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Socio-psychological factors influencing decision-making and implementation of IPM methods among Finnish farmers

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The European Union's Green Deal aims to reduce the use of chemical pesticides, promoting Integrated Pest Management (IPM) as a sustainable alternative. This study is the first to examine Finnish farmers' perspectives on IPM adoption using a modified Theory of Planned Behaviour (TPB) framework. We included knowledge, moral norms, and well-being as additional factors to the original TPB components: attitude, subjective norms, and perceived behavioural control. Data were collected via an online survey (n=303), and Structural Equation Modelling (SEM) was used to analyse factor relationships. The model explained 72% of the variance in Intention and 49% in Behaviour. Moral norms, subjective norms, and perceived behavioural control explained attitudes towards IPM. Attitude explained intention directly, which in turn explained actual IPM use. Knowledge of IPM emerged as a strong mediator, affecting both intention and usage of IPM methods. Based on our study, there is a need for targeted educational initiatives and support systems to facilitate the adoption of IPM while also considering broader socio-psychological factors that shape farmers' attitudes.

Key words: integrated pest management, plant protection, agriculture, behavioural science, theory of planned behaviour

Introduction

Crops need protection from plant pathogens, viruses, weeds, and animal pests to ensure optimal productivity (Kumar 2016). Plant protection consists of various practices and strategies designed to manage risks that can harm crop productivity and quality in agriculture. Chemical pesticides have been used for the past 60 years to manage pests, leading to progress in food production (Hashemi and Damalas 2011, Sharifzadeh et al. 2018). However, the inappropriate use of pesticides, such as overuse, incorrect application, and the use of outdated products, raises concerns about their adverse effects on human health and the environment (Allahyari et al. 2016, Damalas 2021). Pesticide use can also lead to environmental and production challenges, including the development of pesticide resistance and a decline in biodiversity (Tudi et al. 2021).

As a result, alternative plant protection methods have gained attention, aiming to sustain food production while minimising harm to the environment and human health, thereby promoting a more sustainable form of agricultural production (EC 2009, Kabir and Rainis 2015, Gautam et al. 2017). Sustainable agriculture utilises biological, cultural, physical, and chemical methods to manage pests while minimising harm (Kumar 2016), and IPM can be a part of it.

IPM is a strategy that combines various control methods, including crop rotation, biological control agents, resistant cultivars, cultural practices, and, if needed, the use of pesticides to minimise pest damage while reducing human health and environmental impacts (EC 2009, FAO 2025). It also incorporates preventive measures, monitoring, and targeted interventions such as selective pesticide use (Deguine et al. 2021). Although individual non-chemical methods may be less effective on their own, combining them can create benefits, enhance the resilience of cropping systems, and improve our ability to tailor crop protection strategies to local conditions (Barzman et al. 2015). IPM is considered socially, culturally, economically, environmentally, and biologically acceptable, emphasising sustainable crop cultivation (Singh and Singh 2017). Scientific evidence demonstrates the effectiveness of IPM in reducing pesticide use, promoting biodiversity, and fostering long-term agricultural resilience worldwide (Trumble 1998, Power 2010). By successfully implementing IPM, farmers can enhance their sustainability and yields while reducing pesticide use and using them as a last resort (Naranjo 2001, 2011, Allahyari et al. 2016, FAO 2025).

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Decisions in plant protection often require multidisciplinary collaboration and tailoring to agroecological contexts (Llewellyn et al. 2004, Deguine et al. 2021). Informed decision-making, knowledge integration, and accurate pest assessment are part of IPM decisions (Norton and Mullen 1994, Peshin et al. 2009). Due to the holistic approach in IPM, interdisciplinary research and education are needed for its widespread adoption (Moss 2019, Deguine et al. 2021). The factors influencing the adaptation of IPM methods are comprehensively discussed in Deguine et al. 2021. They found that many definitions of IPM have caused confusion among professionals. There are inconsistencies between IPM principles and actual practices. Chemical control often takes precedence in many programs, and farmers rarely adopt the guideline of using chemicals only as a last resort. IPM research is frequently inadequate, and ecological factors are insufficiently considered. In their review, they also noted a lack of studies adopting a multidisciplinary social science approach to IPM adaptation (Deguine et al. 2021).

The existing research literature on the adoption of IPM in Europe and elsewhere highlights factors and obstacles, such as knowledge, risks, costs, farm size, regulation, and availability of information (Dessart et al. 2019, Deguine et al. 2021), which are not necessarily applicable to Finland as such. Finland has been involved in some older studies in the socioeconomics of adopting IPM strategies (Menzler-Hokkanen and Hokkanen 2018), but these are partly outdated and limited. Some of the research focuses only on certain crops or specific diseases or pests, or certain technical solutions, for example, Jalli et al. 2020 or Räsänen et al. 2023. Farmers' attitudes, behaviour, or other socio-psychological factors have been studied in Finland (Peltonen-Sainio et al. 2020, 2021, Sorvali et al. 2021), but not in the context of IPM. Research on the adoption of IPM in Finnish agriculture is needed to understand how the adoption of IPM could be genuinely supported in the Finnish context.

The knowledge gap addressed in this study is the limited understanding of farmers' decision-making regarding plant protection in Finland. Our research aims to explore this decision-making process and investigate whether socio-psychological factors such as attitude, subjective norms, knowledge, well-being, and perceived behavioural control influence Finnish farmers' intention to adopt IPM methods. Our research investigates the socio-psychological factors influencing the decision-making and implementation of IPM methods among Finnish farmers. Using an extended version of the TPB, the study addresses the need for Nordic interdisciplinary research in plant protection.

We formulated the following hypothesis:

H1. Moral norms affect farmers' attitudes, subjective norms, and perceived behavioural control.
H2. Attitude towards IPM affects farmers' intention to use IPM methods.
H3. Subjective norms affect farmers' intention to use IPM methods.
H4. Perceived behavioural control affects farmers' intention to use IPM methods.
H5. Knowledge, a mediator between attitude, subjective norm, perceived behavioural control, and intention, affects farmers' intention to use IPM methods.
H6. High intention to use IPM predicts high use of IPM.
H7. Farmers' well-being, as a mediator between intention and behaviour, affects the use of IPM methods.

Theoretical framework

The Theory of Planned Behaviour (TPB) is a psychological framework widely used in various fields of research, such as health, environmental conservation, and decision-making (Ajzen 1991). It is based on examining behavioural intention and predicting individual behaviour (Ajzen 1991, Gao et al. 2017). It extends the Theory of Reasoned Action (TRA) and focuses on a person's intention to perform a specific action (Ajzen 1991). TPB suggests that intention to engage in a particular behaviour can be accurately predicted using attitudes, perceived behavioural control (PBC), and subjective norms (Ajzen 1991, 2002). TPB posits that behaviour is primarily influenced by intention, which is shaped by attitudes, subjective norms, and perceived behavioural control (Ajzen 1991, Yazdanpanah et al. 2014). These constructs have demonstrated strong predictive power in agricultural contexts (Borges et al. 2014, Senger et al. 2017, Daxini et al. 2019, Despotović et al. 2019, Bagheri et al. 2021a).

Understanding the behavioural drivers behind farmers' pesticide use is needed for designing effective interventions and policies (Abadi 2018, Damalas and Koutroubas 2017). TPB provides a comprehensive framework for understanding the cognitive determinants of behaviour, and it is often used to predict human behaviour in the context of sustainable practices in food production (Biasini et al. 2021, Arya et al. 2024). It is one of the most widely used models for explaining intention-driven actions in farming (Ajzen 1991), and its application potential in plant protection has already been recognised in earlier research (Bagheri et al. 2019a,b).

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Intention reflects an individual's motivation and conscious decision to exert effort towards a specific behaviour (Conner and Armitage 1998). Attitude reflects a person's overall evaluation of behaviour, while subjective norms involve social pressures or expectations from important others. Perceived behavioural control relates to a person's belief in their ability to perform the behaviour. Multiple studies have found positive relationships between attitude, subjective norms, and perceived behavioural control with farmers' intentions, which supports using the TPB to examine farmers' intentions to adopt more sustainable plant protection methods (Daxini et al. 2018, Bagheri et al. 2019a, Rezaei et al. 2019, Vaz et al. 2020, Lalani et al. 2021).

However, TPB does not consider other factors influencing farmers' decision-making, such as moral norms, knowledge, and well-being. The model's explanatory capacity can be enhanced by incorporating additional variables (Monfared et al. 2015, Bagheri et al. 2019a, Rezaei et al. 2019, Savari and Gharechaee 2020). Some studies have attempted to enhance the model's explanatory power by adding additional constructs to predict intentions better (Burton 2004, Bagheri et al. 2019a, Bondori et al. 2019, Kaiser and Burger 2022). Similar additional constructs have been used to study farmers' intention to use pesticides in crop production in Iran (Bagheri et al. 2019a). Ataei et al. (2021) have found that including extra constructs to TPB significantly contributes to the overall understanding of the farmers' intention to use bio-pesticides (Ataei et al. 2021). In our study, we also use three new factors: knowledge, moral norms, and well-being.

Conceptual factors such as knowledge and moral norms have been shown to account for behavioural variance not captured by the original TPB (Burton 2004, Rivis et al. 2009). Bagheri et al. (2019a) proposed an extended TPB model that integrates these two constructs, which was later validated by Govindharaj et al. (2021) in the context of Indian rice farmers. Knowledge enhances awareness and supports stable, informed attitudes (Kallgren and Wood 1986, Wilson et al. 1989, Taherdoost 2018). It refers to the information stored in an individual's memory about a specific subject. High knowledge can have a significant impact on behaviour; this has been observed in relation to environmental protection (Gustafson and Rice 2019, Sturgis et al. 2024) and understanding of environmental ethics (Menatizadeh et al. 2016). Moral norms are the internal rules people should follow as part of their moral code (Hogan 1973), and they reflect internal ethical values that influence behaviour through self-regulation mechanisms (Kaiser and Scheuthle 2003, Arvola et al. 2008). They influence how farmers adapt to new approaches, such as those related to farm safety (Wilmes and Swenson 2019).

We were also interested in discovering how well-being acts as a mediator in the model. Well-being significantly affects various aspects of farming practices, especially when it comes to adopting new techniques such as IPM (Melberg 2003, Dessart et al. 2019, Dudek et al. 2025). Psychological well-being and positive emotions enhance motivation and resilience, allowing farmers to adopt innovations and persevere through challenges (Fredrickson 2001, Dessart et al. 2019). In contrast, stress and anxiety can hinder decision-making and problem-solving abilities, making it difficult for farmers to learn and implement new practices (Marin et al. 2011). Farmers who possess knowledge and confidence in their ability to implement IPM are more likely to adopt it. At the same time, individuals with lower well-being may doubt themselves and revert to traditional practices (Creissen et al. 2021, Sun et al. 2022). Furthermore, well-being affects risk perception and influences, for example, a person's ability to face and prepare for catastrophes (Ashida et al. 2024). Farmers with higher well-being tend to have a more balanced view of the risks and benefits associated with new farming methods. In comparison, those with lower well-being may perceive the risks as too significant to initiate change (Howley et al. 2017).

Understanding the behavioural factors that influence farmers' decision-making is needed to enhance the use of IPM methods, as ultimately, farmers are the ones making pest management decisions at the farm level. By understanding the psychological barriers that prevent the use of IPM, it is possible to design interventions and new policy measures to support the adoption of IPM methods. The farmers' decision-making process concerning plant protection has not been widely investigated in Finland.

Materials and methods

Theory of Planned Behaviour (TPB)

In this study, three new factors, knowledge, moral norms, and well-being, were added to create an extended version of TPB (Fig. 1). This theoretical approach allows the evaluation of the dependencies between socio-psychological factors (Beedell and Rehman 2000, Pouta and Rekola 2001, Bergevoet et al. 2004, Karppinen 2005, Rehman et al. 2007).

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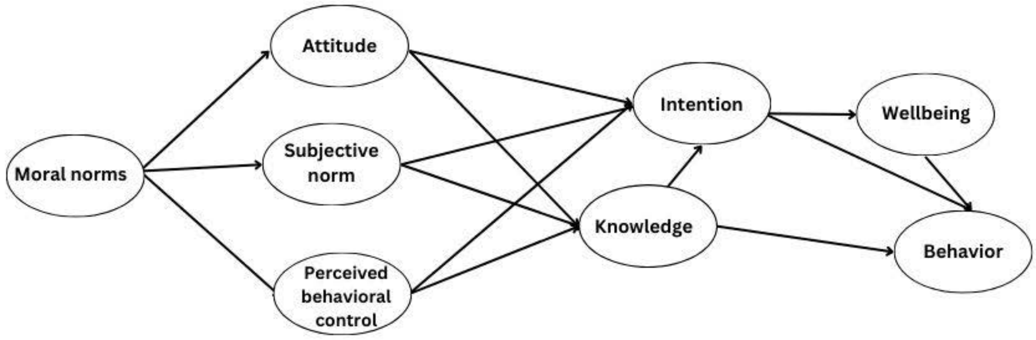

Fig. 1. Theoretical research framework in the context of the Theory of Planned Behaviour (TPB) designed to explore farmers' intention to use Integrated Pest Management (IPM) methods in Finland

Data collection

A survey was conducted in 2023 in Finland, targeting contract farmers of food processing companies Fazer Mills and Atria Plc. Using the Webropol Survey & Reporting program, the survey was distributed via email to all 5 331 contract farmers and was available in Finnish. To maintain anonymity, no personal data was collected, and all data was collected in a way that individual participants could not be identified in any published reports or shared data. Confidentiality was maintained by securely storing all data and limiting access to authorised research personnel only.

Participants were fully informed about the nature and purpose of the study, including any potential risks or benefits involved. They were given the opportunity to ask questions and were assured that their participation was entirely voluntary.

The survey comprised both demographic and farm-specific questions, along with structured statements based on prior research (Bagheri et al. 2019a, Creissen et al. 2019, Despotovic et al. 2019, Bakker et al. 2020). It included 11 demographic and farm-specific questions, 11 structured questions, a total of 275 statements, and two open-ended questions. Farmers received two reminders to encourage them to complete the survey.

This research examined various factors, and the number of statements assigned to each: attitudes (9), perceived behavioural control (10), subjective norms (7), moral norms (7), knowledge (13), well-being (6), and intention (9). These variables were assessed through Likert-type scales, ranging from 1 (strongly disagree) to 5 (strongly agree). At the conclusion of the survey, participants were asked to provide demographic information, including their age, gender, residence, farm size, farm type, production line, and level of education. The specific statements and scales utilised in the survey can be found in the supplementary material (Supplementary 1).

Statistical analysis

The Structural Equation Modelling (SEM) was used to analyse the relationships among the factors: attitude, perceived behavioural control, subjective norms, moral norms, knowledge, well-being, and intention. This approach enabled the testing of the entire model, considering both direct and indirect effects, thus allowing for the simultaneous testing of all seven hypotheses. The internal consistency of the factors was evaluated using Cronbach's alpha, with weakly loaded statements being excluded from the model. Additionally, Pearson correlation coefficients were calculated among the key constructs (Fig. 2) and across all measured variables (Supplementary 2).

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Fig. 2. Correlation heatmap of key constructs. Individual items and their correlations are provided in Supplementary 2. Colours represent Pearson correlation coefficients ranging from –0.2 to 1: blue for positive correlations, white for average correlations, and orange for negative correlations. Numeric correlation values are displayed within each cell for clarity.

The full information maximum likelihood (FIML) estimation method was utilised to handle one missing value for 15 respondents. The assumption of multivariate normality was evaluated using residual plots and multivariate normality tests (Mardia's and relative MV kurtosis) to confirm normality. Three correlated error terms (two in PBC and one in MN) were allowed, based on the Lagrange's multiplier test, to improve the model fit. The model's goodness-of-fit was assessed using the Comparative Fit Index (CFI), the Root Mean Square Error of Approximation (RMSEA), the Standardised Root Mean Square Residual (SRMR), and the chi-square test. CFI values greater than 0.90 can be considered a reasonable fit, and values over 0.95 are considered a good fit (Hu and Bentler 1999). RMSEA and SRMR values below 0.08 are generally considered acceptable. The statistical analyses were performed using SAS Enterprise Guide 8.3 (SAS Institute, Inc., Cary, NC, United States).

Results

Although there were 42 271 farms in Finland in 2023 (Luke 2025), only 303 farmers responded to our survey, resulting in a response rate of 5.7%. Younger individuals, those with larger and more diverse farms, and organic farmers were overrepresented in our sample (Table 1).

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Table 1. Socio-demographic and farm characteristics of Finnish farming population (N=42 271; Luke 2025) and survey respondents (n=303, out of 5 331 farmers reached). Values are shown when available, since the information on the educational background of farmers in Finland is limited.

	Finnish farmers, total		Survey sample	
	N/Mean	%	N/Mean	%
Number of farms	42 271		303	
Farm size, ha	54		127	
Age	54	-	43	-
Female	na	24	43	15
Male	na	76	247	84
Didn´t want to answer	-	-	6	1
Agricultural management				
Conventional	38 035	89	240	81
Organic	4 236	11	46	15
Combination	na	na	11	4
Production				
Crop farm	13 645	32	82	28
Cattle, no pig or poultry	7 755	18	117	40
Combined	1 421	3	95	31
Something else	18 703	47	2	1
Education				
Comprehensive	na	na	28	9
Upper secondary school or vocational school	na	na	132	45
Lower or higher university degree	na	na	136	46
Agricultural education				
Nothing	na	na	37	12
Vocational school or apprenticeship	-	40	172	57
Lower or higher university degree in agriculture	-	14	91	31

Table 2 shows the statement's factor loadings for each factor (measurement model) in the final SEM model. All factors had acceptable and relatively high internal consistencies (0.717–0.897). The highest internal consistencies were observed in the factors Perceived behavioural control (PBC) and intention (INT), while behaviour (BEH) had the lowest Cronbach's alpha. For example, the attitude was best described by statement Q92: "The adoption of IPM methods is an important part of the continuity of food production.", whereas the intention was best described by statement Q84: "I would like to use IPM methods to support the well-being of the agro-ecosystem."

Table 2. Standardised factor loadings for each statement within their corresponding factors in the structural equation model (SEM). Reliability of each factor was evaluated using Cronbach's alpha, with values above 0.7 considered acceptable. The factors include Attitude (ATT), Knowledge (KNL), Subjective norms (SN), Moral Norms (MN), Perceived behavioural control (PBC), intention (INT), while behaviour (BEH) and well-being (WB). This table provides an overview of how well each statement (Supplementary 1) represents its underlying factor and supports the internal consistency of the measurement model.

Statement	Factor	Factor loading	Std Err	*p* value	Cronbach's Alpha
Q91	ATT	0.787	0.026	<.0001	0.852
Q92	ATT	0.863	0.020	<.0001	
Q93	ATT	0.653	0.037	<.0001	
Q94	ATT	0.788	0.026	<.0001	
Q119	KNL	0.723	0.035	<.0001	0.828
Q120	KNL	0.788	0.030	<.0001	
Q121	KNL	0.698	0.037	<.0001	
Q122	KNL	0.765	0.032	<.0001	

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Q99	SN	0.846	0.023	<.0001	0.792
Q100	SN	0.818	0.025	<.0001	
Q101	SN	0.600	0.041	<.0001	
Q131	MN	0.690	0.036	<.0001	0.863
Q132	MN	0.655	0.039	<.0001	
Q133	MN	0.730	0.033	<.0001	
Q112	PBC	0.820	0.046	<.0001	0.897
Q113	PBC	0.816	0.046	<.0001	
Q114	PBC	0.699	0.048	<.0001	
Q115	PBC	0.751	0.045	<.0001	
Q81	INT	0.616	0.038	<.0001	0.882
Q82	INT	0.673	0.034	<.0001	
Q83	INT	0.891	0.016	<.0001	
Q84	INT	0.895	0.015	<.0001	
Q85	INT	0.792	0.025	<.0001	
Q6	BEH	0.610	0.048	<.0001	0.717
Q7	BEH	0.659	0.045	<.0001	
Q8	BEH	0.676	0.044	<.0001	
Q9	BEH	0.553	0.051	<.0001	
Q155	WB	0.532	0.046	<.0001	0.802
Q156	WB	0.847	0.033	<.0001	
Q158	WB	0.916	0.032	<.0001	

Figure 3 illustrates the causal dependencies between the factors in the structural model and indicates a good model fit (CFI=0.93, RMSEA=0.06, SRMR=0.06). As hypothesised, the attitude towards IPM was strongly explained by moral norms (β=0.890, *p*< 0.001; hypothesis 1), as were subjective norms (β=0.950, *p*< 0.001; hypothesis 1), and perceived behavioural control (β=0.420, *p*< 0.001; hypothesis 1). Only attitude explained directly intention (β=0.650, *p*< 0.001; hypotheses 2–4). Knowledge of IPM had a strong mediating effect on behaviour related to the use of IPM (β=0.454, *p*< 0.001; hypothesis 5) but also on intention to use IPM (β=0.141, *p*< 0.001; hypothesis 7). The actual use of IPM methods was also explained by the intention to use IPM methods (β=0.398, *p*< 0.001; hypothesis 6). In contrast, the association between farmers' well-being and IPM behaviour, which was the second part of the mediating effect from intention to behaviour, was not statistically significant (*p*= 0.13).

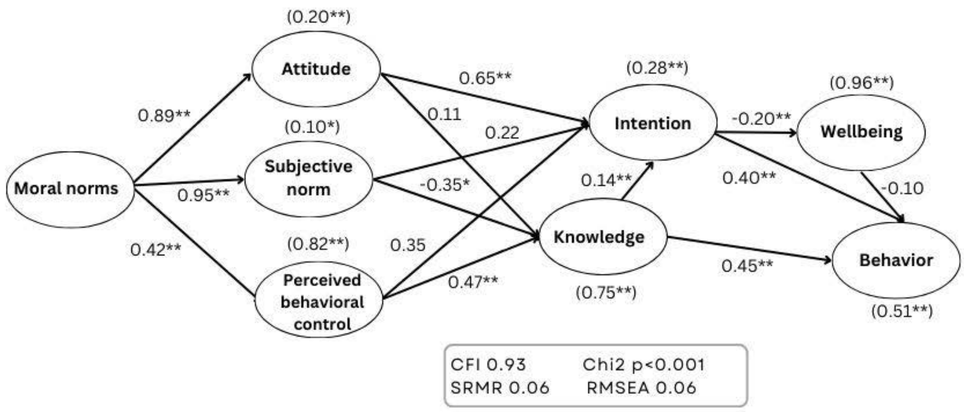

Fig. 3. Structural model of the modified Theory of Planned Behaviour (TPB). The arrows represent standardised regression coefficients, with the value in parentheses indicating the standardised error variance. Statistical significance is denoted by stars (*** *p*< 0.001, ** *p*< 0.01, * *p*< 0.05). Goodness-of-fit measures are provided in the box: CFI, Comparative Fit Index, SRMR, the standardised root mean square residual, RMSEA, and root mean square error of approximation. The measurement model, including the statements within each factor, is detailed in Table 2 for clarity. The arrows represent standardised regression coefficients, with the value in parentheses indicating the standardised error variance. Statistical significance is denoted by stars (*** *p*< 0.001, ** *p*< 0.01, * *p*< 0.05). Goodness-of-fit measures are provided in the box: CFI, Comparative Fit Index, SRMR, the standardised root mean square residual, RMSEA, root mean square error of approximation. N=297.

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The direct effect (DE) of intention on actual use explained 95% of the total effect (TE) (p< 0.001), while only 5% was explained through the indirect effect (IE) of wellbeing (p= 0.166). Similarly, only 3% of attitude on intention to use IPM methods was explained through the mediator of IPM knowledge (p= 0.079). The other two mediating effects (Social Norms to Intention via Knowledge and Perceived Behavioural Control to Intention via Knowledge) cannot be interpreted similarly due to inconsistent mediation, which means opposite directions of DE and IE (Table 3).

Table 3. Direct (DE), indirect (IE), and total effects (TE) of key factors in the structural equation model (SEM). The table summarises standardised path coefficients for relationships among latent variables. Direct effects represent the immediate influence of a factor, indirect effects capture the influence mediated through other factors, and total effects are the sum of direct and indirect effects.

Factor	Effect	Estimate	SE	t-value	*p*-value
Intention -> Behaviour	DE	0.399	0.060	6.638	<0.001
via Wellbeing	IE	0.020	0.014	1.386	0.166
	TE	0.418	0.059	7.107	<0.001
Attitude -> Intention	DE	0.654	0.115	5.703	<0.001
via Knowledge	IE	0.050	0.028	1.759	0.079
	TE	0.704	0.112	6.280	<0.001
Subjective Norm -> Intention	DE	0.220	0.124	1.780	0.075
via Knowledge	IE	-0.050	0.030	-1.665	0.096
	TE	0.170	0.121	1.401	0.161
Perceived Behavioural Control >Intention	DE	-0.108	0.058	-1.852	0.064
via Knowledge	IE	0.066	0.028	2.368	0.018
	TE	-0.042	0.050	-0.841	0.400

The results indicate that the intention to use IPM methods significantly influenced their actual use. Attitude toward IPM had a significant direct and total effect on intention. The indirect effect of perceived behavioural control on intention via knowledge of IPM was significant, while the indirect effect of intention on actual use via farmers' well-being was non-significant. Farmers' low well-being was negatively associated with behavioural intentions to use IPM, but it only mediated 5% of that association (p= 0.166). The direct and total effects of social norms on intention were non-significant, as was the direct effect of perceived behavioural control on intention.

Our results show that hypothesis 1 was supported, indicating moral norms influenced attitudes, subjective norms, and perceived behavioural control regarding IPM. Hypothesis 2 was also supported, illustrating that a positive attitude toward IPM practices increased their use. Hypothesis 3 was supported with subjective norms directly affecting intention (p= 0.075). However, the indirect effect via knowledge was complicated by subjective norms negatively impacting knowledge (p= 0.042) and positively affecting intention (p= 0.009).

Our research supports hypotheses 4 and 5, indicating that perceived behavioural control and knowledge influenced intention to use IPM methods. This relationship was negative (p= 0.064), while knowledge of IPM strongly predicted intention and actual behaviour (both p< 0.01). Knowledge mediated 7% of the relationship between attitudes toward IPM and intention (p= 0.079).

Our research supports hypothesis 6, as the results indicate that the intention to use IPM methods significantly influenced their actual use. Hypothesis 7 assumed that farmers' well-being affects the use of IPM. Our results indicate that the low well-being of farmers was associated with a negative correlation in their intentions to adopt IPM. However, this accounted for only 5% of the relationship (p= 0.166).

Discussion

This study is the first to examine the views of Finnish farmers on the adoption of IPM within the framework of the EU Green Deal. We utilised an adapted version of the TPB to analyse the factors that affect Finnish farmers' decisions to adopt IPM. In addition to the traditional TPB elements of attitude, subjective norms, and perceived behavioural control, we included knowledge, moral norms, and the rarely used factor of well-being. These new factors proved to be significant.

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Our results indicate that farmers with a positive attitude toward IPM practices were more likely to use them. This finding is consistent with previous studies by Bagheri et al. (2021b) and Rezaei et al. (2019), which also observed that farmers' intention to use pesticides was influenced by their attitude toward them. Among our respondents, the most commonly used IPM methods were taking care of soil health ($\bar{X}$=4.5 on the Likert scale), crop rotation ($\bar{X}$=4.4), and conducting intensive vegetation observation ($\bar{X}$=4.3). Previous research has shown that similar IPM methods have been adopted well in horticulture in Ireland (Byrne et al. 2025), arable farms in Norway (Steiro et al. 2020) and in Ireland (Creissen et al. 2019), but more complex IPM methods are less readily adopted (Steiro et al. 2020).

Our findings align with Ataei et al. (2021), indicating that subjective norms and perceived behavioural control do not significantly affect farmers' intention to use IPM. Our findings can also be considered surprising because there is evidence that farmers' decisions to adopt sustainable practices appear to be influenced by their neighbours' actions, and subjective norms have a significant influence on farmers' decisions. A lack of experience with neighbouring farmers who implement agri-environmental measures correlated with reduced adoption of these schemes in the research of Defrancesco et al. (2008), Läpple and Rensburg (2011) and Vanslembrouck et al. (2002). The lack of availability and reference to influencers in the region may also contribute to the insignificant relationship between perceived behavioural control and intention to use methods for sustainable farming.

Knowledge of IPM predicts both the intention and actual use of IPM, while mediating only 7% of the relationship between farmers' attitudes and intention, which is partly inconsistent with previous research. Bagheri et al. (2021b) found that knowledge about pesticide hazards was the most critical variable affecting farmers' intentions to use pesticides. In our research, knowledge primarily influences perceived behavioural control of pesticide use and attitudes toward pesticides. Still, the influence of knowledge is not without meaning; according to Defrancesco et al. (2008), the more a farmer perceives that they can implement the practices associated with a given agri-environmental scheme, the more likely they are to participate in them (Defrancesco et al. 2008).

According to Bagheri et al. (2021b), promoting knowledge about pesticides is a fundamental step in regulating pesticide use among farmers, and it may help stabilise and render farmers' attitudes resistant to change. Based on the review of Dessart et al. (2019), acquiring information and knowledge about sustainable practices is a social process. Understanding how peer opinion, contact, beliefs, and risks affect people's intentions and actions is also necessary in Finland. Farmers are more likely to adopt sustainable practices when their neighbouring farmers have already done so, when they follow the example and opinions of social referents who support adoption, and when they seek to gain social status (Dessart et al. 2019). Recognising farmers' beliefs helps us challenge opposing views and strengthen those that support the change towards more sustainable farming practices. This approach can also help develop new beliefs that align with sustainable behaviour (Ajzen et al. 2011).

Although our model does not strongly support this, a person's well-being may influence their ability to follow through on intentions to adopt new farming methods, such as IPM, particularly when facing challenges or setbacks (King et al. 2023). Compromised well-being can lead to behavioural biases, such as a preference for the status quo and further hinder the adoption of new farming practices (Kallioniemi et al. 2024). To better understand farmers' well-being, their adaptability in sustainable agriculture, and their adoption of methods such as IPM, farmers need to be met where they are (King et al. 2023). This is also true in Finland, where the surroundings change and the social and productional environment varies a lot between regions. For example, farmers in Southern Finland were more positive about their possibilities to mitigate climate change than those from Western and Northern Finland (Sorvali et al. 2021).

It has been recognised that, despite good intentions, IPM faces weaknesses, including confusion over definitions, inconsistencies in practice, and a lack of farmer engagement (Deguine et al. 2021). Additionally, there is a reliance on chemical control and an inadequate focus on ecological considerations in IPM research. The misinterpretation of IPM rules has hindered its effective implementation since the 1960s (Deguine et al. 2021).

Many factors influence farming decisions, such as demographics, economic constraints, environmental conditions, and regulatory frameworks, which TPB may not fully capture. Our survey was targeted at the farmers of the project collaborators, which may have introduced selection bias. Additionally, the response rate was low, resulting in a relatively small dataset that limits the generalizability of the findings. Since our analysis is based on self-reported data, it may result in underreporting of unfavourable behaviours or overreporting of favourable ones. There is also a risk of self-selection bias, as more engaged individuals may be more likely to participate in the study. A comparison of our sample demographics with those of the broader population reveals potential demographic biases that may influence our findings and interpretations.

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Our survey was targeted at the farmers of the project collaborators, but the response rate was low, resulting in a small dataset. The sample consisted of younger farmers with larger farms, a higher representation of organic farming, and a more diverse range of production types, with a focus on cattle and combined farms. There was also a higher level of education and agricultural education among the survey respondents compared to the general Finnish farming population. Due to the subjective nature of these factors, accurately measuring subjective norms and moral values can be a challenging task. Farmers' attitudes and subjective norms can change over time, influenced by new information, experiences, and external pressures. Longitudinal studies with larger and more representative samples may be needed to capture these dynamics fully.

Farmer-research cooperation is needed for successfully adopting sustainable practices such as IPM. There is a lack of knowledge in the research of behavioural factors affecting the adoption of sustainable farming practices (Dessart et al. 2019). Farmers provide practical insights and ground-level realities that could enhance the relevance and applicability of research findings. Collaborating with farmers helps build trust, making them more likely to accept and implement research recommendations. Cooperation allows researchers to tailor solutions to farmers' specific needs and conditions, improving the effectiveness of interventions. Continuous interaction with farmers provides a feedback loop, helping researchers refine their approaches and methodologies based on real-world experiences. Engaging farmers in research can enhance their knowledge and skills, empowering them to adopt and advocate for sustainable practices such as IPM.

Conclusions

The modified TPB provides a nuanced understanding of the socio-psychological factors influencing farmers' behaviour. Including knowledge as a mediator aligns with the idea that informed farmers are more likely to adopt innovative practices such as IPM. We identified variables that predict farmers' intentions and behaviour, offering actionable insights for promoting IPM adoption. Understanding society's moral norms and attitudes towards IPM methods encourages their use among farmers.

Statistical analysis revealed that moral norms, subjective norms, and perceived behavioural control influence attitudes towards IPM among Finnish farmers. Only attitudes directly impacted the intention to use IPM methods, which in turn influenced the actual adoption of these methods. Additionally, knowledge of IPM was identified as a significant mediator, shaping both the intention to adopt IPM and the actual use of IPM methods.

Based on our results, we suggest practical implications for agricultural policies, extension services, and farmer engagement in Finland. Organising demonstration projects would showcase the benefits and practical applications of IPM, and offering incentives such as subsidies or financial rewards for farmers who adopt IPM practices might encourage their use. Extension services could facilitate group meetings and workshops with early adopters of IPM, utilising social proof and testimonials from influential farmers to promote positive attitudes, incorporating IPM principles into agronomic education, and providing continuous training. Additionally, fostering cooperation between farmers and researchers is needed for developing practical, effective, and sustainable agricultural practices. These actions may help improve attitudes toward the implementation of IPM. Promoting knowledge about IPM methods and providing educational interventions, training courses, disincentives, and public awareness campaigns may improve farmers' behaviour towards IPM methods and the adoption of IPM in Finland.

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The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request. Researchers share their results in an open, honest, transparent, and accurate manner, and respect the confidentiality of data or findings when legitimately required to do so (Statement based on ALLEA 2023).

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