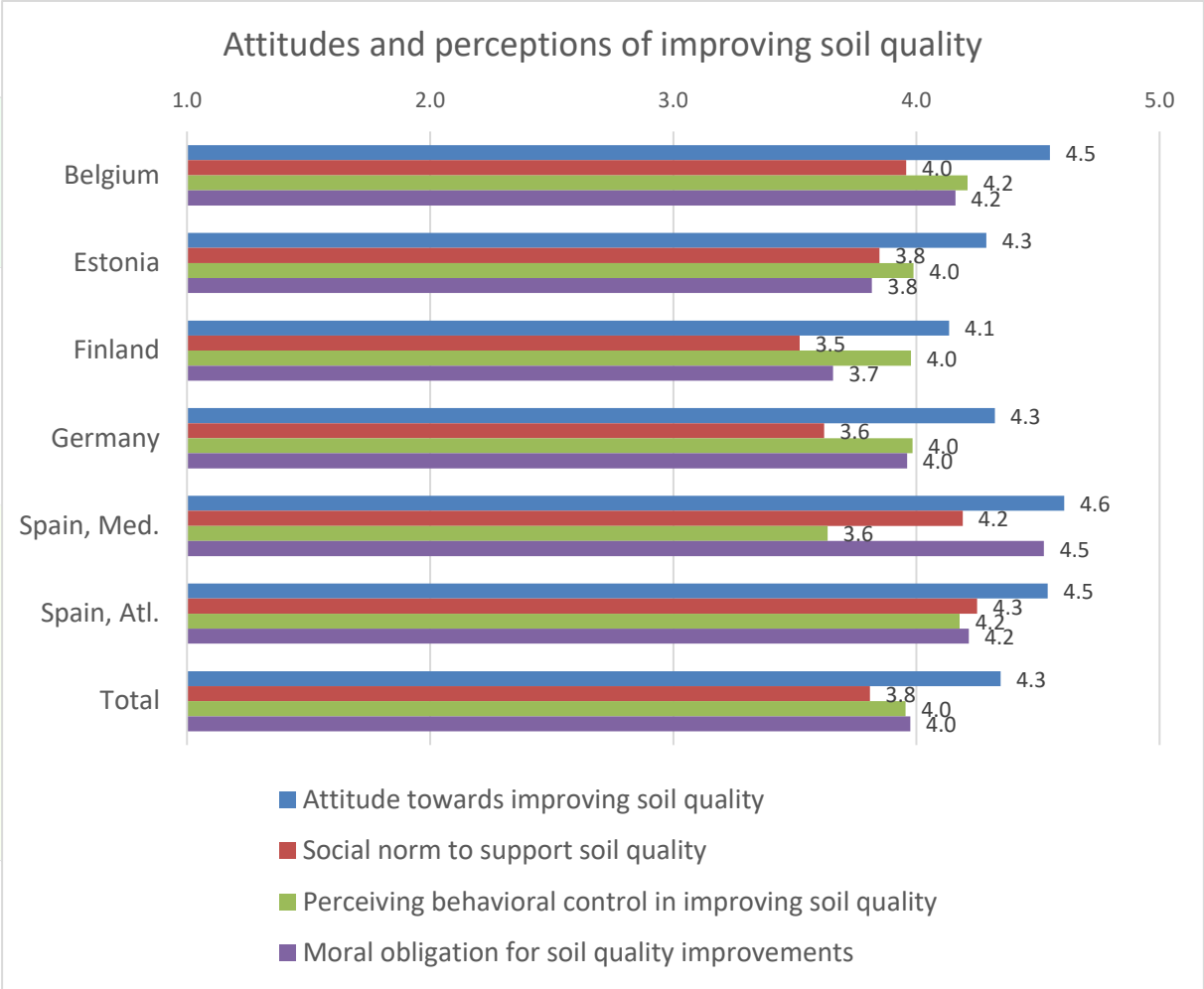


Figure 7. Factors affecting intention based on extended TPB.

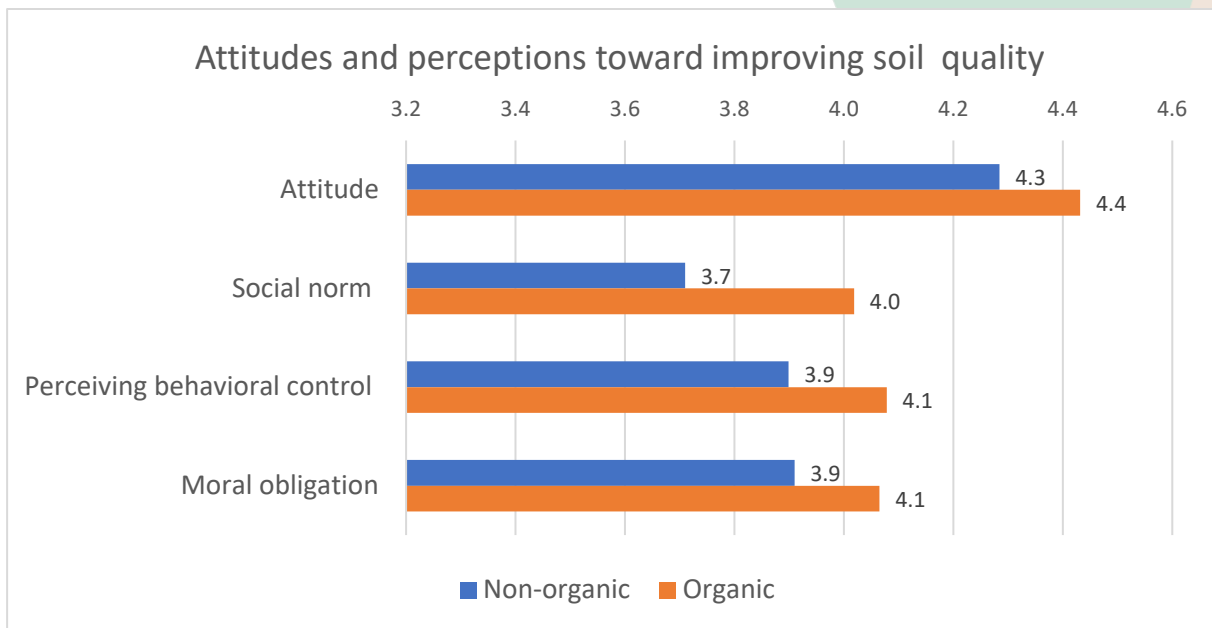


Figure 8. Comparison of attitudes between organic and non-organic farmers (all regions).

We estimated **structural equation models (SEMs)** based on TPB to predict farmers' intentions to invest in soil quality. In alignment with the TPB framework, the analysis examined how farmers' attitudes (F_ATT), subjective norms (F_SN), perceived behavioural control (F_PBC), and moral obligation (F_MORAL) influence their intentions regarding soil management. Specifically, attitudes reflect farmers' evaluations of these practices, subjective norms capture the perceived social pressure to adopt them, perceived behavioural control represents the perceived ease or difficulty of implementing them, and moral obligation reflects the perceived moral responsibility to engage in sustainable soil management practices.

The models were estimated for all regions collectively and for each region separately (Table 6). Notably, Mediterranean Spain differed from other regions, with exceptionally low variation in the key variables. In Atlantic Spain, the model fit was not acceptable due to low number of observations. Consequently, we also estimated a model excluding the two Spanish regions (Figure 9).

The results indicate that moral obligation significantly influenced attitudes, subjective norms, and perceived behavioural control, as well as the intention to invest in soil quality in the overall model. This association of moral obligation with other variables was not observed in the models for individual regions, likely due to the smaller sample sizes.

The intention to invest in soil quality was strongly associated with past behaviour in all regions. The influence of TPB components on intention varied by region. In Belgium and Germany, none of the components significantly predicted intention. In Estonia, behavioural control was a significant predictor of intention ($p < 0.1$). In Finland, both behavioural control and attitude significantly predicted intention. In Mediterranean Spain, subjective norms significantly predicted intention, while in Atlantic Spain, none of the typical TPB predictors were significant.

In the combined model for four regions (Belgium, Estonia, Finland and Germany) (Figure 9), the past behaviour, attitude, moral obligation and perceived behavioural control associated

significantly and almost equally strongly with the intention. Beyond the direct impact, moral obligation had significant impact also via ATT, SN and PCB.

The model fit indices, including the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR), suggest that the models adequately explain the observed data patterns for Finland, Germany, and Estonia, as well as for the combined model and the model excluding the Spanish regions.

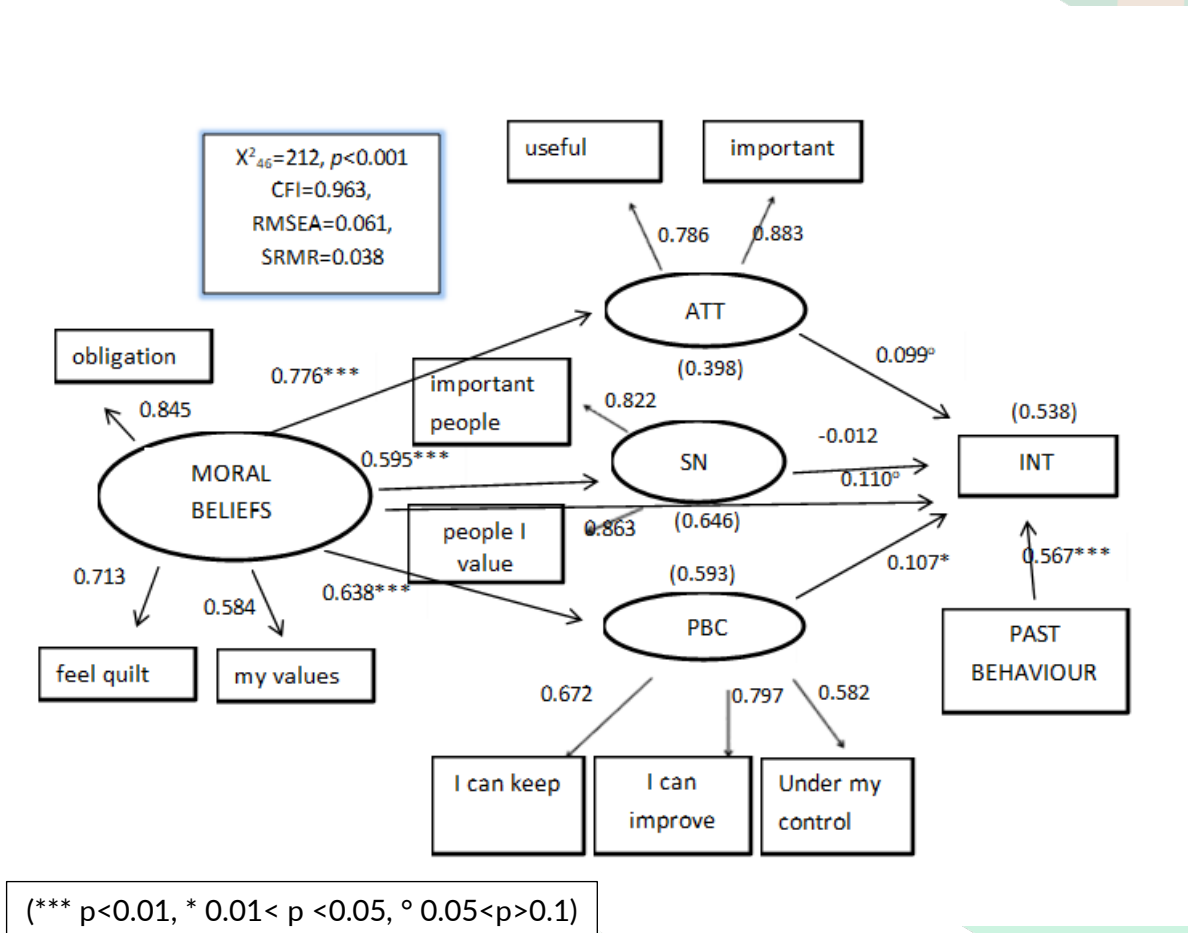


Figure 9. Structural equation model for intention to invest in soil quality for four regions (Belgium, Estonia, Finland and Germany).

Table 6. Estimated SEM models for general intention to invest in soil quality.

		ALL	All but SPAIN	BEL	EST	FIN	GER	SPAIN, Med.	SPAIN, Atl.
<i>Measurer</i>	<i>Factor</i>	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
ATT_m1	F_ATT	0.763***	0.786***	0.698***	0.848***	0.744***	0.697***	0.417***	0.665***
ATT_m2	F_ATT	0.859***	0.883***	0.825***	0.923***	0.915***	0.792***	0.683***	0.583***
SN_m1	F_SN	0.823***	0.822***	0.737***	0.844***	0.800***	0.753***	0.876***	0.675***
SN_m2	F_SN	0.880***	0.863***	0.983***	0.865***	0.893***	0.834***	0.982***	0.520***
PBC_m1	F_PBC	0.725***	0.672***	0.678***	0.675***	0.623***	0.737***	0.987***	0.632***
PBC_m2	F_PBC	0.814***	0.797***	0.601***	0.918***	0.749***	0.917***	0.944***	0.679***
PBC_m3	F_PBC	0.602***	0.582***	0.604***	0.581***	0.614***	0.496***	0.838***	0.283*
MORAL_m1	F_MORAL	0.847***	0.845***	0.767***	0.893***	0.816***	0.839***	0.945***	0.729***
MORAL_m2	F_MORAL	0.757***	0.713***	0.578***	0.795***	0.706***	0.525***	0.942***	0.450***
MORAL_m3	F_MORAL	0.653***	0.584***	0.615***	0.572***	0.603***	0.509***	0.937***	0.250***
<i>Outcome</i>	<i>Predictor</i>								
F_ATT	F_MORAL	0.758***	0.776***	0.781***	0.785***	0.713***	0.869***	0.493***	0.951***
F_SN	F_MORAL	0.586***	0.595***	0.546***	0.688***	0.557***	0.498***	0.236***	0.649***
F_PBC	F_MORAL	0.561***	0.638***	0.463***	0.644***	0.637***	0.717***	0.166**	0.908***
INT_sum	F_ATT	0.041	0.099*	0.144	0.014	0.133*	0.197	0.047	
INT_sum	F_SN	0.050*	-0.012	0.129	-0.010***	-0.002	-0.122	0.326	0.143
INT_sum	F_PBC	0.010	0.107**	0.072	0.146*	0.122*	-0.004	-0.266**	-0.071
INT_sum	F_MORAL	0.144***	0.110*	0.088	0.159	0.028	0.204	-0.015	-0.003
INT_sum	PB_sum	0.715***	0.567***	0.521***	0.517***	0.614***	0.294***	0.841***	0.822***
N		1151	922	130	257	340	195	172	57
CFI		0.972	0.971	0.918	0.953	0.966	0.968	0.911	0.925
RMSEA		0.057	0.061	0.082	0.075	0.056	0.050	0.152	0.656
SRMR		0.033	0.035	0.067	0.048	0.045	0.048	0.070	0.078

*** p<0.01, ** 0.01< p<0.05, * 0.05<p>0.1

4.2 Regional measures

In the survey, we asked about farmers' intentions to implement a certain soil conservation measure in each region. Figure 10 displays the survey results regarding these region-specific soil management practices across different regions showing the percentage of respondents who answered "No," "Maybe," or "Yes" for their intention to implement the practice. The regions with the highest interest in applying the given agricultural practices were Atlantic Spain and Finland, indicating a strong inclination towards crop diversification and combined plant cover with shallow tillage respectively. Belgium had a nearly equal distribution among respondents with almost half showing definite interest in non-inversion tillage. Estonia and Germany had similar distributions indicating the lowest levels of interest, with a significant majority either not interested or uncertain about adopting no-till and underseeding practices. Mediterranean Spain showed a mixed response, with a slight lean towards interest in

biostimulants, as nearly half the respondents were uncertain, while a significant portion expressed interest.

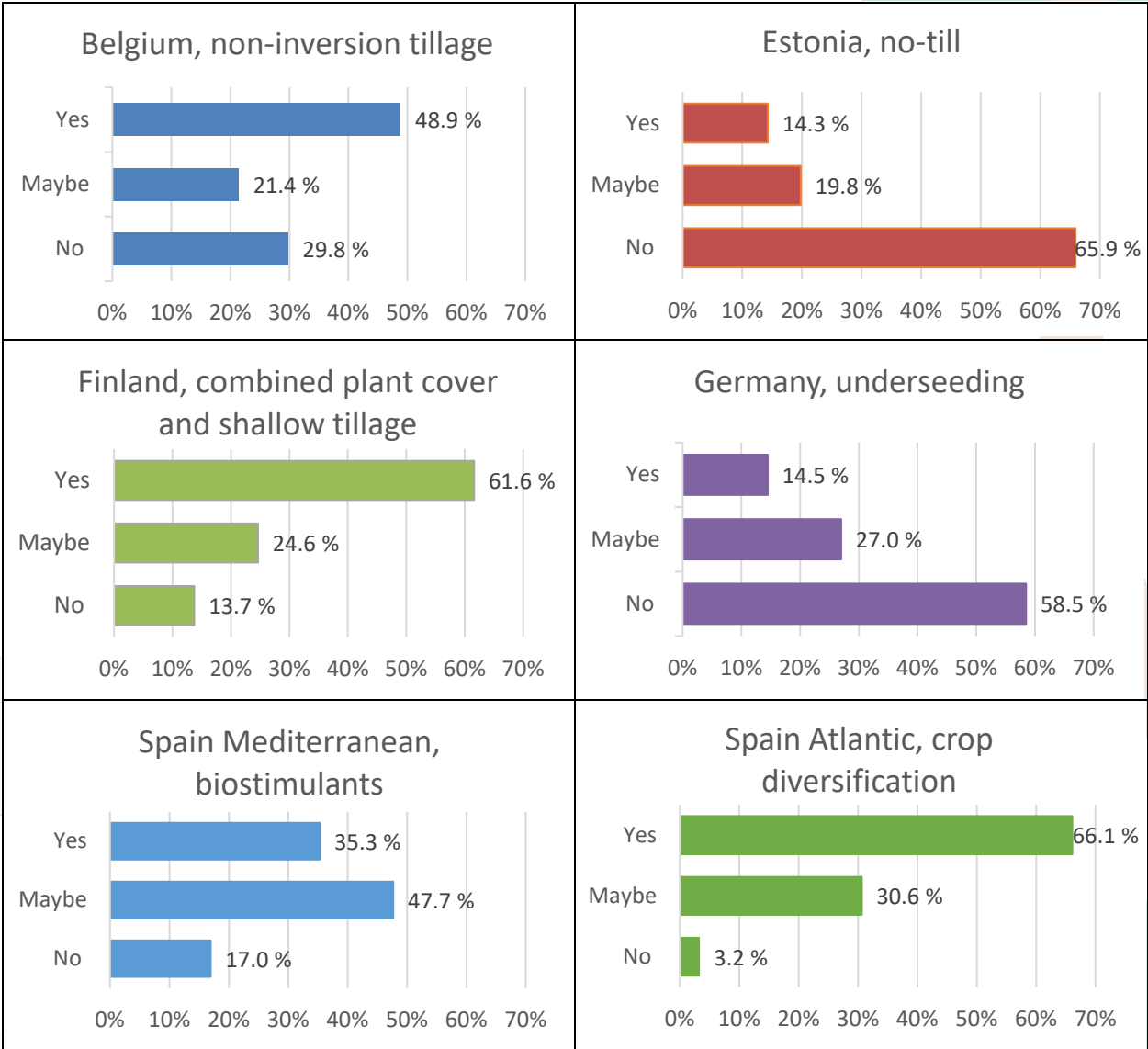


Figure 10. Farmer's intention to apply the farming practice next season in at least one field (%).

In Belgium, Germany and Mediterranean Spain, the intention to use the regional management practice was significantly ($p < 0.01$) higher in organic farming than in conventional farming (Figure 11). In Finland and Estonia, the difference was not significant, while in Atlantic Spain it was significant at the 0.1 level.

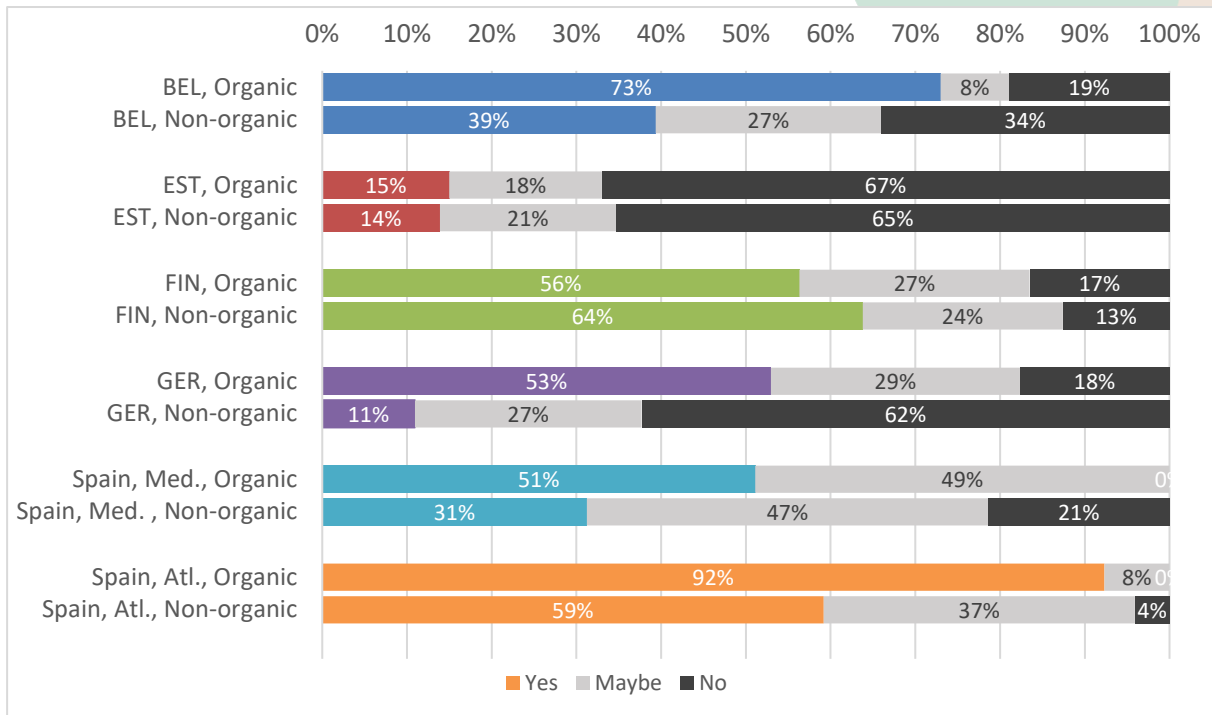


Figure 11. Intention to implement regional practice in organic and non-organic farms, share of “Yes” responses with region colours.

The general attitude towards regional practices was quite neutral in all the regions (Figure 12). On a scale from one (very negative) to five (very positive), the attitudes were most positive in Mediterranean Spain towards biostimulants and biofertilizers and most negative in Germany towards underseeding. Spanish farmers especially perceived pressure from reference groups they consider important to them in farming issues. Other regions were rather neutral in their perceived subjective norms. Additionally, opinions towards control factors were generally neutral, implying that applying the regional practice was not seen as easy or difficult.

According to TPB, behind attitude, subjective norm, and PBC, there are beliefs that are salient for the farmer in forming the intention to use a management practice. Figure 13 reports the behavioural beliefs in each region by combining the importance of each outcome and the likelihood of the outcomes into their product (importance x likelihood). In Belgium, the behavioural beliefs show that farmers evaluated most highly the impact of non-inversion tillage on the moisture conditions of soil, but also held beliefs concerning weed pressure and soil life. In Estonia, the key beliefs about direct seeding were associated with the need for machinery and weed problems. In Finland, soil moisture and structure were emphasized in the evaluation of impacts of plant cover and shallow tillage. In Germany, when evaluating the impacts of under seeding, farmers emphasized the need for plant protection and the impacts on the costs of agriculture. In Mediterranean Spain, all impacts were considered equally important and equally likely, but in Atlantic Spain, impacts on soil moisture and structure were emphasized. The beliefs mentioned here were highly evaluated but not necessarily have an impact on the attitude towards the management practice. Those beliefs having impact in SEM-model are marked with * in Figure 13.

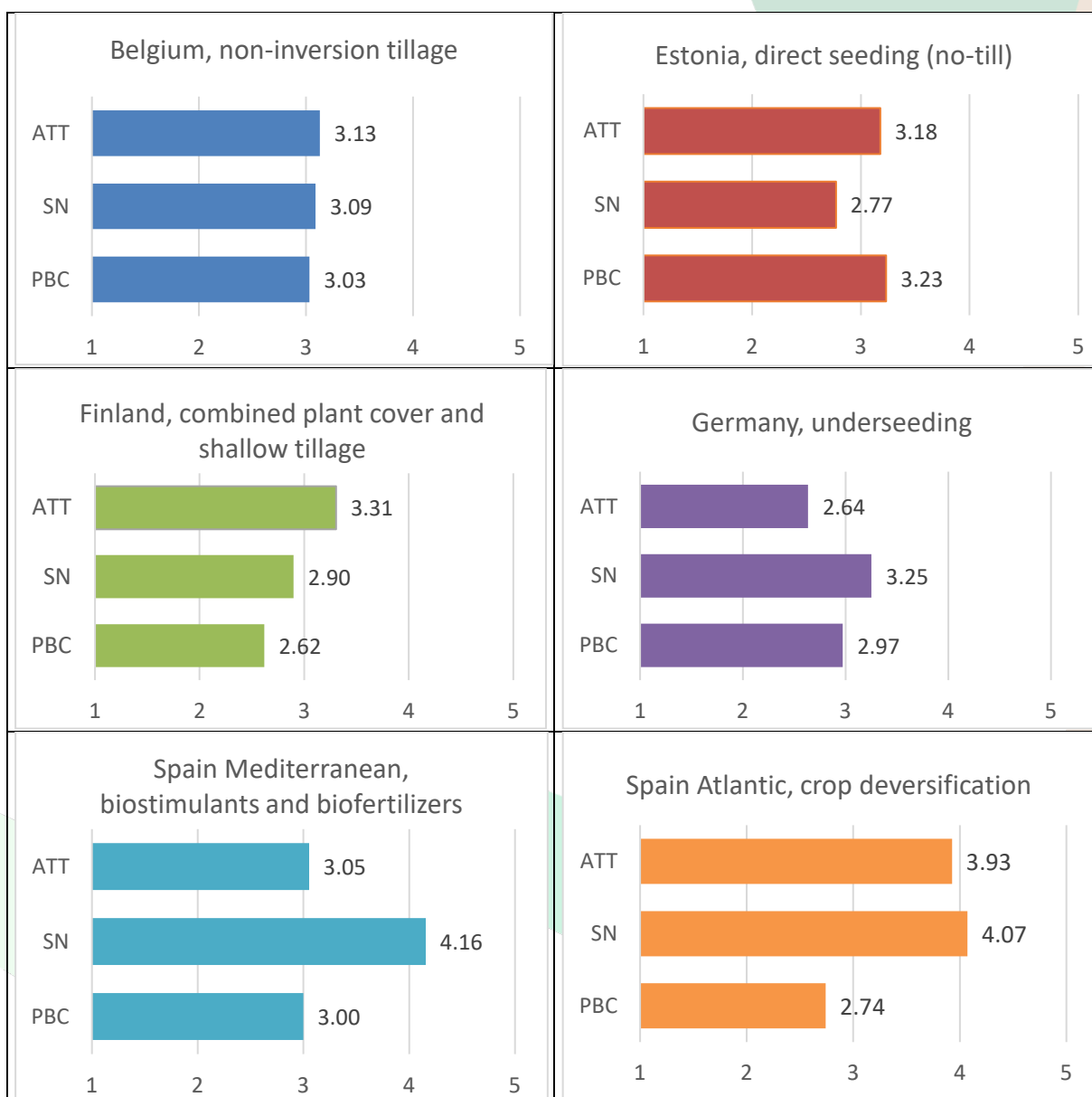


Figure 12. Attitudes, subjective norms and perceived behavioral controls towards the regional practices (1 weak ...5 strong positive ATT, / strong SN / strong PBC).

In normative beliefs (Figure 14), farmers from Belgium, Estonia, Germany, and Mediterranean Spain emphasized expert opinions, such as practice centres and researchers, as key normative groups. In Finland, environmentally oriented peer farmers opinions were emphasized. In Atlantic Spain, the opinions of agricultural machinery suppliers were highlighted.

In control beliefs (Figure 15), there were few shared beliefs between the regions and management practices. The costs related to implementation were emphasized in Finland, Germany, and Mediterranean Spain. To cover the costs, farmers also shared the beliefs in the need for related policies and subsidies in Finland and Germany. Additionally, information and knowledge related beliefs were shared between regions. In Estonia, farmers stressed the importance of availability of knowledge. In Mediterranean Spain, ease of use as well as advising were emphasized. In Belgium, information was stressed in the form of examples. Some constraints, such as climate conditions in Estonia or difficulties in accessing the plot in Atlantic Spain, were not issues that could easily be removed with policy or advising services.

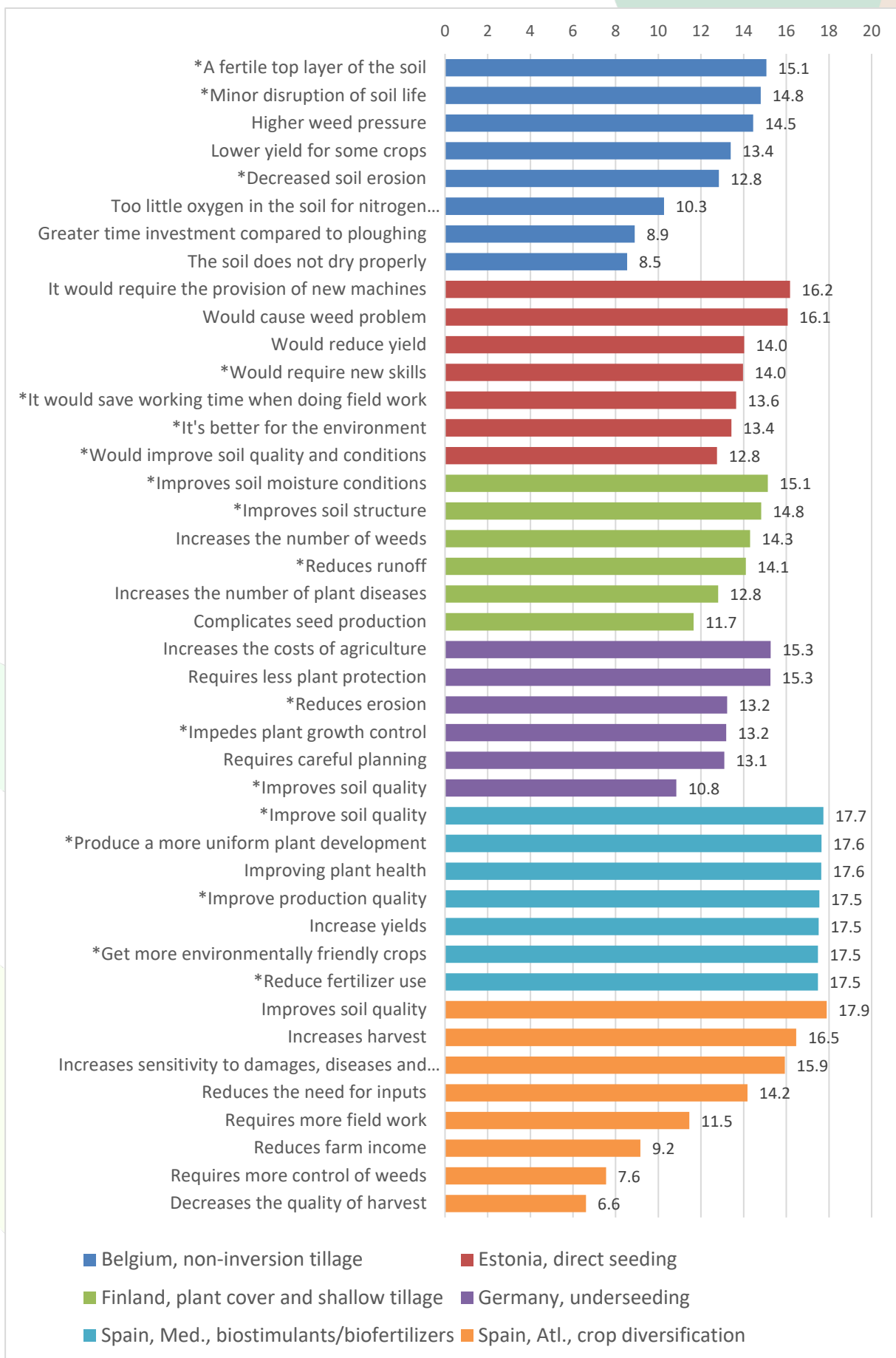


Figure 13. Behavioural beliefs about outcome and their importance (b x e), scale 1-25 (* belief was significant in SEM model).

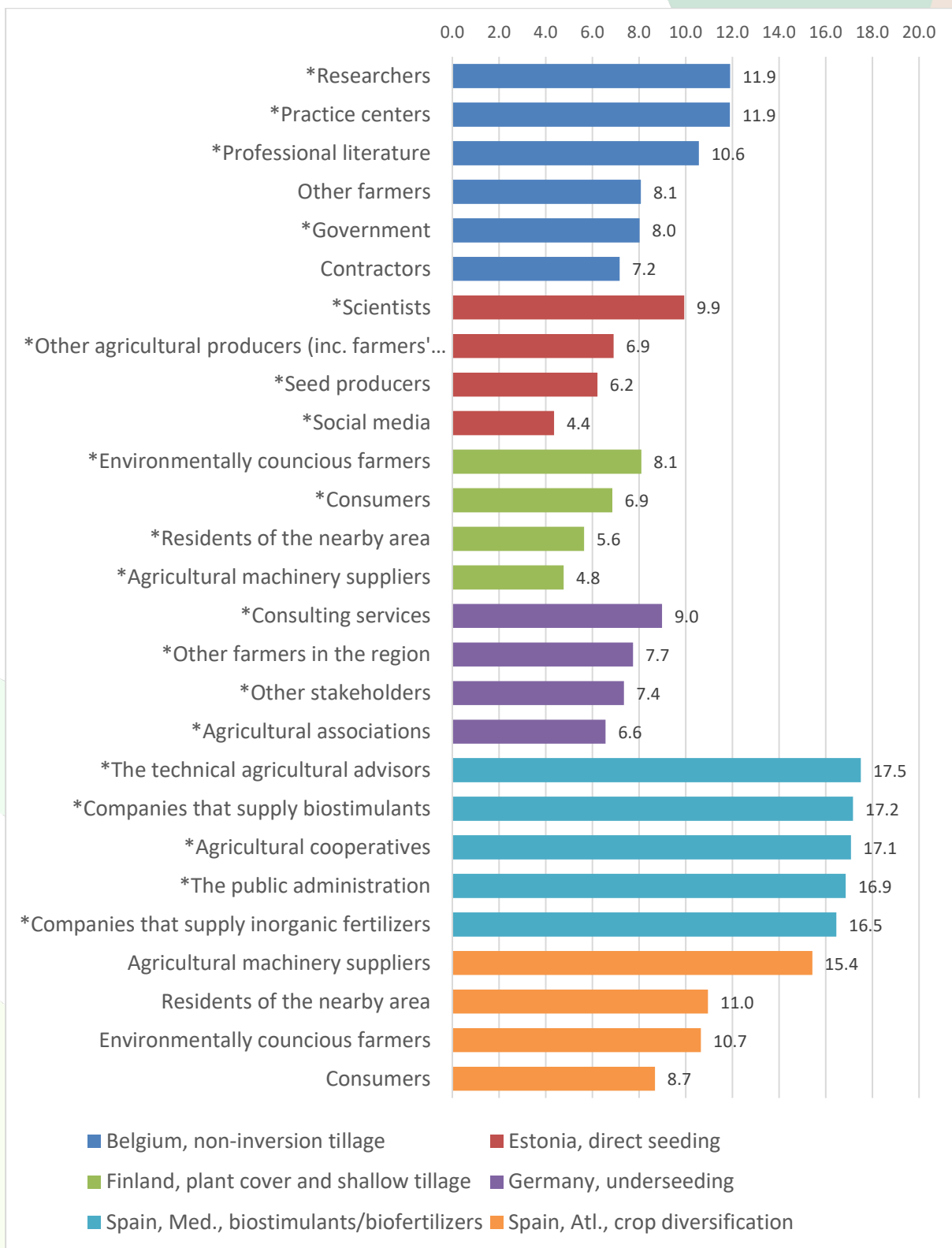


Figure 14. Normative beliefs (perceived expectations x importance of the group), scale 1-25 (* belief was significant in SEM model).

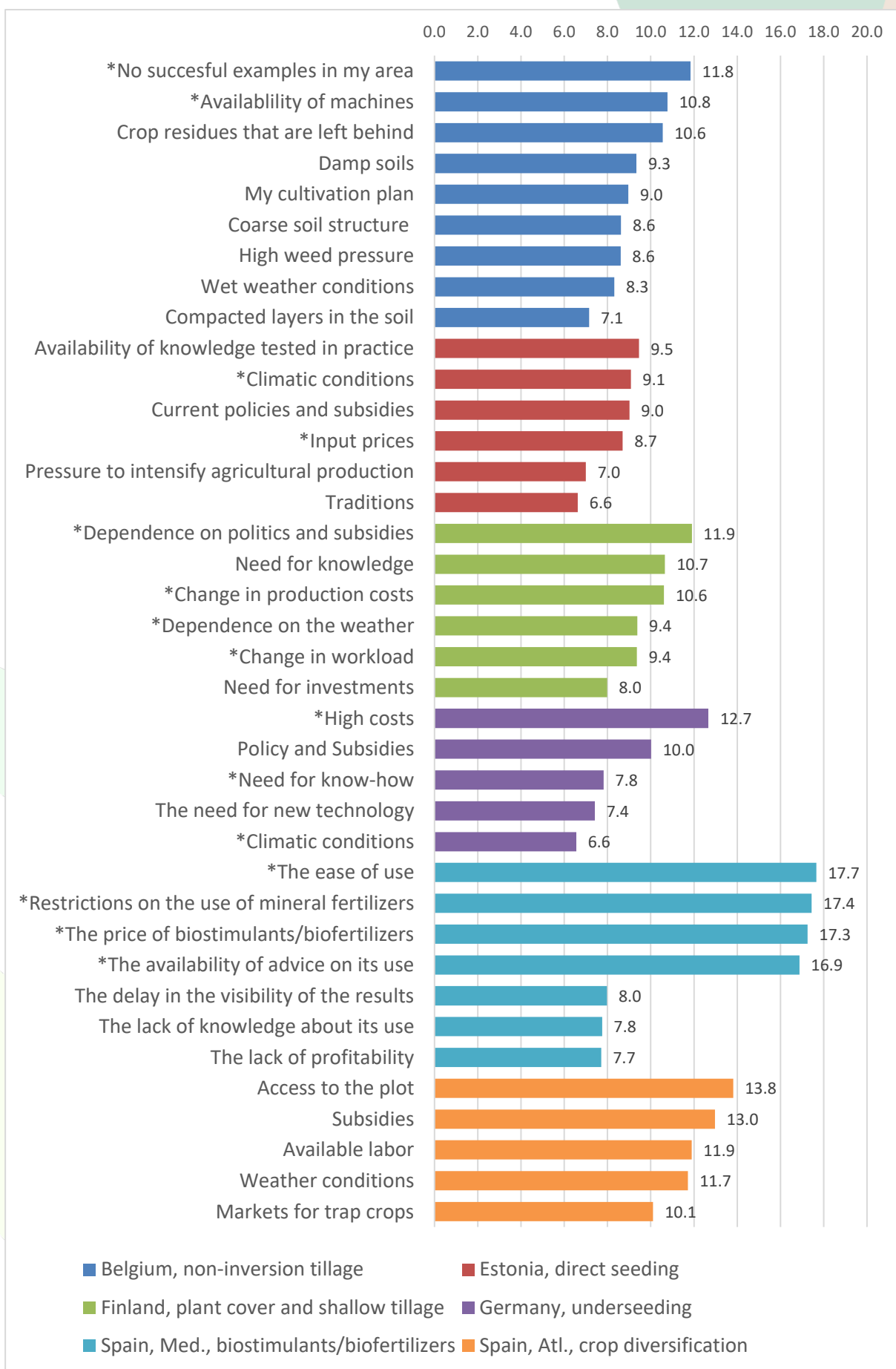


Figure 15. Control beliefs (likelihood * importance), scale 1-25 (* belief was significant in SEM model).

We estimated a SEM based on the TPB to predict farmers' intentions to adopt the regional practices. In alignment with the TPB framework, the analysis examines how farmers' attitudes (F_ATT), subjective norms (F_SN), perceived behavioural control (F_PBC), and their corresponding beliefs influence their intentions to use the regional practice. The models were estimated for each region separately as the management practices of interest differed essentially between regions. The model for Atlantic Spain was not adequate due to low number of observations and was left out from the results.

The models are summarized in Table 7. The results show that among attitudes, subjective norms, and perceived behavioural control, especially attitudes were important for the intention to use the practice. This can be seen from the significant coefficient with relatively high values from almost all regions, Mediterranean Spain being an exception. Additionally, PBC was significant in most regions, implying that the perceived ease or difficulty of implementing the practices was significantly associated with the intention to use them. The subjective norm was significant ($p < 0.1$) only in Estonia, but with low coefficient. Furthermore, past behaviour was associated strongly and significantly with the intention to apply the practice. Indicating that farmers familiar with the methods from their prior experiences maintained their interest in applying the methods. The various beliefs participated significantly in the formation of attitudes, SN and PBC. The significant beliefs are marked with * in Figures 13-15.

Figure 16 illustrates one regional model, the model for Estonia. It shows that the intention to use direct seeding was associated most strongly with attitude and past behaviour. Attitude was strongly related to behavioural beliefs. The significant beliefs considered impacts for soil quality and the environment, but also the use of time and demand of skills. Several normative groups, such as other producers, seed producers, scientists, and social media, were significant components of normative beliefs. Among the control beliefs, only input prices and climatic conditions were significant.

The model fit indices, including the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) (Table 6), suggest that the models adequately explain the observed data patterns for the implementation of regional practices in the four regions.

Table 7. Summary of the model results, key variables only. ($p < 0.01^{***}$, $0.01 < p < 0.05^{**}$, $0.05 < p > 0.1^*$)

		BEL	EST	FIN	GER	SPAIN, MED.
Outcome	Predictor	Coefficients and significances				
F_ATT	F_BBI	0.959***	0.754***	0.774***	0.950***	0.350***
F_SN	F_NBI	0.462***	0.863***	0.769***	0.850***	0.821***
F_PBC	F_CBI	0.869***	0.587***	0.046	-0.103	0.828***
F_INT	F_ATT	0.357***	0.489***	0.351***	0.758***	0.081
F_INT	F_SN	-0.078	0.098*	0.030	-0.045	-0.029
F_INT	F_PBC	0.244**	0.190***	0.125***	0.018	-0.166**
F_INT	past behavior (log of years)	0.416***	0.282***	0.567***	0.218***	0.327***
CFI		0.9	0.9	0.91	0.91	0.87
RMSEA		0.1	0.08	0.08	0.08	0.14
SRMR		0.11	0.09	0.14	0.07	

MODEL FOR ESTONIA

(INTENTION R²=0.599)

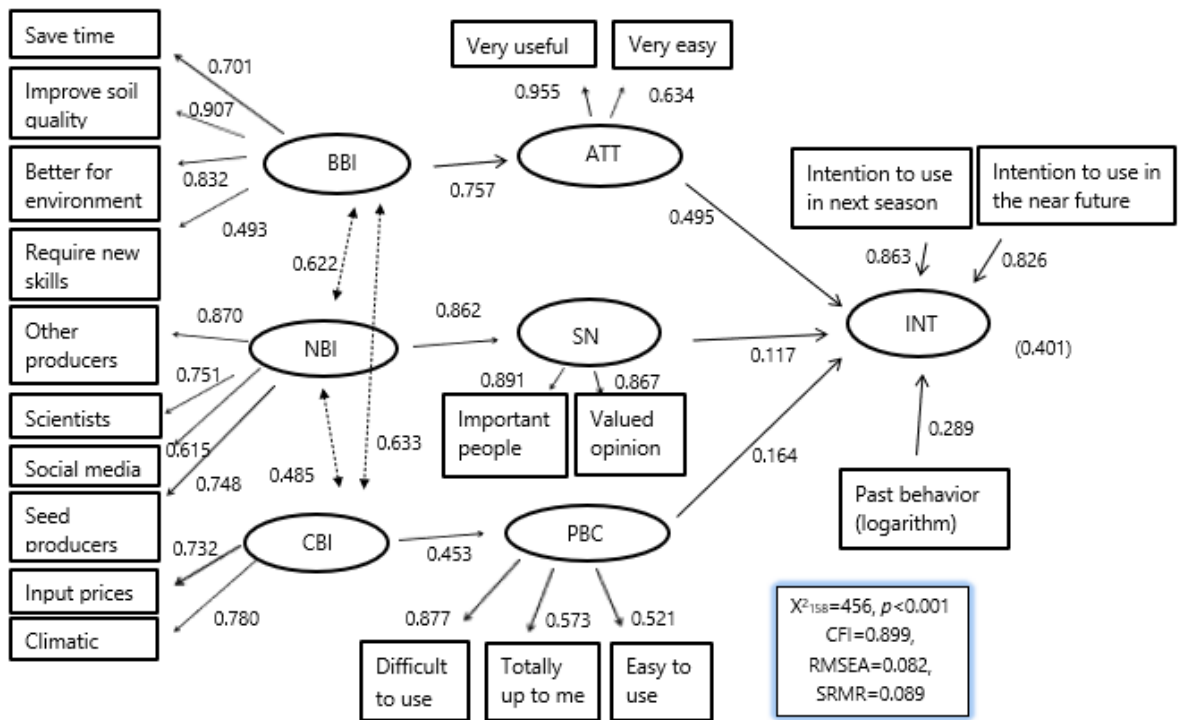


Figure 16. Example of SEM for intention to apply the regional practice, Estonia.

Compensation requests to apply the regional practices

Beyond the SEM models, the intentions to apply the regional practices were modelled with an econometric approach using a triple hurdle model to focus on the intention to apply regional the practices and the compensation demands of farmers. The results of farmers decisions (Table 8): 1) whether the farmers intend to apply soil friendly practices, 2) whether they intend to apply soil friendly practices if compensation is provided, and 3) farmers compensation demands to implement the practices (WTA), are reported in Tables 10-13.

Table 8. Summary statistics of dependent variables in econometric model for intention to apply the regional practices.

Dependent variable	Unit	Observations				Mean/frequency			
		Finland	Estonia	Belgium	Germany	Finland	Estonia	Belgium	Germany
Intention to apply	1-no	49	180	39	117	0.14	0.67	0.30	0.59
	2-maybe	88	54	28	54	0.25	0.20	0.21	0.27
	3-yes	220	39	64	29	0.62	0.14	0.49	0.15
Intention to apply if compensated	0-no	17	76	17	104	0.46	0.62	0.52	0.52
	1-yes	20	46	16	96	0.54	0.38	0.48	0.48
Compensation amount	Euro					273	290	173	159

Note: Atlantic and Mediterranean Spain were excluded from WTA analysis due to lack of data

As explanatory variables, we used three types of variables: first, the socio demographics characteristics (Table 4), second, farm characteristics (Table 4) and third, variables related to attitudes and beliefs.. The attitudinal and belief-related variables captured farmers' perceptions of the benefits of practices for them and their farms. These variables were measured on a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). The variables were:

- Perceived soil quality (perception of the average soil quality of farm, q16)
- The perceived benefit that adoption of soil practice improves soil structure (How likely is regional practice helps to achieve the following results on your farm? Improve soil structure, q. 31)
- The community influence (Do you feel that the following people or entities expect you to use regional soil friendly practice? People whose opinions I value think I should use regional soil friendly practice, q. 32_row4)
- Government subsidization policy (How do the following factors affect your decision to use regional soil friendly practice? Dependence on politics and subsidies q. 35);
- Knowledge (How would the following factors affect your decision to use regional soil friendly practice? Need for knowledge q. 35).

Table 9 presents the measures of beliefs and their explanation for each region.

Table 9. Measures of beliefs for each region

Variable	Unit	Question in survey	Country	Explanation
Perceived community influence	1-5	Do you think the following people or institutions expect you to use MP?	Finland	The people whose opinions I value think that I should use MP
			Estonia	
			Germany	
			Belgium	
Perceived benefits from implementation MP	1-5	How likely is MP to achieve the following results on your farm?	Finland	Improves soil structure
			Estonia	Would improve soil quality and conditions
			Germany	Improve soil quality
			Belgium	A fertile top layer of the soil
Government policy and subsidies	1-5	How do the following factors influence your decision to use MP?	Finland	Dependence on politics and subsidies
			Estonia	Current policies and subsidies
			Germany	Policy and subsidies
Farmer's knowledge	1-5	How do the following factors influence your decision to use MP?	Finland	Need for knowledge
			Estonia	Availability of knowledge tested in practice
			Germany	Need for know-how

Note: MP means regional management practice; for Belgium, data for the last two questions are unavailable because they were part of a previous survey. The earlier survey results indicated that these questions were unnecessary for further analysis in this country.

Table 10 presents the ordinal regression model results (first hurdle) for the intention to apply the practices. Education positively influences the outcome in Finland, Estonia, and Belgium but not in Germany. The coefficient for “community influence” was positive and statistically significant for Estonia ($p < 0.05$) This means that community influence, like people whose opinion is important for respondents, increases the likelihood of adopting friendly practices. Specifically, for each unit increase in “community influence”, the log odds of moving to a higher category (“Yes” or “Maybe”) increases for Finland, Estonia, Belgium and Germany by 0.04, 0.27, 0.06 and 0.02 respectively.

The “perceived benefits from the implementation of soil practice” was positive for all countries and statistically significantly associated with positive responses in Finland (0.30), Estonia (0.23) and Belgium (0.50). A negative and statistically non-significant coefficient for “government policies and subsidies” indicates that subsidy policy decreased the probability of responding “Yes” or “Maybe” to applying of the management practice in all countries analyzed. Knowledge about combined plant cover in Finland and under seeding in Germany increased the probability of saying “Yes” or “Maybe” to applying these farming practices. Threshold effects (1|2 and 2|3) are positive and indicate that as the predictor variable increases, the likelihood of being in a higher category (e.g., 2 (saying “Maybe”) or 3 (saying “Yes”)) increases.

Table 10. Ordered logistic regression analysis results for the intention to apply the management practices (Yes, Maybe, No).

Explanatory variables	Finland	Estonia	Belgium	Germany
Male	0.26 (-0.46, 0.99)	0.16 (-0.52, 0.84)	0.01 (-1.19, 1.21)	-0.57 (-1.62, 0.47)
Age	-0.01 (-0.03, 0.01)	-0.01 (-0.03, 0.01)	-0.003 (-0.04, 0.03)	0.003 (-0.03, 0.03)
Education	0.52** (0.04, 1.00)	0.06 (-0.45, 0.58)	0.74* (-0.002, 1.48)	-0.18 (-0.78, 0.43)
Land	0.003 (-0.001, 0.01)	0.0002 (-0.0003, 0.001)	0.003 (-0.01, 0.01)	-0.000 (-0.001, 0.001)
Fulltime farmer	-0.07 (-0.60, 0.45)	0.21 (-0.38, 0.80)	0.40 (-0.42, 1.21)	0.76 (-0.31, 1.83)
Perceived soil quality	0.18 (-0.16, 0.52)	0.08 (-0.30, 0.47)	0.43 (-0.13, 0.99)	-0.03 (-0.43, 0.37)
Perceived benefits from implementation of MP	0.30** (0.03, 0.56)	0.23* (-0.02, 0.47)	0.50** (0.11, 0.88)	0.19 (-0.33, 0.70)
Community influence	0.04 (-0.18, 0.26)	0.27* (-0.01, 0.55)	0.06 (-0.26, 0.37)	0.02 (-0.31, 0.35)
Government policies and subsidies	-0.13 (-0.32, 0.05)	-0.18 (-0.49, 0.12)		-0.05 (-0.30, 0.20)
Farmers' knowledge	0.38** (0.05, 0.72)	0.08 (-0.17, 0.33)		0.33* (-0.02, 0.68)
1 2	0.636	2.177**	3.350*	1.874
2 3	2.060*	3.364***	4.374**	3.350*
Akaike Inf. Crit.	657.77	483.81	273.05	394.40

Note: $p < 0.01^{***}$, $0.01 < p < 0.05^{**}$; 95% confidence intervals are reported in parentheses; for Belgium, data for the last two questions are unavailable because they were part of a previous survey. The earlier survey results indicated that these questions were unnecessary for further analysis in this country.

The results from the binomial probit models (Table 11) for Finland, Estonia, Belgium, and Germany examine the factors influencing decision of whether a respondent is willing to accept (WTA) compensation or not (yes/no) for implementing MP. Positive coefficients indicate a higher likelihood of agreeing to WTA for MP implementation, while negative coefficients suggest a lower likelihood.

Table 11. Binomial probit model results: Determinants of respondents' WTA.

	Finland	Estonia	Belgium	Germany
Male	-0.41 (-1.84, 1.02)	-0.23 (-0.86, 0.40)	-0.67 (-2.82, 1.48)	0.28 (-0.78, 1.33)
Age	0.03 (-0.03, 0.09)	0.004 (-0.02, 0.02)	0.01 (-0.04, 0.05)	0.01 (-0.02, 0.04)
Education	0.33 (-0.69, 1.34)	0.02 (-0.47, 0.52)	-0.40 (-1.64, 0.84)	0.40 (-0.20, 1.01)
Land	-0.002 (-0.01, 0.01)	-0.0004 (-0.001, 0.0002)	0.01 (-0.02, 0.04)	-0.0001 (-0.001, 0.001)
Fulltime farmer	-0.04 (-1.19, 1.11)	0.63** (0.08, 1.18)	-0.59 (-1.96, 0.77)	-0.73 (-1.81, 0.35)
Perceived soil quality	-0.34 (-1.09, 0.41)	0.01 (-0.34, 0.36)	-0.65 (-1.49, 0.19)	0.26 (-0.14, 0.66)

	Finland	Estonia	Belgium	Germany
Perceived benefits from implementation of MP	-0.16 (-0.88, 0.56)	0.04 (-0.20, 0.28)	-0.16 (-0.68, 0.37)	-0.27 (-0.82, 0.27)
Community influence	0.25 (-0.27, 0.76)	0.06 (-0.20, 0.32)	0.14 (-0.38, 0.67)	0.05 (-0.29, 0.39)
Government policies and subsidies	0.21 (-0.27, 0.70)	-0.27* (-0.57, 0.03)		0.10 (-0.17, 0.38)
Farmers' knowledge	0.06 (-1.00, 1.12)	0.15 (-0.11, 0.41)		0.16 (-0.22, 0.54)
IMR	ns	ns	ns	ns
Constant	-0.98 (-6.99, 5.04)	-0.75 (-2.69, 1.19)	2.90 (-3.62, 9.42)	-0.05 (-3.50, 3.41)
Observations	37	180	33	117
Log Likelihood	-22.64	-75.12	-20.16	-51.75
Akaike Inf. Crit.	67.29	172.24	58.32	125.50

Note: ns means non - significant; $p < 0.01^{***}$, $0.01 < p < 0.05^{**}$; 95% confidence intervals are reported in parentheses; for Belgium, data for the last two questions are unavailable because they were part of a previous survey. The earlier survey results indicated that these questions were unnecessary for further analysis in this country.

Table 12 presents the factors influencing the decision of farmers to obtain compensation for the implementation of regional soil friendly practices (third hurdle). The columns show the coefficient estimates for predicting the WTA value conditional on applying soil-friendly practices.

Table 12. Truncated Poisson model results: Determinants of respondents' WTA.

	Finland	Estonia	Belgium	Germany
GenderMale	2.39*** (1.84, 2.95)	0.086*** (0.040, 0.131)	2.552*** (1.980, 3.123)	0.166** (0.063, 0.269)
Age	-0.19*** (-0.23, -0.15)	0.001 (-0.001, 0.002)	-0.003 (-0.012, 0.005)	-0.006*** (-0.009, -0.004)
Education	-1.76*** (-2.18, -1.34)	-0.541*** (-0.582, -0.500)	0.689*** (0.519, 0.859)	-0.063 (-0.158, 0.032)
Land	0.021*** (0.02, 0.03)	0.001*** (0.000, 0.001)		0.000 (0.000, 0.000)
Fulltime farmer	-0.04 (-0.16, 0.07)	-0.327*** (-0.370, -0.284)	0.359*** (0.231, 0.486)	0.309*** (0.158, 0.461)
Perceived soil quality	2.56*** (2.10, 3.02)	-0.437*** (-0.467, -0.407)	0.935*** (0.644, 1.225)	0.045 (-0.018, 0.108)
Perceived benefits from implementation of MP	0.43*** (0.22, 0.64)	0.252*** (0.233, 0.272)	0.284*** (0.175, 0.393)	0.064* (-0.007, 0.134)
Community influence	-2.158*** (-2.49, -1.82)	0.072*** (0.052, 0.092)	-0.212*** (-0.279, -0.144)	0.087*** (0.064, 0.109)
Government policies and subsidies	-1.60*** (-1.87, -1.33)	0.081*** (0.059, 0.102)		-0.043** (-0.069, -0.017)
Farmers' knowledge	-0.795*** (-0.93, 0.66)	-0.005 (-0.028, 0.018)		0.003 (-0.037, 0.043)

	Finland	Estonia	Belgium	Germany
IMR	-13.42*** (-15.73, -11.12)	ns	-2.027*** (-2.733, -1.321)	-0.823** (-1.440, -0.206)
Constant	25.13*** (22.16, 28.11)	6.802*** (6.599, 7.005)	0.266 (-0.741, 1.273)	4.724*** (4.251, 5.197)
Observations	20	46	16	96
Log Likelihood	-367.79	-3657.56	-588.98	-1505.46

Note: **ns** means non - significant; $p < 0.01^{***}$, $0.01 < p < 0.05^{**}$; 95% confidence intervals are reported in parentheses; for Belgium, data for the last two questions are unavailable because they were part of a previous survey. The earlier survey results indicated that these questions were unnecessary for further analysis in this country. We removed variable "land" from our analysis for Belgium due to multicollinearity issues.

Being male was linked to a higher average compensation expectation in all countries analyzed. Older age increased expected compensation in Estonia but slightly lowered it in Finland, Belgium and Germany, where younger farmers expected more. Higher education raised average compensation expectations in Belgium, but in Germany, Finland, and Estonia, it led to lower expectations. More arable land slightly increased expected compensation in Finland and Estonia. In Finland and Estonia, identifying as a "full-time farmer" lowered compensation expectations, whereas in Belgium and Germany, it raised them.

Those who perceived soil quality as high on their farms tended to demand higher compensation in Finland and Belgium, whereas in Estonia, those with a high perception of soil quality were willing to accept less compensation. Farmers motivated by direct soil practice benefits tended to expect higher compensation in all countries analyzed.

Farmers influenced by others' opinions expected more compensation in Estonia and Germany but less in Finland and Belgium. In Finland and Germany, reliance on subsidies was associated with lower expected compensation, while in Estonia, it led to a slightly higher expectation. Finally, in Finland and Estonia, farmers who needed more knowledge on regional practices expected lower compensation, whereas in Germany, this need slightly increased expectations.

Calculated expected WTA (€/per ha/year) are shown in Table 13. Respondents were willing to adopt the management practice if compensated with 312 € in Finland; 228 € in Estonia; 195 € in Belgium, and 136 € in Germany for the implementation of regional soil friendly practices. These values are realistic and not too different from the mean compensation amount in the raw data (Table 8). The difference between mean values of compensation amount in the raw data and calculated expected values, was 39 € higher for Finland, 62 € lower for Estonia, 22 € higher for Belgium, and 23 € lower for Germany. This difference is due to the fact that not everyone who starts the survey finishes all the steps. In our analysis, the number of observations in the first stage was 357, 273, 131, and 200 for Finland, Estonia, Belgium, and Germany, respectively. However, by the third-stage regression, only 20, 46, 16, and 96 observations remained. At first, many farmers answered whether they would consider adopting the soil management practice. But only a small number actually reached the final stage, where they stated how much money they would be willing to accept for implementation. This is called sample selection bias, meaning the final results might not fully represent all farmers—only those who stayed in the survey until

the end. In our analysis, the sample selection bias indicator (IMR) was insignificant for all countries in the second stage but significant in the third stage for all countries except Estonia.

Table 13. The expected values of WTA for adopt of regional soil practice in the next season.

Country	Finland	Estonia	Belgium	Germany
WTA in euros	312	228	195	136

The expected value of WTA has been calculated by the formula $E(WTA) = \exp(\beta_0 + \sum_{i=1}^{10} \beta_i \bar{X}_i)$ Where β_0 is constant, β_i are parameters estimated from third hurdle model (Table 12) and \bar{X}_i are mean values of variables included.

5 Summary, discussion and policy implications

5.1 Summary of the results across the regions

The most commonly used indicators to evaluate the soil health across the entire sample were soil structure, pH levels, and water retention capacity. Generally, soil quality was regarded as fairly good by 46% of respondents, while 38% rated it as neither good nor bad. Among the 13 practices to improve soil quality, the most popular were incorporating crop residue and implementing long rotation periods in cultivation. Additionally, farmers expressed strong interest in less frequent ploughing and reducing tillage depth.

From the variables related to TPB, attitudes towards improving soil quality were especially positive. The intention to invest in soil quality was strongly associated with past behaviour in all the regions. The results indicate that moral obligation was significantly associated with attitudes, subjective norms, and perceived behavioural control. Additionally, in the TPB based model explaining the intention to improve soil quality, moral obligation was also significant and had a relatively high association with the intention. This association of moral obligation with other variables was not observed in the models for individual regions, likely due to the smaller sample sizes.

Regarding the tested regional practices and intention to apply those, it is not that obvious to draw conclusions shared between regions. However, concerning the regional practices the importance of attitude and past behaviour was emphasized. The general attitude toward regional practices was quite neutral in all the regions. On one (very negative) to five (very positive) scale the attitudes were most positive in Mediterranean Spain towards biostimulants and biofertilizers and most negative in Germany towards underseeding. Several background variables were associated with intention and the compensation request for those not otherwise interested in implementing the practices.

5.2 National summaries

In this chapter we summarize the survey results for each region.

- In **Belgium**, the response rate was rather low (6.7%), resulting in 131 completed questionnaires that could be used for analysis. Out of these 131, 37 of the farmers were organic farmers. All the indicators to evaluate soil quality that were proposed in the survey, were used by at least 17% of the farmers (varying from 17% for soil crust to organic matter content 81%). The primary indicator for soil quality was the quantity of organic matter, followed by pH and soil structure. Based on these indicators, over half of the respondents viewed the soil quality on their farms as rather good. In the survey, out of 13 soil management practices, farmers on average implemented or intended to implement on average 6 of them. In Belgium, the average number of practices was significantly higher in organic production than in non-organic. Cover crops and incorporating crop residue were particularly appealing to farmers, but they also showed high interest in catch crops and long rotation periods. The lowest interest was (at 15%) in no-till and agroforestry. However, farmers in general believed that all of these practices contribute to maintaining or improving soil quality.

According to TPB, attitudes, social norms and perceived behavioural control have an impact on the intention to commit a behaviour. The attitude towards improving soil quality was on average 4.5 in Belgium. Also average in social norms, perceived behavioural control and moral obligation was higher than 4. The structural equation model predicting farmers intention to invest in soil quality showed that none of the components significantly predicted intention, although the intention to invest in soil quality was strongly associated with past behaviour, suggesting that farmers with prior experience in soil-friendly practices are more likely to continue them. Besides intention to improve soil quality in general, we also asked farmers in Flanders for their intention to implement non-inversion tillage, which means not using a plow to turn the soil at least once a year. Among the farmers, 48.9% indicated having a positive intention to adopt the practice, whereas the other half answered maybe (21.4%) or no (29.8%). The intention was significantly higher in organic farming (73% versus 39%). The average attitude (3.13), subjective norm (3.09) and perceived behavioural control (3.03) were rather positive. Based on the estimated SEM, the following beliefs predicted farmers' intention to adopt non-inversion tillage: the increased fertility of the top layer of the soil, decreased soil erosion, and minor disruption of soil life. Government, research, practice centres, and professional literature were important norm groups. The availability of machinery and the lack of successful examples in the area constrained the adoption.

- In **Estonia**, 273 farmers provided survey answers. Of these 63% were conventional farmers and 37% organic. For the perceived soil quality, the predominant evaluation chosen was neither good nor bad. The survey conducted in Estonia highlighted that the most prevalent indicators used by farmers were crop yield which stood out as a key indicator, along with soil structure and pH monitoring. Estonian farmers prioritized the incorporation of crop residue, with additional interest in longer rotation periods. Practices such as cover and catch crops and precision fertilization were recognized for their contribution to soil quality. In Estonia the survey measured farmers interest to apply no-till. Among respondents, 14.3% were interested to apply it in the future with certainty. 19.8% were hesitant and 65.9% were negative. However, 66% of them were interested in applying this practice next year if the expenses were compensated. The average expected compensation amount for the implementation of no-till was 228 € in

Estonia. The opinions of environmentally conscious peers, as well as policy instruments, particularly subsidy opportunities, were seen as influential factors in the adoption of no-till. Intentions to use the practice were largely shaped by past experiences and attitudes towards it.

- The survey conducted in **Finland** highlighted that the most prevalent indicators used by farmers were soil structure and pH levels, both by 76% of respondents, followed by water retention capacity at 61%. Additionally, 59% of farmers considered groundwater absorption a key indicator. Soil quality on farms was deemed fairly good, with 49% of respondents indicating this. Among the 13 evaluated practices, reduced plowing frequency and shallower tillage depth were favoured. Moreover, extended crop rotation periods were of interest. Practices such as applying organic matter to fields, intercropping, and using cover crops were recognized for their contribution to soil quality. While the overall attitude towards enhancing soil quality was positive, it was lower compared to other countries in the study. The survey also measured farmers' willingness to adopt combined plant cover and minimal tillage, with 61% expressing definite interest in future application. Soil moisture, structure, and weed control were key factors in assessing this practice. The opinions of environmentally conscious peers were encouraging, yet they did not significantly influence practice adoption. Policy instruments, particularly subsidy opportunities, were seen as influential factors. Intentions to use the practice were largely shaped by past experiences and attitudes towards it. The belief that the practice could mitigate runoff also positively impacted farmers' interest in its adoption.
- The farmers data from **Germany** highlighted that the most prevalent indicators used by farmers were soil structure and pH levels, which 81% and 69% of farmers used respectively. They were crop yield (62%) and water holding capacity (61%). Soil quality on farms was deemed rather good by 50% of respondents. Of farmers, 40% considered the quality as neither good or bad. Among the 13 evaluated soil management practices, incorporation of crop residue, intercropping and catch crops were favoured. Moreover, less frequent plowing and reduced tillage depth were of interest. Practices such as applying intercropping, incorporating crop residue and using catch crops were recognized for their contribution to soil quality. The overall attitude towards enhancing soil quality was very positive but farmers also perceived various restrictions to improving soil quality. The survey also gauged farmers' willingness to adopt underseeding, with 15% expressing definite interest in applying it in the future. Of farmers, 27% were positive but hesitant. Reduction of erosion and controlling plant growth were key factors in assessing this practice. The opinions of consulting services were encouraging, and did significantly influenced practice adoption. High costs were perceived to reduce the opportunities to use this practice. Intentions to use the practice were largely shaped by past experiences and attitudes towards it.
- The survey conducted in the **Mediterranean Spain** study area benefited from a relatively high response rate. Responses show that farmers use a wide range of indicators to evaluate soil quality, including soil structure, water retention capacity, soil sealing and nutrient content, which are consistent with the semi-arid nature of the study area, where water is a priority in soil management. More than 90% of farmers indicated that

soil quality in their farms is good or very good. When asked about thirteen farming practices with potential benefits for soil quality, at least 90% of responding farmers indicated that they were either implementing or intending to implement these in the near future, without differences between organic and non-organic farmers. The highest rates of response correspond to those practices that involve reducing tillage intensity or incorporating organic matter to the soil. Additionally, all surveyed practices are perceived as strongly contributing to maintaining or improving soil quality. Looking at attitudes and perceptions that affect farmers' intention to adopt farming practices that enhance soil quality, both attitudes towards the improvement of soil quality and the moral obligation to improve it were more relevant than social norms (perception that they are expected to invest in soil quality). On the other hand, perceived behavioural control, i.e. the perception that it is easy for farmers to impact on the soil quality, is relatively lower. The survey also gauged farmers' willingness to use biostimulants/biofertilizers to enhance plant growth and soil health, with 35% of respondents indicating a clear interest in their future adoption and only 17% indicating no intention for their future use. The intention to adopt is significantly higher among organic farmers (51%). The opinions of reference groups, such as technical experts and researchers were an important factor in the intention to use biostimulants. The cost of biostimulants decreased the intentions to use the practice, while their ease of use and the increasing restrictions on the use of mineral fertilizers increased them. Intentions to use the practice were largely shaped by past experiences and, to a lesser extent, by perceived behavioural control (ease of use). Policy instruments, particularly regulations on fertilization, were seen as influential factors.

- The sample from **Atlantic Spain** highlighted that the most prevalent indicators used by farmers were pH levels (63% of farmers used), crop yield (60%) and organic matter content (53%). Additionally, 52% of farmers considered soil structure as a key indicator. Soil quality on farms was deemed rather good by 48% of respondents but neither good or bad by 47% of farmers. Among the 13 evaluated practices, reduced plowing frequency and incorporation of crop residue were favoured. Moreover, catch crops and intercropping were of interest. Practices such as covering fields with organic matter, long rotation periods and precision fertilization were recognized for their contribution to soil quality. The overall attitude towards enhancing soil quality was positive, even higher than in other regions of the study. The survey also measured farmers' willingness to adopt crop diversification in potato farming, with 66% expressing definite interest in future application. The intention to apply this practice was especially high in organic farming, with 92% intended to apply it. Positive impacts on soil quality and harvest were key factors in assessing this practice. The opinions of agricultural machinery suppliers were perceived as encouraging, yet they did not significantly influence practice adoption. Difficult access to plots decreased the intentions to use the practice. Policy instruments, particularly subsidy opportunities, were seen as influential factors.

5.3 Discussion about data and methods, critical points

In some regions, like in Spain (Atlantic) there were difficulties in obtaining farmers' contact details due to national confidentiality legislation. To reach more farmers, it was necessary to work with various organizations - such as agricultural research centres, farmers' associations and local development groups - to distribute the survey to their contacts. Still, the sample sizes were rather small and the final number of observations was low. In some regions, the number of farmers potentially adopting the regional practice was low. For example, this was mainly due to the limited number of commercial potato growers identified in Galicia limiting the pool of potential survey respondents. However, when the response rate could be calculated (in Finland and Galicia), it was around 20%, which is rather good for farmer surveys. In Belgium, a considerably lower response rate was obtained.

The responses seemed to be reliable and valid from most of the regions. The models revealed significant associations between the variables following the theory-based structures. In some regions however the variation in measures was rather low. For example, in Mediterranean Spain many measures showed surprisingly low heterogeneity among respondents. This most probably relates to specific characteristics of the sample, such as high representation of industrial farmers. This is an important observation for designing future studies, the family farms and commercial big farming enterprises may not be surveyed with the same survey questionnaires.

TPB led to a long survey that was demanding for the respondents. It was also demanding for survey planning to implement the theory-based measures that targeted different management practices in different regions. Still, we could build theory-based models for two behavioral intentions in all regions and also econometric models for compensation claims.

5.4 Policy implications

Farmers perceived the soil quality typically as rather good or neither good nor bad. The intention to invest in soil quality in general was very strongly associated with previous soil management actions. Therefore, it is hard to create change in farmers' behaviour. The key question in building policy for extension services is how to break the habits, if they do not support the soil conditions.

Some promising signs were however observed. The general intention to improve soil quality can be influenced by arguments targeting farmers' attitudes and perceived moral obligations. Additionally, perceptions of controlling factors might be addressed through policy measures. However, the strong impact of past behaviour is not easily mitigated through advice alone.

Regarding the policies supporting regionally tested management practices farmers' beliefs can provide ideas for policy design. The findings indicate that a limited selection of behavioural beliefs regarding the impact of soil management practices significantly predicted attitudes towards these practices. The most influential beliefs were related to environmental and soil quality factors. Key beliefs impacting attitudes included soil moisture, soil structure, and reduced erosion and runoff, which had consistently impact across all regions.

Social norm was associated with the opinions of diverse groups of important others, including environmentally conscious peers, consulting services, scientists, and media sources. However, the subjective norm derived from these beliefs did not significantly influence practice adoption in three out of the four regions. This highlights the difficulty of influencing behaviour through advisory services and peer networks.

Control beliefs that were significant in the model for intention to adopt the regional practices emphasized the importance of production costs, dependence on weather conditions, and the need for know-how and examples in the area. The significance of policies supporting the management practice and subsidies was notable only in one of the four regions. As policy-related control beliefs were not significant in the model, we cannot expect policy changes to have a strong impact on intention.

The significant beliefs in the models underscore the challenges in changing the intention to apply soil management practices. Furthermore, intentions to use the regional practice were largely shaped by past experiences. The most promising route to behavioural change appears to be through attitudes, by including information on soil characteristics and environmental impacts in the content of advisory material for farmers.

The analysis of farmers compensation needs revealed the heterogeneity in compensation expectations. Farmers' compensation demands varied not only between countries and management practices but also within them, influenced by factors such as gender, age, education, and farm size. Firstly, these findings underscore the need for regionally tailored compensation schemes rather than one-size-fits-all approaches. Secondly, gender differences in compensation expectations suggest varying priorities, with men and women valuing soil-friendly practices differently depending on the country. Similarly, younger farmers in Finland, Belgium and Germany were more willing to adopt practices for lower compensation, whereas in Estonia, older farmers had higher compensation expectations, suggesting generational differences in risk perception and valuation. Thirdly, the higher education levels in Belgium generally increased WTA, highlighting the importance of aligning educational outreach with economic incentives. However, in Finland, Estonia, and Germany, higher education levels were associated with lower compensation demands. Fourthly, government trust and subsidy reliance influenced compensation expectations differently across countries. In Estonia, greater trust in government subsidies increased WTA, while in Finland and Germany, existing government support lowered compensation expectations. This emphasizes the critical role of stable and reliable policy frameworks.

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ANNEXES

Belgian survey

Estonian survey

Finnish survey

German survey

Survey for Mediterranean Spain

Survey for Atlantic Spain