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RESEARCH PAPER

Modeling pear farmers' pesticide use behavior in Türkiye through the theory of planned behavior

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Abstract

Despite the critical role of pesticide management in sustainable agriculture, no prior study has applied the Theory of Planned Behavior within a Structural Equation Modeling framework to examine pear farmers' pesticide use in Türkiye. To address this gap, this study investigates factors shaping pear farmers' intentions and behaviors regarding pesticide use in Bursa Province, a region with high agricultural potential and one of Türkiye's highest pesticide consumption rates. Data were collected from 290 pear producers through face-to-face surveys and complemented by official statistics. A quantitative approach was employed, using Structural Equation Modeling to test associations among Theory of Planned Behavior constructs: attitude, subjective norms, perceived behavioral control, intention, and pesticide use behavior. Results show that subjective norms exert a significant negative effect on pesticide use intention, whereas perceived behavioral control has a positive and significant influence on intention. Attitudes toward pesticide use were not significantly associated with pesticide use intention, and neither perceived behavioral control nor intention had a significant direct effect on pesticide use behavior, indicating a clear intention–behavior gap. These findings highlight that social pressures and perceived control shape intentions, yet structural, informational, or contextual barriers may prevent intentions from translating into practice. The study contributes to the literature by integrating the Theory of Planned Behavior with Structural Equation Modeling in pear production, offering empirical evidence to inform policymakers and agricultural extension services in designing targeted interventions for sustainable pesticide management. The insights are particularly relevant for regions with high pesticide dependence and for enhancing global pear production sustainability.

Keywords

Agriculture, pear farmers, pesticide, structural equation modeling, theory of planned behavior

Introduction

Global population growth continues to exert pressure on agricultural systems, raising urgent concerns about whether agriculture can generate enough food and raw materials to satisfy the needs of future populations (FAO 2022a; UN 2022). Increasing productivity per unit area has therefore become a critical goal, and farmers rely on various pest and disease control strategies including chemical, biological, and integrated pest management to protect crops and sustain yields (Pan et al. 2021; Wang and Liu 2021; FAO 2022b). Among these, chemical control through pesticides gained prominence during the Green Revolution of the 1940s and has since played a vital role in boosting agricultural productivity (USDA 2022). However, while pesticides remain indispensable for food security, their misuse and overuse continue to pose severe environmental, food safety, and public health risks (Bagheri et al. 2021b; WHO 2022).

The paradox is clear: pesticides protect food supply but simultaneously threaten human and environmental

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health. Less than 1% of applied pesticides reach their intended targets, with the rest contaminating soil, water, and air, entering the food chain, and causing diseases such as cancer and immune suppression (Tariq et al. 2007; Fianko et al. 2011; Gill and Garg 2014). Misuse has been documented globally, from Europe where over 2,400 food safety issues linked to pesticide residues were reported between 2015 and 2020 (RASFF 2020; Pan et al. 2021) to Africa, where unregulated pesticide use has heightened risks to human health and food security (Ntow et al. 2006; Williamson et al. 2008). Fruits and vegetables are especially affected (Pan et al. 2021). Against this backdrop, the key research question motivating this paper is: What drives the intentions and actual behaviors of pear farmers concerning pesticide application in Türkiye?

Türkiye ranks among the world's top ten agricultural producers (FAO 2022c) and is a significant pesticide consumer. In 2023, the country used 57,576 tons of pesticides, ranking 11th globally and accounting for 1.54% of world pesticide consumption (FAOSTAT 2025). Bursa, alongside Antalya, Manisa, Adana, and Mersin, is one of the provinces with the highest pesticide use (Ministry of Agriculture and Forestry 2022a). Although these inputs have contributed to productivity, misuse and over-application largely stem from farmers' decisions about dosage, timing, and application methods (Tudi et al. 2022). Globally, scholars have investigated pesticide use behaviors through various lenses, with many adopting the Theory of Planned Behavior (TPB) and Structural Equation Modeling (SEM) to capture the psychological and social determinants of farmer decisions (Beedell and Rehman 2000; Rezaei et al. 2018; Bagheri et al. 2021a; Lou et al. 2021). The TPB has been widely applied to explain pro-environmental practices, including pesticide use and safety. Prior studies consistently demonstrate that attitudes, subjective norms, and perceived behavioral control (PBC) are central in shaping farmers' intentions and behaviors. For example, Asante et al. (2023) showed that these constructs significantly influenced both intentions and actual pesticide-use behaviors in Ghana. Similarly, Bagheri et al. (2021b) found that TPB variables predicted farmers' intentions toward safe pesticide handling in Iran, which in turn determined actual practices. In Türkiye, Batbay and Kahramanoğlu (2024) confirmed the strong predictive power of attitudes, subjective norms, and PBC on pesticide-use intentions, with attitudes emerging as the most influential factor. Extending the framework, Sapkota et al. (2025) demonstrated in Nepal that the Extended TPB further improves explanatory power by incorporating additional psychosocial dimensions. Collectively, these studies underscore TPB's robustness in agricultural contexts, while also pointing to the value of model extensions for capturing contextual variations in farmers' decision-making. In Türkiye, however, most studies have focused on farmers' knowledge and awareness (Isin and Yildirim 2007; Tiryaki and Akar 2018; Erdil and Tiryaki 2020), with only limited research addressing behavioral drivers directly (Özkan et al. 2016; Bayraktar and Boz 2020). To date, no study has applied TPB within an SEM framework to systematically analyze pesticide use behaviors among pear farmers in Türkiye.

This paper makes three contributions. First, it fills a research gap by applying TPB to the pesticide use behavior of pear farmers, thereby linking socio-psychological theory with empirical evidence in an agricultural context. Second, it provides novel data from Bursa Province, a region that combines high agricultural potential with some of Türkiye's highest pesticide consumption rates, making it a critical case for understanding farmer behavior. Third, by employing SEM, the study rigorously tests the TPB framework and quantifies the relative influence of attitudes, subjective norms, and perceived behavioral control on farmers' intentions and behaviors. Together, these contributions enrich the literature on sustainable pest management by clarifying the determinants of pesticide use intention and pesticide use behavior, and they provide actionable insights for policymakers.

The remainder of this paper is structured as follows. Section 2 outlines the conceptual framework. Section 3 describes the study area, data collection, and methodology. Section 4 presents the empirical findings, while Section 5 discusses their theoretical and policy implications. Section 6 concludes with the key contributions and future research directions.

Theoretical framework

Numerous theories have been developed to explain human behavior, yet the TPB proposed by Ajzen (1991) remains one of the most widely applied frameworks. The TPB (Fig. 1) has been widely used to predict farmers' pesticide use intentions and pesticide use behavior (Damalas et al. 2006; Damalas 2021), providing a structured framework for understanding why farmers act in particular ways when making pesticide application decisions (Daxini et al. 2019). According to the theory, behavior is primarily determined by behavioral intention, which is influenced by three key constructs: attitude toward the behavior, subjective norms (SN), and perceived behavioral control (PBC) (Ajzen 1991; Shirahada and Zhang 2022).

Attitude refers to an individual's favorable or unfavorable evaluation of performing a particular behavior (Ajzen 1991). In agricultural contexts, farmers are more likely to develop positive pesticide use intentions when they perceive appropriate pesticide use behavior as beneficial for their economic outcomes, health, and environmental sustainability. Subjective norms describe the perceived social pressure from important others to engage in or avoid specific behaviors (Ajzen 1991; Aliabadi et al. 2020; Gholamrezai et al. 2021; Khan et al. 2021; Pirmoghni et al. 2024). Individuals often comply with these social expectations to avoid disapproval or social rejection (Bamberg and Möser 2007). Consequently, farmers' pesticide use intentions are likely to strengthen when they perceive that respected peers or community members support appropriate pesticide use behavior, as social approval reinforces behavioral

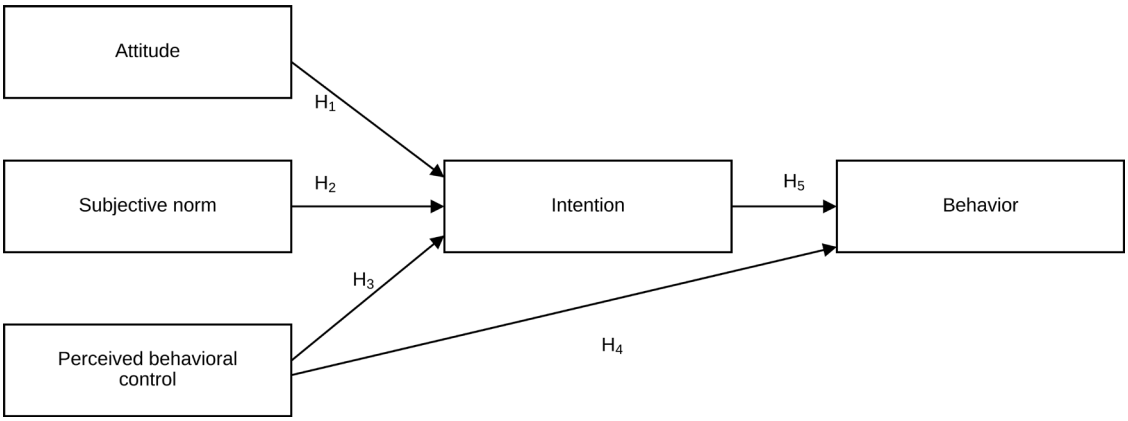


Figure 1. TPB model illustrating pear farmers' pesticide use behavior in Türkiye.

motivation (Daxini et al. 2019; Bagheri et al. 2021b; Gowda et al. 2021; Rajeh 2022; Shirahada and Zhang 2022; Sok et al. 2024; Uikey et al. 2025).

PBC, on the other hand, represents an individual's perception of how easy or difficult it is to perform a behavior, reflecting both personal capabilities and situational constraints (Bamberg and Möser 2007). This construct indicates the degree to which a person feels capable of exercising volitional control over a given behavior (Fishbein and Ajzen 2011; Mahdavi 2021). Accordingly, farmers' pesticide use intentions are strengthened when they feel confident in their ability to perform appropriate pesticide use behavior effectively (Daxini et al. 2019; Despotović et al. 2019; Rajeh 2022; Sarma 2022; Shirahada and Zhang 2022; Bhandari et al. 2025; Sharifzadeh et al. 2025; Sookhtanlou and Khoshnodifar 2025).

Material and method

This study draws on both primary and secondary data sources. The primary data were obtained through a specifically designed questionnaire administered via face-to-face interviews with pear farmers in the study area, while the secondary data were derived from official statistical databases and sectoral reports.

Research design, questionnaire, variables, and scale

This study employed a quantitative approach to examine pesticide use behaviors among pear farmers within the framework of the TPB. A structured questionnaire was developed based on prior research on TPB applications and pesticide use behavior (Bagheri et al. 2021a, 2021b; Sarma 2022) and was administered between April and May 2023.

The questionnaire captured data on the socio-demographic characteristics of the pear farmers as well as contextual variables related to their pesticide use behaviors. TPB-related constructs were measured using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), in line with previous studies in this field.

To ensure the reliability and validity of the scale, a reliability analysis was performed. Reliability analysis evaluates the internal consistency of survey items, providing a measure of the coherence and dependability of the collected data (Chan and Idris 2017). In this study, Cronbach's Alpha for the thirteen items was 0.648, indicating moderate internal consistency for the overall scale. Each construct's reliability was assessed separately. All CR values exceeded 0.70. AVE values acceptable. Reliability in survey-based behavioral research is commonly evaluated using Cronbach's Alpha coefficient. According to established benchmarks, a Cronbach's Alpha value below 0.40 indicates that a scale is unreliable, values between 0.40 and 0.60 indicate low reliability, values between 0.60 and 0.80 indicate acceptable reliability, and values above 0.80 indicate high reliability (Cortina 1993; Ritter 2010). In line with SEM practice, reliability was assessed separately for each latent construct rather than for the overall scale.

However, Cronbach's Alpha alone may underestimate reliability in latent-variable models, particularly when constructs contain few indicators or unequal factor loadings. Therefore, composite reliability (CR) and average variance extracted (AVE) were also examined to assess internal consistency and convergent validity. Following the criteria suggested by Hair et al. (2017), CR values above 0.70 indicate satisfactory reliability, while AVE values above 0.50 support convergent validity.

Research area

Bursa holds a prominent place in pear production. In 2023, global pear output was 26,507,458.1 tons, of which Türkiye produced 534,513.0 tons (2.01% of global production). Bursa alone contributed 247,795 tons, representing 46.36% of Türkiye's total pear production (FAOSTAT 2025; TURKSTAT 2025).

Fig. 2 illustrates the geographical location of Türkiye within the world and the position of Bursa Province within Türkiye. The figure also provides a detailed representation of the districts within Bursa. The study area is specifically focused on the districts of İnegöl, Gürsu, and Kestel.

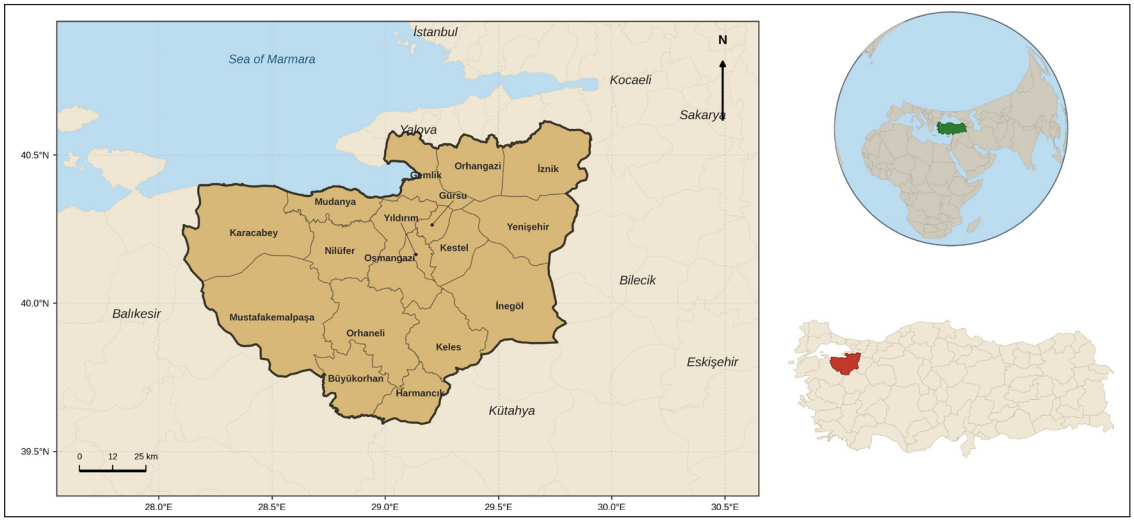


Figure 2. Geographical location of the study area.

Sampling

According to data obtained from the Bursa Provincial Directorate of Agriculture and Forestry for the year 2021, the total number of pear-producing farmers across all districts of Bursa Province was reported as 4,340 (Ministry of Agriculture and Forestry 2022b).

For the second stage, in order to implement stratified random sampling, data on pear cultivation areas and other necessary information for all 4,340 farmers were requested from the Bursa Provincial Directorate of Agriculture and Forestry. However, the request could not be fulfilled due to the unavailability of these data at the Directorate. Therefore, proportional sampling was applied based on the total number of farmers (Equation 1) (Chan et al. 1996; Chen et al. 2001; Bayraktar and Boz 2020). To determine the required sample size, proportional sampling based on population size was applied. The sample size was calculated using the finite population sampling formula:

$$n = \frac{N \cdot p \cdot (1-p)}{(N-1) \cdot \sigma_p^2 + p \cdot (1-p)} \quad (1)$$

where:

- n = required sample size;
- N = population size (4,340 pear-producing farmers);
- p = assumed population proportion;
- $1 - p$ = complementary proportion;
- σ_p = standard error of the population proportion.

Because no prior information on the proportion was available, $p = 0.50$ was assumed, which maximizes sampling variance and yields the most conservative sample size estimate. The standard error of the population proportion was calculated based on the selected confidence level and margin of error using:

$$\sigma_p = \frac{d}{Z} \quad (2)$$

where d is the margin of error and Z is the Z-value corresponding to the confidence level. In this study, a 90% confidence level was used ($Z = 1.645$) and the margin of error was set at 0.05, resulting in $\sigma_p = 0.03039$.

Substituting the study parameters into Equation (1), the required sample size was calculated as follows:

$$n = \frac{4340 \times 0.50 \times 0.50}{(4340-1) \times (0.03039)^2 + 0.50 \times 0.50} \quad (3)$$

First, the numerator was calculated:

$$4340 \times 0.50 \times 0.50 = 1085 \quad (4)$$

Then, the denominator was obtained:

$$(4340-1) \times (0.03039)^2 + 0.25 = 4339 \times$$

$$0.0009236 + 0.25 = 4.006 + 0.25 = 4.256 \quad (5)$$

Finally, the required sample size was determined:

$$n = \frac{1085}{4.256} = 254.9 \approx 255 \quad (6)$$

Thus, the minimum required sample size was calculated as 255 farmers. To increase statistical reliability and account for potential non-response or incomplete questionnaires, 290 valid surveys were ultimately collected and included in the analysis.

Based on the proportional sampling formula, it was determined that at least 254 pear-producing farmers in Bursa Province should be surveyed face-to-face. During the study, a total of 290 reliable and valid surveys were collected. Therefore, the research was conducted based on these 290 responses.

The 2021 data from the Bursa Provincial Directorate of Agriculture and Forestry also provide the number of pear producers and total pear cultivation areas by district (Table 1). The three districts with the highest number of pear producers, representing 61.6% of the total, were İnegöl, Gürsu, and Kestel. In terms of total pear cultivation area, the leading districts were Karacabey (33.2%), İnegöl (16.2%), Gürsu (15.5%), and Kestel (10.5%). Although Karacabey ranked first in cultivation area, it was only 11th in terms of the number of producers, indicating that

Table 1. Distribution of the number of pear producers and total pear cultivation areas by district in Bursa Province, based on 2021 data.

Districts	Number of pear producers	Percentage of total pear producers in the province (%)	Total cultivation area (da)	Percentage of total pear cultivation area in the province (%)
İnegöl	1,086	25.00	20,810	16.20
Gürsu	802	18.50	19,912	15.50
Kestel	734	18.10	13,483	10.50
Osmangazi	440	10.1	11, 928	9.3
Mustafakemalpaşa	280	6.5	4,813	3.8
Yıldırım	259	6.0	6,265	4.9
İznik	216	5.0	1,832	1.4
Nilüfer	114	2.6	1,072	0.8
Yenişehir	112	2.5	2,214	1.7
Mudanya	96	2.2	1,135	0.9
Karacabey	56	1.3	42,583	33.2
Orhangazi	32	0.8	1,817	1.4
Keles	22	0.5	130	0.1
Orhaneli	21	0.5	197	0.2
Gemlik	20	0. 4	103	0.1
Harmancık				
Büyükorhan				
Total	**4,340**	**100.0**	**128,301**	**100.0**

Source: Bursa Provincial Directorate of Agriculture and Forestry 2021.

large-scale producers operate there. Considering both the ease of accessing survey participants and the potential influence of outliers in farm size, Karacabey was excluded from the study. Consequently, the study focused on İnegöl, Gürsu, and Kestel, which ranked among the top three in producer numbers and the top four in production area.

Although Karacabey district accounts for a substantial share of total pear cultivation area in Bursa Province, it was excluded from the sampling frame due to its markedly different farm structure. Official statistics show that Karacabey is characterized by a small number of very large-scale commercial producers, whereas the selected districts (İnegöl, Gürsu, and Kestel) consist predominantly of small and medium-scale family farms. Including Karacabey in the sample would therefore have introduced substantial structural heterogeneity in farm size, production organization, and pesticide management practices.

Since Structural Equation Modeling assumes a relatively homogeneous population in terms of behavioral mechanisms, combining large-scale commercial farms with smallholder producers could have biased parameter estimates and obscured the behavioral relationships under investigation. The study therefore focused on districts that represent the majority of pear farmers in terms of producer numbers and typical farm structures, ensuring a more internally consistent sample for behavioral analysis.

Based on this, the allocation of the 254 surveys according to the number of pear producers in each district is presented in Table 2. Within the study, a minimum of 103 surveys were planned for İnegöl, 76 for Gürsu, and 75 for Kestel. In practice, a total of 290 reliable surveys were collected. The actual distribution of these 290 surveys by district is also shown in Table 2, with 107 surveys in İnegöl, 95 in Kestel, and 88 in Gürsu.

Since the data obtained from the Bursa Provincial Directorate of Agriculture and Forestry pertain to 2021 and the study was conducted in 2023, updated data were requested from the District Agriculture Directorates and Chambers of Agriculture for İnegöl, Gürsu, and Kestel. Accordingly, the distribution of the number of pear producers and cultivation areas by village in İnegöl district is presented in Table 3.

The distribution of the number of pear producers and cultivation areas by village in Gürsu district is presented in Table 4. Surveys were planned for the four villages with the highest number of pear producers, and the allocation of surveys by village is also provided in Table 4.

The distribution of the number of pear producers and cultivation areas by village in Kestel district is presented in Table 5. Surveys were planned for the four villages with the highest number of pear producers, and the allocation of surveys by village is also shown in Table 5.

Table 2. Proportional distribution (%) of surveys planned for the districts with the highest number of pear producers in Bursa Province.

Districts	Number of pear producers	Percentage of total producers (%)	Planned number of surveys based on percentage	Actual number of surveys conducted
İnegöl	1,086	40.6	103	107
Gürsu	802	30.0	76	88
Kestel	784	29.4	75	95
Total	**2,672**	**100.0**	**254**	**290**

Table 3. Number of pear producers and pear cultivation areas in İnegöl district, Bursa Province.

Village name	Total number of pear producers in the village	Total pear cultivation area in the village (da)	Number of surveys conducted
Deydinler	86	1,026.77	15
Süle	75	1,381.89	13
Akıncılar	64	608,55	11
Kayapınar	58	871.04	10
Edebey	56	625.91	10
İsaören	56	472.98	10
Turgutalp	54	963.55	10
Çeltikçi	53	671.49	10
Yeniceköy	52	604.61	9
Paşaören	45	384.29	9
Other	614	6,240.13	0
Total	**1,213**	**13,851.21**	**107**

Source: İnegöl District Directorate of Agriculture and Forestry 2021.

Table 4. Number of pear producers and pear cultivation areas in Gürsu district.

Village name	Number of pear producers	Cultivation area (da)	Number of surveys conducted
Adaköy	174	4,400	25
Kazıklı	150	3,300	22
Karahıdır	140	3,000	21
Hasanköy	138	2,600	20
Other	602	13,300	0
Total	**1,116**	**22,884**	**88**

Source: Gürsu District Directorate of Agriculture and Forestry 2021.

Table 5. Number of pear producers, cultivation areas, and planned surveys in Kestel district.

Village name	Number of pear producers	Cultivation area (da)	Number of surveys conducted
Serme	179	2,032,507	26
Babasultan	164	1,172,399	24
Barakfakih	162	1,772,407	23
Gölcük	149	1,610,152	22
Other	565	4,465,851	0
Total	**1,219**	**11,053,316**	**95**

Source: Kestel Chamber of Agriculture 2021.

Structural equation modelling

This study investigates the pesticide use behaviors of pear farmers in Bursa, Türkiye's leading pear-producing region, by employing SEM within the framework of the TPB.

SEM is a robust statistical approach that allows for the simultaneous examination of causal and reciprocal relationships among both observed and latent variables. Unlike traditional regression techniques, SEM accounts for measurement errors and interdependencies among constructs, providing a more precise and comprehensive evaluation of theoretical models (Hair et al. 2017). SEM is composed of two key components: the measurement model and the structural model. The measurement model links observed indicators to latent constructs, enabling the estimation of underlying variables. The structural model, on the other hand, assesses the directional relationships among latent variables.

In this study, SEM was utilized to test the following hypotheses (H_1–H_5) concerning the determinants of pesticide use intentions and behaviors among pear farmers within the TPB framework.

Attitude represents an individual's positive or negative evaluation of pesticide use behavior. In agricultural settings, farmers evaluate pesticide use in terms of crop risk, production costs, environmental impacts, and long-term farm sustainability. Studies applying the TPB in pesticide contexts show that more favorable attitudes toward appropriate pesticide use behavior strengthen farmers' pesticide use intentions (Bagheri et al. 2021b; Damalas 2021). Therefore:

H_1: Pear farmers' attitudes influence their pesticide use intentions.

Subjective norms reflect perceived social pressure from peers, extension agents, input suppliers, buyers, and family members. In many agricultural communities, pesticide application practices are shaped by local production culture and peer expectations. Farmers may feel compelled to spray more frequently to meet market standards or to conform to dominant farming practices (Beedell and Rehman 2000; Bagheri et al. 2019). Thus:

H_2: Pear farmers' subjective norms influence their pesticide use intentions.

PBC reflects farmers' perception of their capacity to manage pesticide use behavior given their knowledge, financial resources, pest pressure, and access to available pest-control options. Prior research shows that farmers with greater confidence in their ability to manage pests effectively are more likely to develop stronger pesticide use intentions (Daxini et al. 2019). Accordingly:

H_3: Pear farmers' perceived behavioral control influences their pesticide use intentions.

H_4: Pear farmers' perceived behavioral control influences their pesticide use behaviors.

Within the TPB, behavioral intention is the most immediate predictor of behavior. Farmers with stronger pesticide use intentions are expected to exhibit corresponding pesticide use behavior in their application decisions. However, structural constraints such as pest outbreaks, market requirements, or financial pressures may weaken this relationship. Therefore:

H_5: Pear farmers' intentions regarding pesticide use influence their actual pesticide use behaviors.

Within the SEM framework based on the TPB, factors expected to exert direct or indirect effects on both pesticide use intentions and behaviors were included (Rezaei et al. 2018; Bagheri et al. 2019; Despotović et al. 2019; Farani et al. 2019; Rezaei et al. 2019a, 2019b; Yazdanpanah et al. 2019). First, the intention construct within the TPB framework was calculated using the following formula:

$$I = w_A \cdot A + w_{SN} \cdot SN + w_{PBC} \cdot PBC \quad (7)$$

The calculation of the three basic factors in the formula is as follows:

$$A = \sum_{i=1}^{n} b_i e_i \quad (8)$$

$$SN = \sum_{i=1}^{n} n_i m_i \quad (9)$$

$$PBC = \sum_{i=1}^{n} c_i p_i \quad (10)$$

Behavior is defined by the formula below. The effect of intention and PBC variables on the behavior variable is tested in this way.

$$B = w_i I + w_{PBC} PBC \quad (11)$$

b, n, c represent the strength of each item related to a specific outcome or attribute;

m, p denote the evaluation of the outcome and the corresponding attribute.

B stands for behaviors, I for intentions, A for attitudes, SN for subjective norms, and PBC for perceived behavioral control, w is an empirically derived coefficient, as suggested in prior studies (Ajzen 1991; Ajzen 2002; Damalas 2021; Govindharaj et al. 2021; Lou et al. 2021).

Results

Demographics

The demographic characteristics of 290 pear producers are summarized in Table 6. Most (57.9%) are aged 41–60, showing that production is dominated by middle-aged and older farmers. Education levels are low, with 36.2% primary and only 3.5% university graduates. A majority (74.5%) are covered by Bağ-Kur, while 3.1% lack social security. Households commonly have 3–4 members. Producers average 31.8 years in farming and 30.3 years in pear production, though nearly 60% fall below the average. Farming is the primary occupation for 98.6%, but 27.9% also earn non-agricultural income, mainly pensions or secondary jobs. Cooperative membership reaches 59.3%, mostly in agricultural development cooperatives, while 36.9% participate in associations, largely irrigation-related. Average annual agricultural income is 888,482.8 TL, with 661,620.7 TL from pears, though most earn less. Expenditures average 407,310.3 TL in agriculture and 303,344.8 TL in pear production, again with most below the mean.

Structural equation modelling

SEM was conducted using LISREL 11.2 to validate the measurement model and to test the hypothesized structural relationships.

Measurement model

First, the relationships between the measurement model, the latent variables, and their observed indicators were examined. The results of the measurement model are presented in Table 7. The model was evaluated in terms of reliability and validity. Convergent validity was assessed using Composite Reliability (CR), and Average Variance Extracted (AVE). According to Hair et al. (2017), convergent validity is supported when AVE values exceed 0.55 and CR values exceed 0.70. The results of the measurement model met these criteria (Table 7). As shown in Table 7, all constructs met these thresholds, confirming the adequacy of the measurement model despite some moderate factor loadings. Indicators with loadings slightly below 0.50 were retained due to their theoretical relevance and because construct-level CR and AVE statistics remained within acceptable limits, a practice considered acceptable in exploratory agricultural behavior research (Rezaei et al. 2018; Bagheri et al. 2021a; Lou et al. 2021). Although several observed indicators ex-

Table 6. Demographic characteristics of the pear producers in the study.

Demographic characteristics	n	%	Demographic characteristics	n	%
Age			**Social Security Status**		
22–30 years	10	3.4	Bağkur (self-employed)	216	74.5
31–40 years	60	20.7	SSK (wage earners)	62	21.4
41–50 years	94	32.4	No social security	9	3.1
51–60 years	74	25.5	Pension fund	3	1
61 years and above	52	17.9	Total	290	100
Total	290	100	**Membership in agricultural cooperatives**		
Education Level			Member	172	59.3
Did not complete primary school	6	2	Non member	118	40.7
Primary school graduate	105	36.2	Total	290	100
Secondary school graduate	69	23.8	**Type of cooperative joined**		
High school graduate	100	34.5	Agricultural development	88	51.2
University graduate	10	3.5	Development & Credit	54	31.4
Total	290	100	Credit	30	17.4
Household Size			Total	172	100
1–2 persons	22	7.6	**Membership in agricultural associations**		
3–4 persons	127	43.8	Member	107	36.9
5–6 persons	95	32.8	Non member	183	63.1
7 or more persons	46	15.9	Total	290	100
Total	290	100	**Type of association joined**		
Agricultural Experience (Avg: 31.8 years)			Irrigation only	88	82.2
Avg. & below	162	55.9	Irrigation & sugar beet/fruit	19	17.8
Avg. & above avg.	128	44.1	growers		
Total	290	100	Total	107	100
Pear production experience (Avg: 30.3 years)			**Main occupation**		
Avg. & below	173	59.7	Farmer	286	98.6
Avg. & above avg.	117	40.3	Other	4	1.4
Total	290	100	Total	290	100
Non-agricultural income status			**Sources of non-agricultural income**		
Yes	81	27.9	Pension	39	48.2
No	209	72.1	Rent	2	2.5
Total	290	100	Secondary job	40	49.3
Non-agricultural income level (Avg.: 97,222.2 TL)			Total	81	100
Avg. & below	46	56.8	**Agricultural expenditure (Avg: 407,310.3 TL)**		
Above avg.	35	43.2	Avg. & below	205	70.7
Total	81	100	Above avg.	85	29.3
Agricultural income level (Avg: 888,482.8 TL)			Total	290	100
Avg. & below	190	65.5	**Income from pear production (Avg: 661.620,7 TL)**		
Above avg.	100	34.5	Avg. & below	197	67.9
Total	290	100	Above avg.	93	32.1
Expenditure on pear production (Avg: 303,344.8 TL)			Total	290	100
Avg. & below	202	69.7			
Above avg.	88	30.3			
Total	290	100			

Note: The exchange rate on May 15, 2023, was 1 USD = 19.6386 TRY (Central Bank of the Republic of Türkiye 2025).

hibited factor loadings slightly below the commonly recommended threshold of 0.50 (B1, I2, and PBC1), these items were retained for both theoretical and methodological reasons. First, each of these indicators represents a conceptually important dimension of the respective latent construct. Removing them would have reduced the content validity of the constructs and potentially narrowed their conceptual coverage within the TPB framework. Second, in covariance-based SEM, factor loadings between 0.40 and 0.50 may be considered acceptable when composite reliability (CR) and average variance extracted (AVE) values remain within recommended thresholds (Hair et al. 2017). In the present study, all constructs demonstrated satisfactory CR (> 0.70) and AVE (> 0.50), indicating adequate internal consistency and convergent validity despite moderate individual loadings. Third, given the applied and field-based nature of agricultural behavioral research, slight deviations from ideal loading thresholds are not uncommon due to contextual heterogeneity among farmers. A model refinement procedure was considered. However, removing the lower-loading

Table 7. Outcomes of the measurement model.

Variables of measurement model	Factor loadings	T-values
Pesticide Use Behavior (B) (CR = 0.746 AVE = 0.610)		
B1. I use pesticides frequently and in large quantities when cultivating pears.	0.46	2.70
B2. Regardless of their hazard level, I must use the most effective pesticides available on the market when cultivating pears.	0.61	2.77
Pesticide Use Intention (I) (CR = 0.728 AVE = 0.576)		
I1. I would prefer to cultivate pears using smaller quantities of pesticides.	0.69	2.43
I2. I would prefer to cultivate pears using less hazardous pesticides that cause the least harm to nature.	0.43	2.10
Attitudes (A) (CR = 0.955 AVE = 0.877)		
A1. I feel guilty when I use more pesticides than necessary.	0.88	18.93
A2. I feel a moral obligation regarding the overuse of pesticides nowadays.	0.92	20.18
A3. I feel a moral obligation regarding the overuse of pesticides for the sake of future generations.	0.94	21
Subjective Norms (SN) (CR = 0.883 AVE = 0.716)		
SN1. Farmers around me try to use fewer pesticides.	0.89	16.12
SN2. Farmers around me think that I should reduce my pesticide use.	0. 89	16.11
SN3. I care about the opinions of farmers around me regarding excessive pesticide use.	0.51	8.84
Perceived Behavioral Control (PBC) (CR = 0.779 AVE = 0.544)		
PBC1. I believe I can reduce my pesticide use in pears if I want to.	0.41	5.97
PBC2. I have sufficient knowledge and skills to use fewer pesticides.	0.88	9.62
PBC3. I can manage to use exactly the amount of pesticide that the pears need (neither more nor less).	0.53	7.25

References: Bagheri et al. 2021a, 2021b; Sarma 2022.

indicators did not substantially improve model fit indices or construct reliability, and therefore the theoretically grounded measurement structure was retained. Together, these findings provide strong evidence that the measurement model possesses acceptable convergent and discriminant validity, supporting the robustness of the SEM results.

Structural model

Following the assessment of the measurement model, the analysis proceeded to the structural model to examine the pesticide use behavior of pear producers. In the structural model, the latent variables behavior and intention were treated as endogenous constructs, while attitudes, SN, and PBC were considered exogenous constructs. Initially, the observed indicators corresponding to the exogenous latent variables were entered into the path diagram and linked to their respective latent constructs. Subsequently, the endogenous latent variables were added, and unidirectional paths were specified to establish the hypothesized relationships. According to the TPB, attitudes, subjective norms, and PBC are expected to influence intention, which in turn affects behavior. In addition to the effect of PBC on intention, its direct effect on behavior was also tested. The structural model was therefore specified in accordance with these theoretical expectations. The overall model fit was first assessed using goodness-of-fit indices to determine its adequacy (Table 8). As shown in Table 8, the structural model demonstrated acceptable fit according to multiple indices, including CFI, GFI, NFI, RMSEA, and RMR. Moreover, other fit statistics also supported the model's adequacy ($\chi^2 = 88.55$, df = 57, p = 0.00469, $\chi^2/df = 1.6$).

After establishing the adequacy of the model based on goodness-of-fit indices, the detailed results of the structural model are presented. Table 9 summarizes the significance of the relationships among latent variables and the corresponding hypotheses for pesticide use behavior among pear producers. Variables were considered significant if the p-value was below 0.05 and the t-value exceeded 2.0. Key findings from Table 9 can be summarized as follows:

Table 8. Goodness-of-fit indices for the structural model.

Fit Index	Value	Recommended Threshold	Interpretation
CFI	0.97	≥ 0.95	Excellent fit
GFI	0.95	≥ 0.95	Excellent fit
NFI	0.93	≥ 0.90	Acceptable fit
IFI	0.97	≥ 0.95	Excellent fit
RMSEA	0.04	≤ 0.05	Excellent fit
RMR	0.05	≤ 0.05	Excellent fit

Note: CFI = Comparative Fit Index; GFI = Goodness-of-Fit Index; NFI = Normed Fit Index; IFI = Incremental Fit Index; RMSEA = Root Mean Square Error of Approximation; RMR = Root Mean Square Residual. Values indicate the overall adequacy of the structural model.

Subjective norms significantly influenced pear producers' pesticide use intention ($t = 3.53$, $p < 0.001$) with a negative path coefficient, indicating that perceived social pressure may weaken farmers' pesticide use intentions. Perceived behavioral control (PBC) had a significant positive effect on pesticide use intention ($t = 2.022$, $p = 0.044$), suggesting that farmers who perceive greater control over their actions are more willing to adopt appropriate pesticide use behavior. Attitudes toward pesticide use were not significantly associated with intention, indicating that current attitudes of pear producers do not translate into pesticide use intentions. PBC did not have a significant direct effect on pesticide use behavior, and pesticide use intention likewise did not translate into observable changes in pesticide use behavior, revealing a clear intention–behavior gap.

Table 9. Structural model results.

Hypothesis	Regression path	Path coefficient	t-statistics	p-Value	Interpretation
H_1	A --> I	-0.031	0.516	0.606	Not supported
H_2	SN --> I	-0.183	3.53	0.000*	Supported
H_3	PBC --> I	0.183	2.022	0.044**	Supported
H_4	PBC --> B	-0.135	1.787	0.075	Not supported
H_5	I --> B	0.031	0.405	0.686	Not supported

Note: Significance levels are indicated as follows: *p < 0.01, ** p < 0.05. Variables with t-values greater than 2.0 and p-values below 0.05 are considered statistically significant.

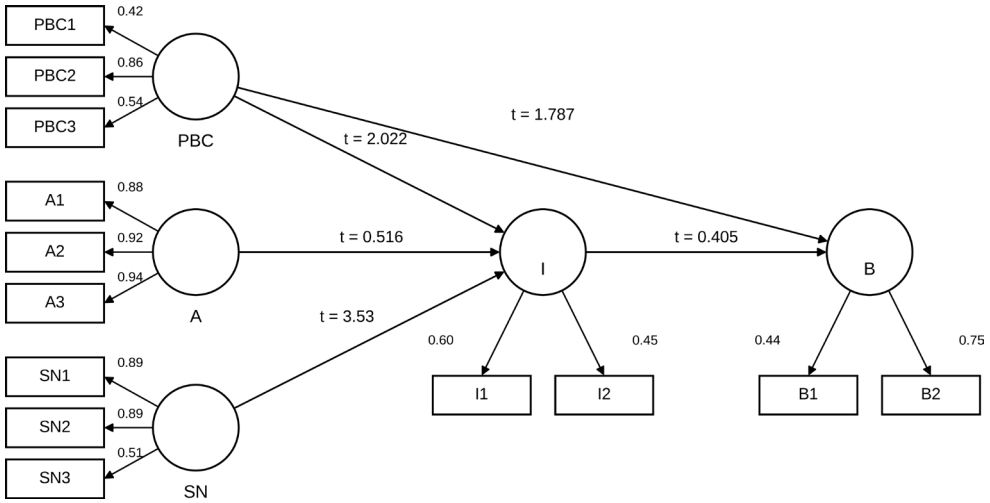


Figure 3. Visual results of SEM.

These findings suggest that, while social norms and perceived control play a role in shaping intentions, the translation of intentions into actual behavioral change is limited among pear producers. This highlights a potential intention-behavior gap in pesticide management practices, which may be influenced by structural, informational, or contextual constraints.

The visual representation of the estimated SEM is presented in Fig. 3. The path coefficients among latent variables, reported in Table 9, are depicted schematically. Additionally, the factor loadings of the observed indicators that define the latent constructs, as reported in Table 7, are also illustrated in the diagram.

Discussion

This study situates its findings within the literature by comparing results with four key TPB-based studies (Bagheri et al. 2019; Damalas 2021; Govindharaj et al. 2021; Wang et al. 2018). Bagheri et al. (2019) extended the TPB with additional contextual factors and found that subjective norms and perceived behavioral control (PBC) strongly influenced pesticide-use intentions. Damalas (2021) incorporated risk perception, showing that subjective norms, PBC, and attitudes significantly shaped intentions, which were central to pesticide reduction. Similarly, Govindharaj et al. (2021) highlighted the influence of subjective norms and PBC among rice farmers, while attitudes were mediated by socio-economic and environmental conditions. Wang et al. (2018) confirmed the relevance of attitudes, subjective norms, and PBC as determinants of pesticide application in China.

The present study on pear producers reveals patterns both consistent with and divergent from previous research. In line with earlier findings, subjective norms and perceived behavioral control significantly influenced pesticide use intention, underscoring the importance of social expectations and farmers' perceived capacity to manage pesticide use behavior. An unexpected result, however, is the negative effect of subjective norms on pesticide use intention. Within the framework of the Theory of Planned Behavior, subjective norms are typically expected to strengthen behavioral intention by reflecting perceived social approval. In agricultural production systems characterized by strong performance expectations and risk aversion, however, social pressure may operate in the opposite direction.

In the pear-producing regions of Bursa, farmers are embedded in tightly connected local production networks where yield stability, visual crop quality, and market acceptance are highly valued. Peer farmers, input suppliers, and local traders often emphasize preventing pest-related losses, which may implicitly encourage intensive pesticide use behavior. Under such conditions, subjective norms may reinforce conventional spraying practices rather than encourage change, especially when farmers perceive that deviating from established practices could result in lower yields, reputational risk, or economic loss. This pattern is consistent with agricultural sociology research showing that production culture and peer influence can sustain high-input practices even when farmers are personally motivated to adopt more responsible pesticide use behavior. Farmers may

experience normative pressure not only from neighbors and family members but also from market intermediaries, pesticide retailers, and extension agents who prioritize crop appearance and short-term productivity. The negative coefficient may also reflect farmers' perceived responsibility for maintaining family income and farm continuity, suggesting that subjective norms may align with economic survival rather than environmental sustainability.

While subjective norms and PBC influenced pesticide use intention, attitudes were not a significant predictor, contrasting with some earlier studies. Moreover, pesticide use intention did not translate into pesticide use behavior, revealing a clear intention–behavior gap. Within the Theory of Planned Behavior, such gaps often emerge when structural constraints limit individuals' ability to act on their intentions.

Several contextual factors may explain this discrepancy in Bursa's pear-growing systems. First, market dependency plays a critical role. Farmers frequently operate under contracts or informal agreements that prioritize visual crop quality and yield stability, encouraging intensive pesticide use behavior to secure market access. Second, pest risk uncertainty discourages changes in pesticide use behavior, as unpredictable outbreaks lead farmers to rely on preventive spraying. Third, extension and advisory services may be insufficient or inconsistent, leaving farmers without practical guidance for alternative pest-management strategies. Fourth, input supplier influence is substantial, since pesticide retailers often serve as primary information sources and may emphasize product use rather than integrated pest management. Fifth, economic pressures including rising input costs, price volatility, and limited insurance coverage encourage risk-averse pesticide use behavior. Finally, regulatory enforcement gaps may weaken incentives for behavioral change when monitoring and penalties are inconsistent.

Taken together, these structural constraints explain why pesticide use intention does not automatically translate into pesticide use behavior. Effective policy interventions should therefore go beyond awareness campaigns and address systemic barriers by strengthening extension services, improving pest monitoring systems, regulating input advisory practices, supporting market incentives aligned with recommended pesticide use behavior, and enhancing enforcement mechanisms.

Overall, the results reaffirm the central role of subjective norms and PBC in shaping farmers' intentions while highlighting two critical nuances: the limited role of attitudes in this context and the disjunction between intentions and behavior. These findings contribute to TPB-based agricultural research by emphasizing the need to examine contextual factors that may hinder the realization of intended sustainable practices.

Conclusions

This study modeled pear farmers' pesticide use behavior in Bursa, one of Türkiye's leading production regions, using the Theory of Planned Behavior framework. The results indicate that, despite extensive farming experience, farmers rely heavily on pesticides, often applying them preventively and with limited attention to safety and environmental risks. Improper disposal practices further highlight important public health and ecological concerns.

The structural model revealed that subjective norms negatively influence farmers' pesticide use intention, suggesting that social pressure within farming communities may reinforce conventional high-input pesticide use behavior rather than more responsible practices. Peer expectations, market quality standards, and the perceived responsibility to secure farm income appear to discourage deviation from intensive spraying regimes. Perceived behavioral control, on the other hand, positively affected pesticide use intention, indicating that farmers who feel capable of managing pest risks are more willing to adjust their pesticide use behavior. However, pesticide use intention rarely translated into pesticide use behavior, revealing a clear intention–behavior gap. Farmers' attitudes were not significant predictors of intention, underscoring the importance of structural and social constraints in pesticide-related decision making.

The observed gap between pesticide use intention and pesticide use behavior suggests that changing pesticide practices requires addressing systemic barriers rather than relying solely on individual awareness. Market dependency on cosmetically perfect produce, uncertainty about pest outbreaks, limited access to effective extension services, strong influence from input suppliers, economic pressures, and gaps in regulatory enforcement all constrain farmers' ability to act on their intentions. Policies aimed solely at raising awareness are therefore unlikely to be sufficient.

More concrete policy measures are needed. First, community-based extension programs, demonstration orchards, and farmer field schools can help reshape social norms by visibly demonstrating successful low-pesticide practices. Second, strengthening pest monitoring systems and providing localized IPM decision-support tools can reduce uncertainty and improve farmers' perceived behavioral control. Third, market incentives such as price premiums, certification schemes for low-residue produce, and public procurement standards can align economic rewards with safer practices. Fourth, improved oversight and training for input suppliers can ensure balanced advisory services that promote integrated pest management rather than routine pesticide use. Finally, targeted subsidies, crop insurance mechanisms, and consistent residue monitoring and enforcement can reduce financial risks and reinforce behavioral change.

This study should be interpreted in light of certain limitations related to sampling and external validity. The empirical analysis is based primarily on small and medium-scale pear producers located in İnegöl, Gürsu, and Kestel districts of Bursa. Although these districts represent the dominant production structure in the region, large-scale commercial farms, particularly those concentrated in districts such as Karacabey, were not included due to structural differences in production organization and market integration. Therefore, the findings are most

appropriately generalized to small and medium-scale pear farmers in Bursa Province and similar agricultural contexts. Future research should compare behavioral determinants across different farm-size categories and examine how institutional and market conditions shape pesticide-related decision making.

Overall, the study demonstrates that changing pesticide use behavior requires more than individual awareness. It requires coordinated interventions that reshape social norms, reduce economic and informational barriers, and align market and policy incentives with recommended pesticide use practices.

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References

Ajzen I (1991) The theory of planned behavior. Organizational Behavior and Human Decision Processes 50(2): 179–211. https://doi.org/10.1016/0749-5978(91)90020-t

Ajzen I (2002) Perceived behavioral control, self–efficacy, locus of control, and the theory of planned behavior 1. Journal of Applied Social Psychology 32(4): 665–683. https://doi.org/10.1111/j.1559-1816.2002.tb00236.x

Aliabadi V, Gholamrezai S, Ataei P (2020) Rural people's intention to adopt sustainable water management by rainwater harvesting practices: application of TPB and HBM models. Water Supply 20(5): 1847–1861. https://doi.org/10.2166/ws.2020.094

Asante IK, Ocran JK, Inkoom EW (2023) Modeling pesticide use behavior among farmers in the Upper East Region of Ghana: An empirical application of the Theory of Planned Behavior. Environmental Protection Research 130–149. https://doi.org/10.37256/epr.3120232074

Bagheri A, Bondori A, Allahyari MS, Damalas CA (2019) Modeling farmers' intention to use pesticides: An expanded version of the theory of planned behavior. Journal of Environmental Management 248: 109291. https://doi.org/10.1016/j.jenvman.2019.109291

Bagheri A, Emami N, Damalas CA (2021a) Farmers' behavior in reading and using risk information displayed on pesticide labels: a test with the theory of planned behavior. Pest Management Science 77(6): 2903–2913. https://doi.org/10.1002/ps.6326

Bagheri A, Emami N, Damalas CA (2021b) Farmers' behavior towards safe pesticide handling: An analysis with the theory of planned behavior. Science of the Total Environment 751: 141709. https://doi.org/10.1016/j.scitotenv.2020.141709

Bamberg S, Möser G (2007) Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. Journal of Environmental Psychology 27(1): 14–25. https://doi.org/10.1016/j.jenvp.2006.12.002

Batbay Ö, Kahramanoğlu İ (2024) Using theory of planned behaviour to understand and manage the factors affecting farmers' intention in pesticide use. Cleaner and Circular Bioeconomy 9: 100126. https://doi.org/10.1016/j.clcb.2024.100126

Bayraktar A, Boz İ (2020) Attitudes and behaviours of farmers in using of pesticides in Çarşamba district of Samsun. Turkish Journal of Agriculture-Food Science and Technology 8(2): 392–398.

Beedell J, Rehman T (2000) Using social-psychology models to understand farmers' conservation behaviour. Journal of Rural Studies 16(1): 117–127. https://doi.org/10.1016/s0743-0167(99)00043-1

Bhandari G, Pandey A, Sapkota U, Singh SP, Murano H (2025) Pesticide use and safety behavior among rice farmers in Nepal: The assessment of theory of planned behavior and potential health risk: G. Bhandari et al. Environment, Development and Sustainability, 1–30. https://doi.org/10.1007/s10668-025-06385-z

Bursa Provincial Directorate of Agriculture and Forestry (2021) Official statistics.

Central Bank of the Republic of Türkiye (2025) Indicative exchange rates of the Central Bank. Retrieved August 19: 2025. https://www.tcmb.gov.tr/wps/wcm/connect/TR/TCMB+TR/Main+Menu/Istatistikler/Doviz+Kurlari/Gosterge+Niteligindeki+Merkez+Bankasi+Kurlarii/

Chan FT, Chen TY, Mak IK, Yu YT (1996) Proportional sampling strategy: guidelines for software testing practitioners. Information and Software Technology 38(12): 775–782. https://doi.org/10.1016/0950-5849(96)01103-2

Chan LL, Idris N (2017) Validity and reliability of the instrument using exploratory factor analysis and Cronbach's alpha. International Journal of Academic Research in Business and Social Sciences 7(10): 400–410. https://doi.org/10.6007/ijarbss/v7-i10/3387

Chen TY, Tse TH, Yu YT (2001) Proportional sampling strategy: A compendium and some insights. Journal of Systems and Software 58(1): 65–81. https://doi.org/10.1016/s0164-1212(01)00028-0

Cortina JM (1993) What is coefficient alpha? An examination of theory and applications. Journal of Applied Psychology 78(1): 98. https://doi.org/10.1037//0021-9010.78.1.98

Damalas CA (2021) Farmers' intention to reduce pesticide use: The role of perceived risk of loss in the model of the planned behavior theory. Environmental Science and Pollution Research 28(26): 35278–35285. https://doi.org/10.1007/s11356-021-13183-3

Damalas CA, Georgiou EB, Theodorou MG (2006) Pesticide use and safety practices among Greek tobacco farmers: a survey. International Journal of Environmental Health Research 16(5): 339–348. https://doi.org/10.1080/09603120600869190

Daxini A, Ryan M, O'Donoghue C, Barnes AP (2019) Understanding farmers' intentions to follow a nutrient management plan using the theory of planned behaviour. Land Use Policy 85: 428–437. https://doi.org/10.1016/j.landusepol.2019.04.002

Despotović J, Rodić V, Caracciolo F (2019) Factors affecting farmers' adoption of integrated pest management in Serbia: An application of the theory of planned behavior. Journal of Cleaner Production 228: 1196–1205. https://doi.org/10.1016/j.jclepro.2019.04.149

Erdil M, Tiryaki O (2020) Manisa İli'nde çiftçilerin tarım ilaçları kullanımı konusundaki bilinç düzeyi ve duyarlılıklarının araştırılması. Çanakkale Onsekiz Mart Üniversitesi Fen Bilimleri Enstitüsü Dergisi 6(1): 81–92. https://doi.org/10.28979/comufbed.650582

FAOSTAT (2025) Retrieved August 10: 2025. https://www.fao.org/faostat/en/#data/QCL

Farani A, Mohammadi Y, Ghahremani F (2019) Modeling farmers' responsible environmental attitude and behaviour: A case from Iran. Environmental Science and Pollution Research 26(27): 28146–28161. https://doi.org/10.1007/s11356-019-06040-x

Fianko JR, Donkor A, Lowor ST, Yeboah PO (2011) Agrochemicals and the Ghanaian environment, a review. Journal of Environmental Protection 2(3): 221–230. https://doi.org/10.4236/jep.2011.23026

Fishbein M, Ajzen I (2011) Predicting and Changing Behavior: The Reasoned Action Approach. Psychology press, 1st edn., 538 pp. https://doi.org/10.4324/9780203838020

FAO [Food and Agriculture Organization of the United Nations] (2022a) The World Food System: Sustained Improvement in Food Availability. Retrieved February 01: 2022. https://www.fao.org/3/y4683e/y4683e06.htm

FAO [Food and Agriculture Organization of the United Nations] (2022b) Pest and Pesticide Management. Retrieved February 05: 2022. https://www.fao.org/pest-and-pesticide-management/en/

FAO [Food and Agriculture Organization of the United Nations] (2022c) Turkey Profile.

Gholamrezai S, Aliabadi V, Ataei P (2021) Understanding the pro-environmental behavior among green poultry farmers: Application of behavioral theories. Environment, Development and Sustainability 23(11): 16100–16118. https://doi.org/10.1007/s10668-021-01331-1

Gill HK, Garg H (2014) Pesticide: environmental impacts and management strategies. Pesticides-Toxic Aspects 8(187): 10–5772.

Govindharaj GPP, Gowda B, Sendhil R, Adak T, Raghu S, Patil N, Mahendiran A, Rath PC, Kumar G, Damalas CA (2021) Determinants of rice farmers' intention to use pesticides in eastern India: Application of an extended version of the planned behavior theory. Sustainable Production and Consumption 26: 814–823. https://doi.org/10.1016/j.spc.2020.12.036

Gowda B, Sendhil R, Adak T, Raghu S, Patil N, Mahendiran A, Rath PC, Kumar GAK, Damalas CA (2021) Determinants of rice farmers' intention to use pesticides in eastern India: Application of an extended version of the planned behavior theory. Sustainable Production and Consumption 26: 814–823. https://doi.org/10.1016/j.spc.2020.12.036

Gürsu District Directorate of Agriculture and Forestry (2021) Official statistics.

Hair Jr JF, Babin BJ, Krey N (2017) Covariance-based structural equation modeling in the Journal of Advertising: Review and recommendations. Journal of Advertising 46(1): 163–177. https://doi.org/10.1080/00913367.2017.1281777

İnegöl District Directorate of Agriculture and Forestry (2021) Official statistics.

Isin S, Yildirim I (2007) Fruit-growers' perceptions on the harmful effects of pesticides and their reflection on practices: the case of Kemalpasa, Turkey. Crop Protection 26(7): 917–922. https://doi.org/10.1016/j.cropro.2006.08.006

Kestel Chamber of Agriculture (2021) Official statistics.

Khan FZA, Manzoor SA, Akmal M, Imran MU, Taqi M, Manzoor SA, Lukac M, Gul HT, Joseph SV (2021) Modeling pesticide use intention in Pakistani farmers using expanded versions of the theory of planned behavior. Human and Ecological Risk Assessment: An International Journal 27(3): 687–707. https://doi.org/10.1080/10807039.2020.1750345

Lou S, Zhang B, Zhang D (2021) Foresight from the hometown of green tea in China: Tea farmers' adoption of pro-green control technology for tea plant pests. Journal of Cleaner Production 320: 128817. https://doi.org/10.1016/j.jclepro.2021.128817

Mahdavi T (2021) Application of the 'theory of planned behavior'to understand farmers' intentions to accept water policy options using structural equation modeling. Water Supply 21(6): 2720–2734. https://doi.org/10.2166/ws.2021.138

Ministry of Agriculture and Forestry (2022a) Official Pesticide Statistics. Retrieved February 01: 2022. https://www.tarimorman.gov.tr/GKGM/Menu/115/Resmi-Tarimsal-Ilac-Istatistikleri

Ministry of Agriculture and Forestry (2022b) Bursa Provincial Directorate of Agriculture and Forestry, Farmer Registration System Data.

Ntow WJ, Gijzen HJ, Kelderman P, Drechsel P (2006) Farmer perceptions and pesticide use practices in vegetable production in Ghana. Pest Management Science: Formerly Pesticide Science 62(4): 356–365. https://doi.org/10.1002/ps.1178

Özkan B, Akçaöz HV, Karadeniz CF (2016) Antalya İlinde Turunçgil Üretiminde Tarımsal İlaç Kullanımına Yönelik Üretici Tutum ve Davranışları. Anadolu Ege Tarımsal Araştırma Enstitüsü Dergisi 13: 2.

Pan Y, Ren Y, Luning PA (2021) Factors influencing Chinese farmers' proper pesticide application in agricultural products–A review. Food Control 122: 107788. https://doi.org/10.1016/j.foodcont.2020.107788

Pirmoghni A, Shahmoradi B, Taymoori P, Bagheri A, Nasrollahi P, Karimi Z, Mohammadiane F, Emami N, Choi HJ (2024) Application of the theory of planned behavior to model the intention and behavior of tomato growers in pesticide exposure. Heliyon 10(15): e35794. https://doi.org/10.1016/j.heliyon.2024.e35794

Rajeh MT (2022) Modeling the theory of planned behavior to predict adults' intentions to improve oral health behaviors. BMC Public Health 22(1): 1391. https://doi.org/10.1186/s12889-022-13796-4

RASFF [Rapid Alert System for Food and Feed] (2020) The Rapid Alert System for Food and Feed Annual Report 2020. Retrieved February 11: 2022. https://ec.europa.eu/food/system/files/2021-08/rasff_pub_annual-report_2020.pdf

Rezaei R, Mianaji S, Ganjloo A (2018) Factors affecting farmers' intention to engage in on-farm food safety practices in Iran: Extending the theory of planned behavior. Journal of Rural Studies 60: 152–166. https://doi.org/10.1016/j.jrurstud.2018.04.005

Rezaei R, Safa L, Damalas CA, Ganjkhanloo MM (2019a) Drivers of farmers' intention to use integrated pest management: integrating theory of planned behavior and norm activation model. Journal of Environmental Management 236: 328–339. https://doi.org/10.1016/j.jenvman.2019.01.097

Rezaei R, Seidi M, Karbasioun M (2019b) Pesticide exposure reduction: extending the theory of planned behavior to understand Iranian farmers' intention to apply personal protective equipment. Safety Science 120: 527–537. https://doi.org/10.1016/j.ssci.2019.07.044

Ritter NL (2010) Understanding a widely misunderstood statistic: Cronbach's. Online Submission.

Sapkota U, Adhikari S, Bhandari G (2025) Farmers' behavioral intention towards pesticide safety in Nepal: An assessment of the extended theory of planned behavior. Journal of Environmental Management 389: 126185. https://doi.org/10.1016/j.jenvman.2025.126185

Sarma PK (2022) Farmer behavior towards pesticide use for reduction production risk: A Theory of Planned Behavior. Cleaner and Circular Bioeconomy 1: 100002. https://doi.org/10.1016/j.clcb.2021.100002

Sharifzadeh MS, Abdollahzadeh G, Damalas CA (2025) Farmers' behaviour in the use of integrated pest management (IPM) practices: perspectives through the social practice theory. International Journal of Pest Management 71(3): 406–419. https://doi.org/10.1080/09670874.2023.2227607

Shirahada K, Zhang Y (2022) Counterproductive knowledge behavior in volunteer work: perspectives from the theory of planned behavior and well-being theory. Journal of Knowledge Management 26(11): 22–41. https://doi.org/10.1108/jkm-08-2021-0612

Sok J, Bakker L, van der Werf W, Bianchi F (2024) Not the average farmer: Heterogeneity in Dutch arable farmers' intentions to reduce pesticide use. Environmental Science & Policy 162: 103893. https://doi.org/10.1016/j.envsci.2024.103893

Sookhtanlou M, Khoshnodifar Z (2025) Factors Predicting Tomato Farmers' Safety Behavior in Iran: Presenting an Integrated Model (Theory of Planned Behavior and Health Belief Model). International Journal of Agricultural Management and Development 15: 1.

Tariq MI, Afzal S, Hussain I, Sultana N (2007) Pesticides exposure in Pakistan: a review. Environment İnternational 33(8): 1107–1122. https://doi.org/10.1016/j.envint.2007.07.012

Tiryaki O, Akar Ö (2018) Antalya ili'nde üreticilerin pestisit kullanımı konusunda bilgi düzeyi ve duyarlılıklarının araştırılması. Ziraat Fakültesi Dergisi 13(1): 53–70.

Tudi M, Li H, Li H, Wang L, Lyu J, Yang L, Tong S, Yu QJ, Ruan HD, Atabila A, Phung DT, Sadler R, Connell D (2022) Exposure routes and health risks associated with pesticide application. Toxics 10(6): 335. https://doi.org/10.3390/toxics10060335

TURKSTAT [Turkish Statistical Institute] (2025) Crop Production Statistics. [Retrieved August 18, 2025] https://www.tuik.gov.tr/

Uikey AA, Mishra D, Marak ZR, Saraswat P (2025) Pesticide knowledge and farmers' safety behaviours: insights from the theory of planned behaviour. Sustainable Futures 10: 101079. https://doi.org/10.1016/j.sftr.2025.101079

UN [United Nations] (2022) World Population Day. Retrieved February 11: 2022. https://www.un.org/en/observances/world-population-day https://doi.org/10.18356/9789210014380

USDA [United States Department of Agriculture] (2022) Retrieved February 11: 2022. https://www.ars.usda.gov/oc/timeline/green/

Wang C, Liu W (2021) Farmers' attitudes vs. government supervision: which one has a more significant impact on farmers' pesticide use in China?. International Journal of Agricultural Sustainability 19(2): 213–226. https://doi.org/10.1080/14735903.2021.1901465

Wang J, Chu M, Deng YY, Lam H, Tang J (2018) Determinants of pesticide application: an empirical analysis with theory of planned behaviour. China Agricultural Economic Review 10(4): 608–625. https://doi.org/10.1108/caer-02-2017-0030

Williamson S, Ball A, Pretty J (2008) Trends in pesticide use and drivers for safer pest management in four African countries. Crop protection 27(10): 1327–1334. https://doi.org/10.1016/j.cropro.2008.04.006

WHO [World Health Organization] (2022) Chemical Safety and Health. Retrieved March 14: 2022. https://www.who.int/teams/environment-climate-change-and-health/chemical-safety-and-health/health-impacts/chemicals/pesticides

Yazdanpanah M, Feyzabad FR, Abbaszadeh K (2019) Factors affecting avoiding the use of pesticides to greenhouse vegetables in Bandar Abbas District (Iran). International Journal of Agricultural Management and Development (IJAMAD) 9(3): 237–247.

Additional information

Conflict of interest
The authors have declared that no competing interests exist.

Ethical statement
Ethical approval for this study was obtained from the Scientific Research Ethics Committee of the Graduate School of Çanakkale Onsekiz Mart University on February 17, 2022 (Decision No: 04/04).

Artificial Intelligence (AI) use
The authors accept full responsibility for the content of the manuscript, including the disclosure of any use of AI.
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Data availability
The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Supplementary material

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Supplementary material 2
Ethical approval (.pdf file)
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