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Research Article

A behavioral model of greenhouse owners in healthy crop production: The case of Kerman province

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ABSTRACT- Increasing agricultural production in greenhouses is vital to meet the demands of a growing global population. However, this expansion is often accompanied by environmental challenges and product contamination resulting from the excessive use of agricultural inputs. In response, there is a growing global interest in greenhouse products with lower contamination and improved health attributes. This study aims to examine the psychological factors influencing Iranian agricultural greenhouse owners' intentions to produce healthy products, using the Theory of Planned Behavior (TPB) as the analytical framework. Data were collected using a structured questionnaire, which was validated for content, structural, and discriminant validity, and assessed for composite reliability. Hypothesis testing was conducted using SmartPLS 3 software. The findings revealed that while greenhouse owners expressed positive intentions and a sense of responsibility toward healthy production, actual implementation remained limited. The psychological constructs assessed in the model accounted for 44% of the variance in owners' intentions to produce healthy products. These results suggest that fostering sustainable behavior requires enhancing intrinsic motivation and strengthening behavioral intentions. Accordingly, policies and educational programs should prioritize strategies that reinforce the commitment of greenhouse owners to healthy and sustainable production practices. The insights gained from this study can inform policymakers, agricultural extension agents, and researchers seeking to promote more sustainable agricultural systems.

INTRODUCTION

Increasing food production while minimizing environmental pollution has become a global priority, especially in light of concerns over environmental protection and human health (Radulescu et al., 2021). A major public health concern across both developed and developing countries is the rise in foodborne illnesses, which occur daily and are often linked to agricultural products (Rezaei et al., 2018). According to the World Health Organization, millions of people die each year from foodborne diseases caused by microbiological contamination in food and water (WHO, 2014). Agricultural products—particularly fresh fruits and vegetables—are widely recognized as primary sources of foodborne disease outbreaks. Over the past decade, the incidence of such illnesses has risen significantly (Tobin et al., 2013; Marine et al., 2016; Rezaei et al., 2018). Despite these risks, agricultural products are essential for maintaining a balanced and nutritious diet (Losio et al., 2015). Within this context, the role of greenhouse production has become increasingly important. Driven by government support, policy initiatives, and favorable climatic conditions, greenhouse cultivation has expanded significantly in recent years, with estimates placing the area under cultivation at approximately 23,000 hectares in Iran (Iran's Ministry of Agriculture Jihad, 2022). However, this growth has also brought a range of environmental challenges. Greenhouse products are particularly susceptible to contamination due to the intensive use of fertilizers, chemical pesticides, and irrigation with polluted wastewater (Rezaei et al., 2018; Li et al., 2020). Several studies have reported that concentrations of heavy metals such as zinc, copper, lead, and cadmium in Iranian greenhouse products often exceed the safety thresholds set by the World Health Organization (Baghaie & Keshavarzi, 2019; Nazemi et al., 2010). Such chemical contamination poses serious health risks, including neurological and hematological disorders, cancer, genetic mutations, hormonal imbalances, and infertility (Jahaed Khaniki et al., 2011). To mitigate these threats and address growing public concern, it is essential to ensure food safety across the entire farm-to-fork chain (De Sousa et al., 2020). In this light, the global movement toward the production and consumption of healthy and organic products has gained momentum over the last two decades, extending to environmental, economic, social, and ethical dimensions (Issa & Hamm, 2017; Radulescu et al., 2021). As prevention is the most effective approach to managing

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food safety, interventions must begin at the farm level. Implementing sound agricultural practices can significantly reduce the risk of contamination (Nayak et al., 2015; Rezaei et al., 2018). In recent years, a number of institutions have developed guidelines promoting good agricultural practices (GAPs) covering aspects such as water, soil, fertilizer, pesticide use, facilities, and personnel management (Razikordmahaleh et al., 2018; Rezaei et al., 2018). Nevertheless, the adoption and effectiveness of these food safety programs remain inconsistent. Several studies have raised concerns about their limited acceptance and practical impact among producers (Parker et al., 2012; Nayak et al., 2015). Hollyer et al. (2009) suggest that internal processes within farmers, such as personal motivation, awareness, and ethical commitment, are critical for reducing contamination at the source. Encouraging environmentally responsible behaviors among agricultural producers can thus play a pivotal role in mitigating food safety risks (Razikordmahaleh et al., 2018). Since these behaviors are deeply tied to individual values and decision-making processes, it is essential to understand the psychological and cognitive factors that influence environmentally relevant practices (Onwezen et al., 2013). A growing body of literature identifies a variety of determinants shaping farmers' environmental behavior, including attitudes, perceived behavioral control, social norms, awareness of consequences, responsibility perceptions, and personal values (Shaw et al., 2015). Building on this foundation, the present study aims to expand our understanding of the environmental behavior intentions of agricultural producers, specifically greenhouse owners, with respect to the production of healthy food. By identifying the key psychological drivers behind these decisions, the study contributes valuable insights for designing more effective interventions, policies, and educational programs.

Several theories and models have been proposed to examine behavioral intentions, with Ajzen's Theory of Planned Behavior (TPB) (1991) being one of the most widely applied (Rezaei et al., 2018). This theory is an extension of the Theory of Reasoned Action, developed by Fishbein and Ajzen in 1975 (Tikir & Lehmann, 2011). The TPB offers a comprehensive framework for understanding intentional actions, particularly in the context of environmental behavior (Haji et al., 2021), and has proven effective across diverse settings (Haji et al., 2024). A meta-analytic review found that nearly 40% of published studies in environmental psychology employ TPB as their foundational framework (Haji & Valizadeh, 2024). The theory explains behavior by considering the interplay of attitudes, subjective norms, and perceived behavioral control, which collectively influence behavioral intention—a central construct that has consistently been a strong predictor of actual behavior (Rezaei et al., 2018; Zemore & Ajzen, 2014). TPB is widely regarded as a useful and reliable tool for predicting behavioral intentions and understanding the motivations behind them (Savari & Gharechaee, 2020). Despite its broad applicability and success, TPB continues to evolve (Ateş, 2020). Researchers have adapted the theory to specific audiences and objectives (Azadi et al., 2019; Savari & Gharechaee, 2020). Ajzen (2005) has emphasized that incorporating new variables and structural relationships can enhance the model's explanatory power. Scholars across various disciplines also argue for expanding the theory to improve its predictive and interpretive capacity (Yazdanpanah et al., 2015; Ding et al., 2018). Consequently, many have proposed additional constructs not originally included in TPB to refine its accuracy (Yazdanpanah et al., 2015; Ding et al., 2018; Savari et al., 2021). In line with this evolving approach, the present study incorporates four new constructs into the TPB framework: awareness of consequences, ascription of responsibility, biospheric values, and altruistic values.

According to the TPB, behavioral intention is a key determinant of actual behavior, shaped through both voluntary and involuntary processes (Han, 2021). In this study, behavioral intention is considered as the most influential factor in determining the production of healthy agricultural products (Qasim et al., 2019). Several empirical studies have investigated the relationship between intention and farmers' behaviors (Lubran, 2010; Hsu et al., 2016; Lim et al., 2016; Rezaei et al., 2018; Kim, 2019). Hypothesis 1 (H1): Intention has a positive correlation with the behavior of greenhouse farmers toward producing healthy products. Attitude refers to an individual's overall evaluation—positive or negative—of engaging in a specific behavior. A favorable attitude increases the likelihood of performing that behavior (Rezaei et al., 2018). In this study, attitude is defined as the level of positive, negative, or neutral inclination a producer holds toward the idea of producing healthy products. Prior research indicates that greenhouse producers tend to exhibit positive attitudes toward this practice, which in turn facilitates behavioral change (Cachero-Martínez, 2020). Empirical findings confirm that such attitudes significantly influence behavioral intentions (Hsu et al., 2016; Lim et al., 2016; Kim, 2019). Hypothesis 2 (H2): Attitude has a positive correlation with greenhouse owners' intentions toward producing healthy products. Perceived behavioral control is defined as an individual's perception of the ease or difficulty of performing a given behavior (Hauslbauer et al., 2022). It encompasses beliefs about internal and external factors that may facilitate or hinder behavioral performance, such as skills, knowledge, time, and external support (Lubran, 2010; Rezaei et al., 2018). In the context of greenhouse farming, perceived behavioral control reflects a farmer's perceived ability to produce healthy products and manage the factors influencing that behavior (Yanakittkul & Aungvaravong, 2020). Several studies have affirmed the significant impact of perceived behavioral control on intention (Yazdanpanah et al., 2015; Zobeidi et al., 2022; Hauslbauer et al., 2022). Hypothesis 3 (H3): Perceived behavioral control has a positive correlation with greenhouse growers' intention to produce healthy products.

Subjective norms refer to the perceived social pressures exerted on individuals to perform or refrain from a particular behavior (Rezaei et al., 2018). People are more likely to engage in a behavior when they believe that significant others—such as family, peers, or community members—support or approve of it (Shin & Hancer, 2016). In this study, it is argued that when healthy product production becomes a norm within a group of greenhouse producers, individuals are more likely to conform to that behavior (Rezaei et al., 2018). Numerous TPB-based studies have identified social norms as key predictors of behavioral intention, particularly in contexts related to food safety (Lubran, 2010; Yazdanpanah et al., 2015; Rezaei et al., 2018; Hauslbauer et al., 2022). Hypothesis 4 (H4): Subjective norms have a positive correlation with greenhouse growers' intention to produce healthy products. Awareness of consequences refers to an individual's recognition of the potential effects their behavior may have on others or the environment (De Groot & Steg, 2009). It represents the first step toward responsible action and reflects the individual's understanding of how behavior can contribute to problem resolution (Valizadeh et al., 2020; Haji & Hayati, 2022). Individuals who are more aware of the harmful impacts of agricultural contamination are more likely to adopt practices that reduce these risks (Al Mamun et al., 2023). Empirical studies have consistently shown that higher awareness of consequences positively influences behavioral intentions (De Groot & Steg, 2009; Al Mamun et al., 2023). Hypothesis 5 (H5): Awareness of consequences has a positive correlation with greenhouse growers' intention to produce healthy products. The ascription of responsibility pertains to the extent to which individuals feel personally responsible for preventing or mitigating negative outcomes (Xu et al., 2020). A lack of responsibility is often associated with inaction, as individuals may not perceive a need to change their behavior (Xu et al., 2020). When individuals believe that their responsible behavior can help reduce agricultural contamination, their motivation to act accordingly is strengthened (Valizadeh et al., 2020). This psychological mechanism has been supported by several studies linking personal responsibility with intention (De Groot & Steg, 2009; Xu et al., 2020; Al Mamun et al., 2023). Hypothesis 6 (H6): Ascription of responsibility is positively correlated with greenhouse growers' intention to produce healthy products. Values are enduring beliefs that guide individuals' attitudes and behaviors (Haji & Hayati, 2022). While intangible, values are stable over time and strongly associated with various environmental preferences (Ateş, 2020). In this study, two types of values are considered: biospheric and altruistic. Biospheric values reflect concern for nature and the ecosystem, while altruistic values pertain to concern for the well-being of others (De Groot et al., 2012; Ateş, 2020). Individuals who prioritize altruistic values tend to evaluate environmental actions based on their perceived benefits for other people (Perlaviciute & Steg, 2015), whereas those who hold biospheric values focus on outcomes for the environment itself (De Groot et al., 2012). Although many studies confirm a relationship between values, awareness of consequences, and ascription of responsibility (De Groot & Steg, 2009; Pradhananga et al., 2017; Valizadeh et al., 2020; Haji & Hayati, 2022), the direct influence of values on environmental behavioral intention remains less explored (Li et al., 2020). Existing evidence suggests that values exert their influence indirectly through awareness and responsibility rather than directly affecting behavioral intention (De Groot et al., 2012; Qasim et al., 2019). Hypothesis 7 (H7): Bio-spheric and altruistic values have a positive correlation with greenhouse growers' awareness of the consequences regarding producing healthy products. Hypothesis 8 (H8): Bio-spheric and altruistic values have a positive correlation with greenhouse growers' ascription of responsibility regarding producing healthy products. Based on the theoretical foundations, prior empirical research, and the sequential development of the hypotheses outlined above, a modified version of the TPB framework is proposed. This expanded model incorporates additional psychological and value-based constructs to better explain greenhouse growers' intention to produce healthy products. The developed conceptual framework is illustrated in Fig. 1.

Globally, studies on healthy agricultural production and its related factors have predominantly concentrated on examining the technical determinants influencing the production process (Li et al., 2011; Lake et al., 2012; Rezaei et al., 2018; Li et al., 2020). In instances where non-technical factors have been explored, the primary focus has been on identifying challenges and barriers associated with the production of healthy agricultural products. However, based on the reviewed literature, limited attention has been given to understanding healthy production behavior through the lens of behavioral models. The novelty of the present study lies in two key aspects: first, it investigates the behavior of healthy product production using the TPB as a psychological framework; second, it extends the TPB by integrating four additional constructs, awareness of consequences, ascription of responsibility, biospheric values, and altruistic values, to enhance the model's explanatory power.

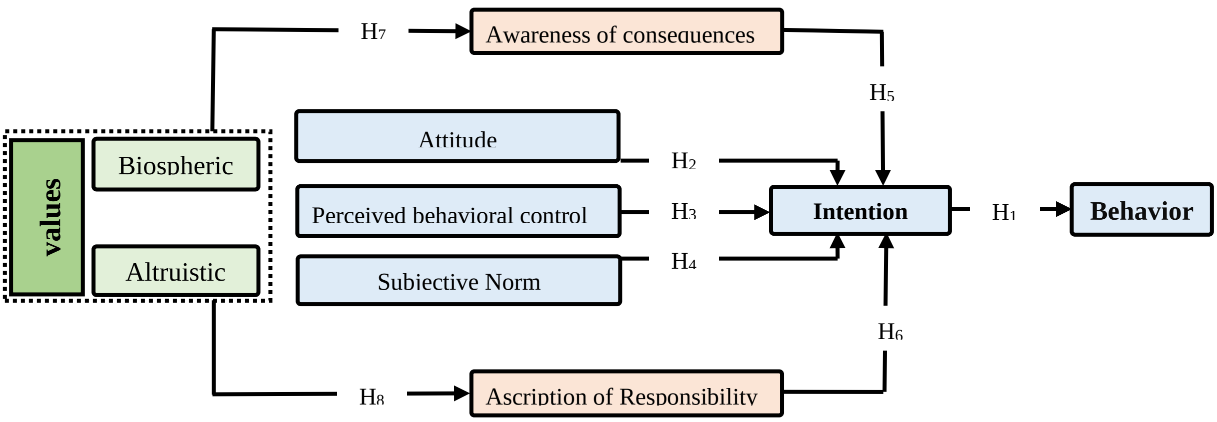

Fig. 1. Research conceptual framework.

MATERIALS AND METHODS

This study is defined by its practical orientation and is classified as field research, given the limited control over the variables under investigation. From a methodological standpoint, it falls under the category of descriptive research, as it involves the systematic collection and analysis of data to describe characteristics of the target population. The research is theoretically grounded in the positivist paradigm, which emphasizes objectivity, empirical observation, and quantifiable evidence (Creswell & Creswell, 2017). Accordingly, the study employs a quantitative research approach, utilizing numerical data and statistical analysis to examine the relationships between variables. This approach aims for precision, reliability, and replicability in data collection and interpretation. The statistical population of this study comprises all agricultural greenhouse growers in Kerman province, Iran (Fig. 2). Based on data obtained from the Agricultural Jihad Organization, the total number of greenhouse growers in the province is 5,429. Using the Krejcie and Morgan sampling table (1970), the appropriate sample size was calculated to be 359 individuals. To ensure adequate representation, a two-stage cluster sampling method was employed. In this method, the population is first divided into clusters, and then samples are selected in two successive stages (Kish, 1996). This sampling approach is particularly useful for geographically dispersed populations and enables a more equitable distribution of the sample across the entire population. Kerman province has experienced significant growth in greenhouse cultivation in recent years, making it a strategic location for this study. According to statistics from the Horticulture Management Division of the Agricultural Organization of Kerman (Iran's Ministry of Agriculture Jihad, 2022), the province ranks first in the country in greenhouse cultivation area, covering over 5,000 hectares, and second in total production volume, with approximately 500,000 tons of various greenhouse vegetable products.

The research tool used in this study was a researcher-designed questionnaire, with various sections developed based on inspiration from previous studies (Table 1). The validity and reliability of the questionnaire were assessed using multiple methods and indicators. To evaluate content and face validity, the initial version of the questionnaire was provided to a panel of academic experts. Following feedback from the experts, the questionnaire was revised accordingly before distribution to the target population. A pilot study was conducted among greenhouse farmers in the northern part of Kerman province. To assess the reliability of the instrument, Cronbach's alpha coefficients were calculated (Table 1). After the main survey was completed, additional methods were employed to further confirm the validity and reliability of the questionnaire. Specifically, two composite reliability indices, CR and Rho A, were used to assess and ensure the instrument's reliability. For validity assessment, both convergent validity (CV) and divergent validity (DV) indices were applied. CV was evaluated using the Average Variance Extracted (AVE), derived from the average variance of the indicators, while DV was assessed using the Fornell-Larcker criterion, which involves calculating the square root of the AVE. All items in the questionnaire (except for behavior) were rated on a five-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree). For measuring actual behavior, a modified five-point Likert scale was used, with the following labels: 1 = Very Low, 2 = Low, 3 = Moderate, 4 = High, and 5 = Very High. Descriptive data were analyzed using SPSS 24 software, while the hypotheses were tested using Partial Least Squares Structural Equation Modeling (PLS-SEM), which allows for simultaneous evaluation of the measurement model and structural model (Savari et al., 2021).

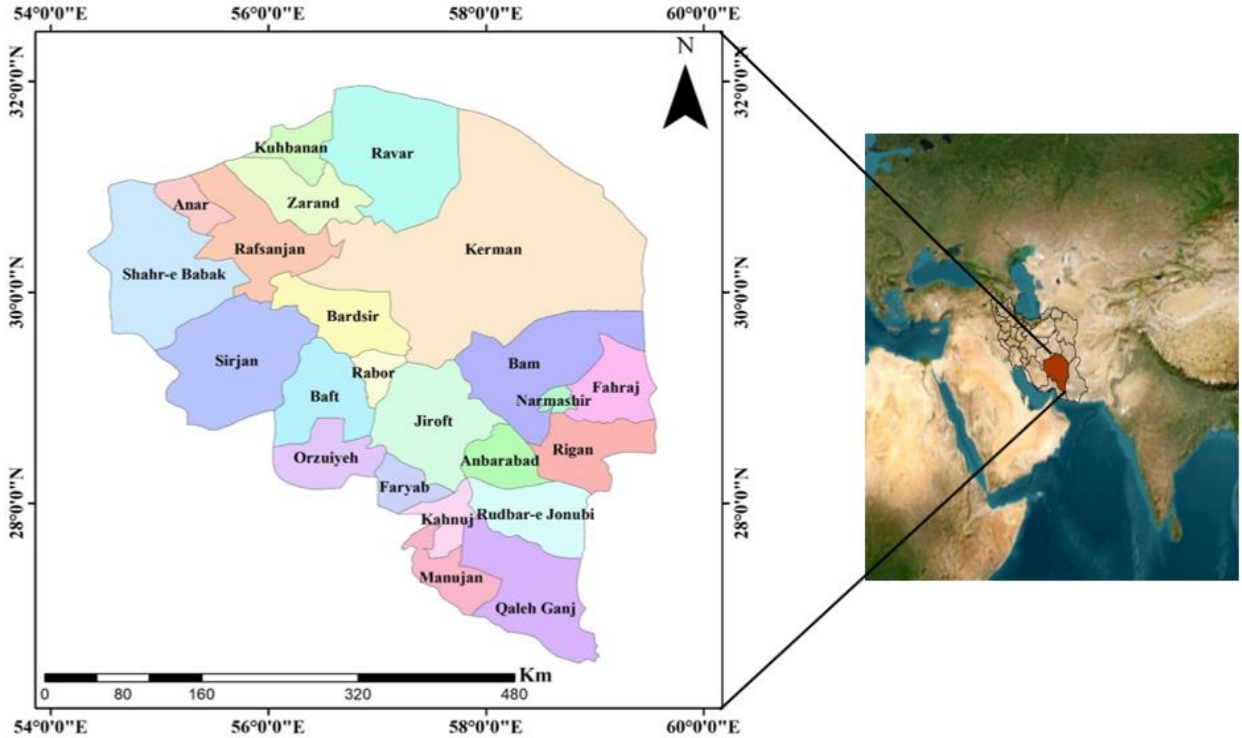

Fig. 2. The site of the study area.

Table 1. Research measurement concepts and variables

Measurement item	Variable	Variable	Cronbach's alpha
I conduct a soil test before planting to understand the soil's nutrient status and determine the crop's requirements.	Be_1	Behavior	0.81
I perform periodic water tests before planting.	Be_2		
I read and follow the guidelines for using chemical substances and pesticides.	Be_3		
I use micronutrient fertilizers and foliar spraying on leaves and plants to enhance absorption and reduce the use of fertilizers and pesticides.	Be_4		
I use organic and bio-fertilizers (compost, vermicompost, and well-rotted animal manure) and avoid chemical fertilizers.	Be_5		
I share my knowledge and experiences about healthy crop production with other greenhouse farmers.	Be_6		
I intend to encourage other farmers to produce healthy crops.	In_1	Intention	0.79
I intend to participate in implementation programs related to healthy crop production.	In_2		
I am willing to make extra efforts to produce healthy crops.	In_3		
I want to produce products that do not harm the environment.	In_4		
I want to produce products that do not harm consumers.	In_5		
I believe that unhealthy greenhouse products negatively affect my family's health.	At_1	Attitude	0.74
I am committed to producing healthy products under any circumstances.	At_2		
Producing healthy products is important to me.	At_3		
I believe that producing healthy products is important for my well-being.	At_4		
I believe that the effort to produce healthy products is a shared responsibility.	At_5		
If I produce healthy products, I will receive support from people whose opinions matter to me.	No_1	Subjective norm	0.83
Most of my neighboring farmers use various safe methods to produce healthy products.	No_2		
I feel that there is an expectation from agricultural experts for me to use healthy production methods.	No_3		
Most of my family members encourage me to produce healthy products.	No_4		
I can afford the costs of producing healthy products.	Con_1	Perceived behavioral control	0.75
Acquiring knowledge and information on how to produce healthy products is possible for me.	Con_2		
Choosing and applying the right methods for producing healthy products is easy and straightforward for me.	Con_3		
Producing healthy products is cost-effective.	Aw_1	Awareness of consequences	0.80
Healthy products are of higher quality than other products.	Aw_2		
Producing healthy products allows us to earn more income.	Aw_3		
Excessive use of agricultural inputs leads to the production of unhealthy products.	Aw_4		
Focusing on producing healthy products does not reduce yield.	Aw_5		
Producing healthy products has high market appeal.	Aw_6		
If consumers' health is jeopardized due to my agricultural products, I accept responsibility for it.	Res_1	Ascription of responsibility	0.82
Farmers have a responsibility to produce healthy products for the well-being of consumers and the environment.	Res_2		
Producing healthy products is my responsibility towards the health of people and the environment.	Res_3		
It is my duty to share any knowledge I have about producing healthy products with other farmers.	Res_4		
Even if others do not strive to produce healthy products, I will still feel a sense of responsibility in this regard.	Res_5		
Producing healthy products is important because it contributes to the well-being of others and society as a whole.	Al_1	Altruistic	0.77
I believe that farmers have a responsibility to adopt healthy production practices for the benefit of society and future generations.	Al_2		
Farmers should avoid using harmful chemicals because it is their responsibility to protect the health of consumers and the environment.	Al_3		
Producing healthy products is important for protecting the environment and ensuring its sustainability for future generations.	Bi_1	Biospheric	0.84
Farmers should not misuse agricultural inputs to increase yield.	Bi_2		
Excessive use of agricultural inputs harms the environment and depletes natural resources, which could have irreversible consequences for future generations.	Bi_3		

References: Haji & Valizadeh, 2024; Adeli Sardooei *et al.*, 2025; Wang *et al.*, 2014; Larson *et al.*, 2015; Bijani & Hayati, 2013.

RESULTS AND DISCUSSION

Demographic properties

An examination of the demographic characteristics of the greenhouse farmers in the study reveals several key statistics. The average cultivation area of agricultural greenhouses in the region was 12,406.5 square meters (SD = 10,641.67). The average greenhouse cultivation experience among participants was 9.45 years (SD = 4.65). Furthermore, the respondents had an average of 12.1 years of formal education (SD = 4.75). In terms of gender distribution, 6.15% of the participants (21 individuals) were women, while 93.85% (320 individuals) were men.

Leveling the behaviors of producing healthy products

To qualitatively describe the variables in the developed TPB model and classify the study participants based on their behavior towards producing healthy products, the Interval of Standard Deviation from Mean (ISDM) method was employed (Table 2). This method categorizes participants into three groups, low, moderate, and high, based on their behavioral scores in relation to healthy product production. The results indicate that the biospheric values of greenhouse owners towards producing healthy products are relatively positive. Greenhouse owners' biospheric values show a tendency toward a positive perception of healthy product production, although not at an exceptionally high level. Conversely, other variables studied, such as behavior, awareness of consequences, subjective norms, attitudes, perceived behavioral control, altruistic values, intention, and ascription of responsibility, are in a relatively moderate state among the greenhouse owners. Despite harboring positive intentions and a sense of responsibility, the greenhouse owners in the study appear to be less proactive in actualizing these behaviors towards producing healthy products. Since behavior reflects the current actions of the participants, while other variables primarily indicate future intentions, it is plausible that with the implementation of promotional initiatives and by addressing perceptual barriers, the likelihood of increased healthy product production among greenhouse owners can be significantly enhanced.

Evaluation of the research structural model

To assess the fit, validity, and reliability of the research constructs, including attitude, subjective norms, perceived behavioral control, awareness of consequences, ascription of responsibility, biospheric values, altruistic values, and intention of greenhouse growers towards their behavior in producing healthy products, various indicators were utilized (Table 3). A comparison of the obtained fit values with the desired values reveals that all values fall within the standard range (Tenenhaus et al., 2004). Consequently, based on the presented index values, it can be concluded that the model used to analyze the behavior of greenhouse growers in producing healthy products demonstrates an appropriate fit.

Unidimensionality

This step was evaluated using factor loadings and t-values. Based on the values presented in Table 4, it can be concluded that the factor loadings for the selected indicators were statistically significant (above 0.7) and at the 1% error level ($P < 0.01$). The results confirmed the unidimensionality of the chosen indicators, indicating that they were appropriately selected to assess the research constructs, thereby ensuring that the same component was measured with precision.

Reliability and validity

At this stage, Combined Reliability (CR), Cronbach's alpha, and AVE were analyzed. As shown in Table 4, all constructs in the proposed research model exhibited CR values above 0.80 and Cronbach's alpha coefficients exceeding 0.74. Additionally, the AVE for each construct in the model was greater than 0.65. Consequently, all latent variables demonstrated high reliability and validity, suggesting that the items selected to measure the research constructs were appropriate and ensured the replicability of the experiment.

Discriminant validity

Diagnostic validity is achieved when questions that measure one variable are clearly separate or distinguishable from those that measure other variables. Statistically, the research variables have sufficient diagnostic validity if the square root of the calculated AVE variance for each variable is greater than the correlation between them (Fornell, 1992). As shown in Table 5, the square root of the extracted variance for the research constructs (0.81 < AVE < 0.91) exceeded the correlations between them (0.06 < r < 0.66). This finding confirms the diagnostic validity of the constructs within the proposed research model.

Table 2. Leveling behaviors of producing healthy products using the Interval of Standard Deviation from Mean (ISDM) method

Variable	SD	Mean*	ISDM							
			Poor		Average		Good		Excellent	
			Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Behavior	0.99	2.41	50	14.7	176	51.6	37	10.9	78	22.9
Intention	1.03	3.03	87	25.5	101	29.6	89	26.1	64	18.8
Awareness	0.85	3.40	49	14.4	144	42.2	100	29.3	48	14.1
Norm	0.96	2.32	62	18.2	129	37.8	105	30.8	45	13.2
Attitude	1.04	2.75	65	19.1	118	34.6	76	22.3	82	24
Control	0.86	2.74	37	10.9	162	47.5	72	21.1	70	20.5
Response	0.85	2.74	49	14.4	110	32.3	121	35.5	61	17.9
Biospheric	1.01	2.57	42	12.3	158	46.3	71	20.8	70	20.5
Altruistic	1.01	2.22	48	14.1	145	42.5	94	27.6	54	15.8

Range 1-5

Table 3. Summary of goodness of fit indices for the measurement model

Fit index	Standardized Root Mean Square Residual (SRMR)	D-G1	D-G2	NFI	RMS-theta
Suggested value	< 0.1	> 0.05	> 0.05	> 0.90	< 0.12
Estimated value	0.08	4.9	2.9	0.71	0.15

Table 4. The results of fit of measurement models

Construct	**Symbol**	**λ**	**t**	**Reliability and validity statistics**
Attitude	At_1	0.94	129.95	AVE: 0.83
	At_2	0.88	78.33	CR: 0.96
	At_3	0.92	96.36	a: 0.95
	At_4	0.95	162.31	
	At_5	0.86	61.05	
Behavior	Be_1	0.81	32.10	AVE: 0.79
	Be_2	0.88	50.10	CR: 0.96
	Be_3	0.87	48.60	a: 0.95
	Be_4	0.94	93.07	
	Be_5	0.92	87.54	
	Be_6	0.91	65.7	
Control	Co_1	0.74	21.50	AVE: 0.65
	Co_2	0.89	75.18	CR: 0.85
	Co_3	0.78	20.51	a: 0.74
Intention	In_1	0.91	86.02	AVE: 0.81
	In_2	0.94	129.46	CR: 0.96
	In_3	0.90	77.35	a: 0.94
	In_4	0.93	115.95	
	In_5	0.81	41.69	
Norm	No_1	0.87	36.33	AVE: 0.78
	No_2	0.87	44.59	CR: 0.93
	No_3	0.91	69.92	a: 0.91
	No_4	0.87	63.11	
Altruistic	Al_1	0.88	41.12	AVE: 0.70
	Al_2	0.75	19.33	CR: 0.87
	Al_3	0.88	51.92	a: 0.78
Biospheric	Bi_1	0.89	44.98	AVE: 0.78
	Bi_2	0.93	76.46	CR: 0.92
	Bi_3	0.83	34.61	a: 0.86
Awareness	Aw_1	0.86	34.60	AVE: 0.77
	Aw_2	0.86	37.88	CR: 0.95
	Aw_3	0.85	33.37	a: 0.94
	Aw_4	0.91	70.57	
	Aw_5	0.86	54.60	
	Aw_6	0.93	124.43	
Response	Res_1	0.81	42.27	AVE: 0.78
	Res_2	0.90	64.79	CR: 0.95
	Res_3	0.84	40.52	a: 0.93
	Res_4	0.93	113.56	
	Res_5	0.93	114.74	

Table 5. Correlations with square roots of the AVEs

Construct	**Altruistic**	**Attitude**	**Awareness**	**Behavior**	**Biospheric**	**Control**	**Intention**	**Norm**	**Response**
Altruistic	0.835[a]								
Attitude	0.623**	0.910[a]							
Awareness	0.326**	0.246**	0.879[a]						
Behavior	0.316**	0.563**	0.220**	0.890[a]					
Biospheric	0.125**	0.212**	0.232**	0.107**	0.885[a]				
Control	0.474**	0.592**	0.388**	0.338**	0.304**	0.808[a]			
Intention	0.459**	0.649**	0.446**	0.660**	0.122**	0.601**	0.899[a]		
Norm	0.343**	0.190**	0.340**	0.225**	0.06**	0.259**	0.465**	0.881[a]	
Response	0.452**	0.573**	0.280**	0.440**	0.417**	0.584**	0.574**	0.154**	0.883[a]

[a] the square roots of AVE estimate.
** Correlation is significant at the $P < 0.01$ level.

Test of the research hypotheses

At this stage, the results of the final impact of variables on farmers' behavior in producing healthy products are presented (Table 6). Accordingly, the bootstrapping method was used to test the research hypotheses. The results showed that all the research hypotheses were confirmed. Based on the findings of this study, the research variables included in this model can explain 44% of the variance observed in farmers' behavior regarding the production of healthy products.

Table 6. Results of research hypotheses.

Hypothesis	λ	t	Result	Variance Inflation Factor (VIF)	R^2	Q^2
H_5: Intention → Behavior	0.66	20.43	Confirm	1	0.44	
H_1: Attitude →Intention	0.36	6.08	Confirm	1.755	0.63	
H_2: Norm → Intention	0.28	6.73	Confirm	1.159		
H_3: Control → Intention	0.14	2.66	Confirm	1.943		
H_4: Awareness → Intention	0.15	4.10	Confirm	1.276		
H_6: Response → Intention	0.20	3.78	Confirm	1.735		0.32
H_7: Biospheric→ Response	0.37	7.30	Confirm	1.019	0.34	
H_9: Altruistic → Response	0.41	9.10	Confirm	1.019		
H_8: Biospheric→ Awareness	0.20	3.91	Confirm	1.016	0.14	
H_{10}: Altruistic → Awareness	0.30	5.87	Confirm	1.016		

To test the hypotheses and examine the correlations and impacts of the variables—intention, attitude, perceived behavioral control, subjective norm, awareness of consequences, ascription of responsibility, and biospheric and altruistic values—on the dependent variable, namely the behavior of producing healthy products among greenhouse farmers, Structural Equation Modeling (SEM) was employed. The research path model, displaying standardized factor loadings and significance levels, is presented in Fig. 3 and Fig. 4. The analysis revealed that intention had a standardized coefficient of 0.66 and a t-value of 20.43, indicating a statistically significant impact on healthy product behavior at the 99% confidence level. Therefore, Hypothesis 1 is supported. This finding is consistent with previous research (Behroozeh et al., 2024; Lubran, 2010; Hsu et al., 2016; Lim et al., 2016; Rezaei et al., 2018; Kim, 2019), which also emphasized the strong correlation between intention and actual behavior. This result suggests that individuals' thoughts, feelings, and internalized standards meaningfully influence their behavioral patterns. Specifically, in agricultural production, growers' intentions and motivations are closely tied to their commitment to quality and safety standards. Furthermore, attitude toward producing healthy products had a coefficient of 0.36 and a t-value of 6.08, also significant at the 99% confidence level, thus supporting Hypothesis 2. This finding implies that greenhouse growers with a positive attitude toward producing healthy products exhibit stronger intentions to engage in such practices. A constructive outlook towards health-conscious agricultural production promotes greater adherence to environmental and safety standards, potentially leading to higher product quality. These findings align with previous studies (Hsu et al., 2016; Lim et al., 2016; Kim, 2019). In addition, perceived behavioral control was shown to have a positive and significant effect on intention, with a coefficient of 0.14 and a t-value of 2.66, confirming Hypothesis 3. This outcome corroborates earlier studies (Yazdanpanah et al., 2015; Zobeidi et al., 2022; Hauslbauer et al., 2022), which demonstrated that individuals who feel confident in their ability to control and manage behaviors are more likely to act in environmentally responsible ways. In this context, greenhouse growers who perceive themselves as capable of navigating the challenges associated with healthy production are more inclined to pursue such behaviors, which in turn enhances consumer trust and product quality.

In this regard, subjective norms exhibited a positive and significant impact on the intention of greenhouse growers to produce healthy products, with a standardized coefficient of 0.28 and a t-value of 6.73 at the 99% confidence level, thereby supporting Hypothesis 4. This finding is consistent with the results of previous studies (Yazdanpanah et al., 2015; Hauslbauer et al., 2022), which also reported a significant association between subjective norms and behavioral intention. The cognitive expectations and social pressures perceived by greenhouse growers, arising from their professional community, family, or society, play a meaningful role in shaping their behavioral intentions. When growers perceive that influential people or institutions expect them to produce healthy products, they are more likely to internalize and act upon these expectations, potentially enhancing the quality, credibility, and sustainability of their production practices. Furthermore, awareness of consequences was found to significantly influence intention, with a coefficient of 0.15 and a t-value of 4.10 at the 99% confidence level, confirming Hypothesis 5. This aligns with findings from De Groot & Steg (2009) and Al Mamun et al. (2023), who emphasized the role of consequence awareness in influencing environmentally and health-conscious behaviors. When greenhouse growers understand the broader implications, such as environmental, economic, and health-related outcomes, of producing healthy products, they are more likely to develop a stronger intention to engage in such practices. This awareness acts as a motivational factor that encourages growers to align their actions with sustainable and health-oriented agricultural standards. Additionally, the ascription of responsibility showed a significant positive impact on intention, with a coefficient of 0.20 and a t-value of 3.78, also at the 99% confidence level, thereby supporting Hypothesis 6. This result corroborates findings by De Groot & Steg (2009), Xu et al. (2020), and Al Mamun et al. (2023), who reported that individuals who perceive themselves as responsible for environmental or public health outcomes are more likely to engage in pro-social and sustainable behaviors. In this context, when greenhouse growers acknowledge their personal responsibility in ensuring the health and safety of their agricultural products, they are more inclined to comply with health standards, adopt sustainable practices, and produce high-quality, trustworthy goods.

On the other hand, biospheric and altruistic values exert a positive and significant influence on greenhouse growers' awareness of the consequences of producing healthy products, with standardized path coefficients of

0.20 and 0.30, and t-values of 3.91 and 5.78, respectively, at the 99% confidence level. These results support Hypothesis 7 and are consistent with previous studies (De Groot & Steg, 2009; Pradhananga et al., 2017; Valizadeh et al., 2020; Haji & Hayati, 2022). These findings suggest that the value systems held by individuals, particularly those emphasizing environmental integrity, public welfare, and ethical responsibility, play a key role in shaping their awareness of the outcomes associated with agricultural practices. In essence, when individuals prioritize values such as respect for ecosystem health, human well-being, and social equity, they are more likely to recognize the positive or adverse impacts of their production behaviors. This elevated awareness can enhance their decision-making capacity, fostering a shift toward more sustainable and health-conscious production practices. Moreover, biospheric and altruistic values also demonstrated a significant positive impact on the ascription of responsibility in relation to producing healthy products, with coefficients of 0.367 and 0.41, and t-values of 7.3 and 9.1, respectively, again at the 99% confidence level. These results confirm Hypothesis 8, further supported by findings from De Groot & Steg (2009), Pradhananga et al. (2017), Valizadeh et al. (2020), and Haji and Hayati (2022). This relationship indicates that individuals who hold strong pro-environmental and humanitarian values are more inclined to accept personal responsibility for the outcomes of their agricultural decisions. When greenhouse growers internalize such values, they are more likely to exhibit a heightened sense of ethical duty and accountability in their production processes. As a result, their actions are guided by conscientious decision-making, which is reflected in the credibility and transparency of any responsibility documents or certifications they provide. These documents serve not only as formal indicators of compliance but also as expressions of growers' value-driven commitment to producing safe and healthy agricultural products.

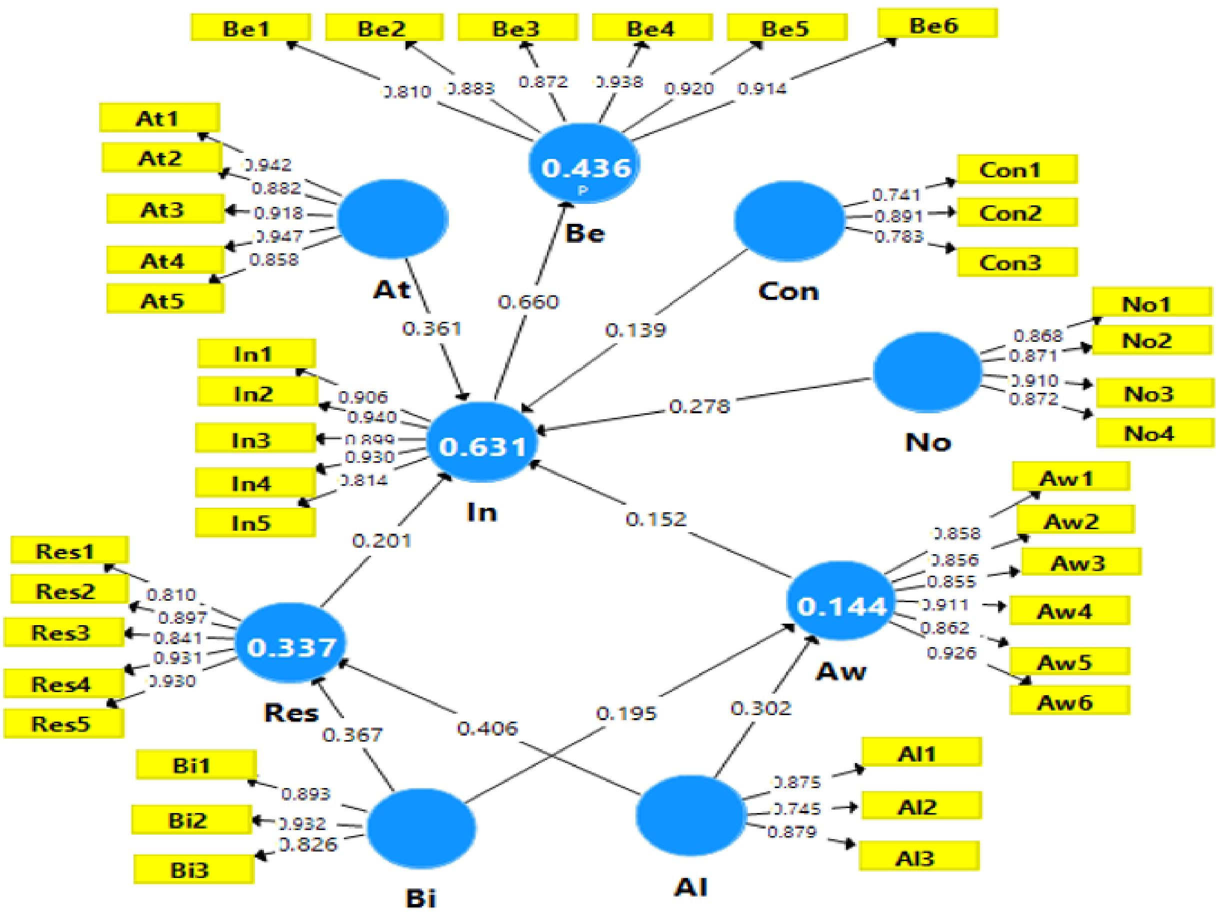

Fig. 3. Path model with standardized factor loadings.

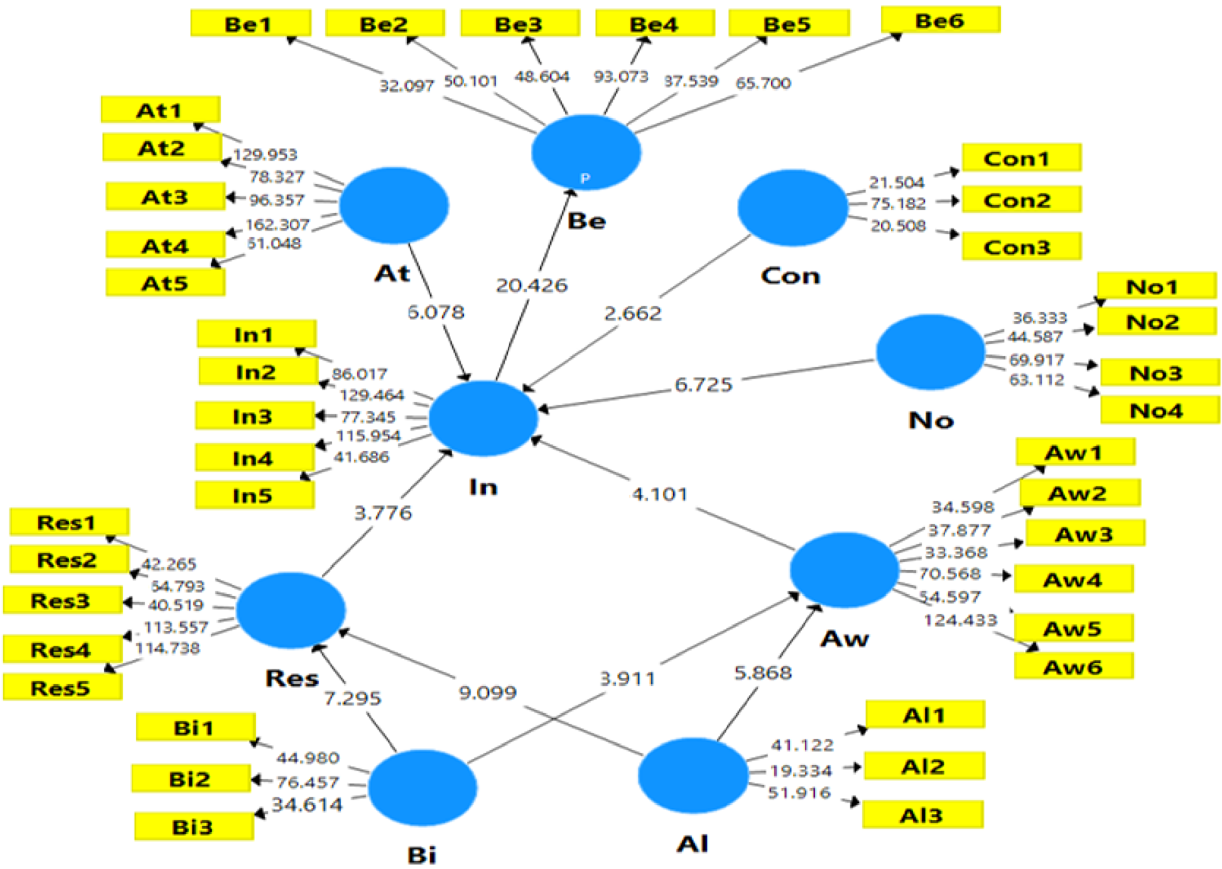

Fig. 4. Path model with t-values.

CONCLUSIONS

Given the central role of applied psychology in understanding and explaining human behavior, this study investigated the key socio-psychological determinants influencing greenhouse farmers' behaviors toward the production of healthy agricultural products. Employing the extended TPB model, the research revealed that greenhouse farmers generally exhibited positive intentions and a sense of responsibility toward producing healthy products. However, these favorable psychological dispositions did not fully translate into actual practices, indicating a gap between intention and behavior. The findings identified intention as the most significant predictor of healthy product production behavior. Accordingly, strengthening farmers' intentions through technical and cultural training is imperative. Such interventions not only enhance knowledge and skillsets but also help bridge the gap between desire and execution by equipping individuals with the competencies necessary to implement best practices in sustainable and health-conscious farming. Moreover, promoting quality standards and encouraging sustainable agricultural practices are essential for both increasing the production of healthy products and enhancing human and environmental well-being. Raising awareness of civil responsibility in the realms of both production and consumption contributes to the protection of public health and environmental resources. In this context, agricultural extension agents play a pivotal role. Through targeted awareness and educational programs, these professionals can effectively communicate the detrimental impacts of unhealthy production practices and foster greater commitment among farmers to adopt more responsible and sustainable methods. Ultimately, encouraging a collective sense of responsibility toward safeguarding environmental and public health can contribute meaningfully to addressing current challenges and improving socio-environmental conditions in agricultural communities.

To enhance farmers' awareness of the positive outcomes associated with the production of healthy agricultural products, norms, attitudes, and biospheric and altruistic values can serve as foundational principles guiding the production, processing, and marketing of agricultural goods. However, the adoption of such practices is often hindered by practical challenges, including financial limitations, restricted market access, and insufficient technical expertise. Addressing these barriers requires a multifaceted strategy. First, the provision of training workshops and educational programs is vital. These initiatives should clearly demonstrate that adopting health-conscious and environmentally friendly production methods not only improves public health outcomes but also plays a pivotal role in environmental preservation. Additionally, financial incentives, such as subsidies or low-interest loans, along with policy support, can alleviate economic constraints and encourage wider adoption of sustainable practices. Public awareness can be further promoted through extension activities and targeted campaigns that emphasize the significance of environmental values and social responsibility in agriculture. Moreover, these biospheric and altruistic values should be integrated into agricultural production guidelines and certification requirements, thereby institutionalizing ethical and environmental considerations within farming protocols. Including environmental and health-oriented responsibilities in producer mandates will create a stronger motivational framework for farmers and serve as a practical roadmap for sustainable production. Finally, financial facilities and support mechanisms linked to adherence to these values can accelerate the transition toward more responsible agricultural practices. Embedding such values into agricultural policy frameworks is essential for promoting long-term sustainability, ecological stewardship, and the production of healthier food products across agricultural systems.

While the study offers valuable insights into the behavioral factors influencing greenhouse farmers' practices, certain limitations should be acknowledged. The research was geographically confined to greenhouse farmers in Kerman province, Iran, and focused on specific crops such as cucumbers, eggplants, strawberries, tomatoes, and various types of peppers. Consequently, the findings may not be generalizable to farmers cultivating other products or operating in different regions. Moreover, although the study employed a well-established psychological framework, it may not capture all relevant variables affecting farmers' behavior. Future research is encouraged to explore additional or alternative constructs and to include a more diverse sample of farmers from various agricultural and geographic backgrounds. Such efforts would enhance the robustness of behavioral models in agricultural contexts and support the development of more inclusive and targeted policies.

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Conceptualization: Mohsen Adeli Sardooei, Samira Behroozeh and Latif Haji; Methodology: Mohsen Adeli Sardooei and Samira Behroozeh; Software: Samira Behroozeh and Latif Haji; Validation: Mohsen Adeli Sardooei, Samira Behroozeh and Latif Haji; Formal analysis: Mohsen Adeli Sardooei and Samira Behroozeh; Investigation: Mohsen Adeli Sardooei, Samira Behroozeh and Latif Haji; Resources: Samira Behroozeh and Latif Haji; Data curation: Data curation; Writing—original draft preparation: Mohsen Adeli Sardooei and Samira Behroozeh; Writing—review and editing: Mohsen Adeli Sardooei, Samira Behroozeh and Latif Haji; Supervision: Samira Behroozeh and Latif Haji; Project administration: Samira Behroozeh and Latif Haji; Funding acquisition: Mohsen Adeli Sardooei.

DECLARATION OF COMPETING INTEREST

The authors do not have any financial interest or any other conflict of interests. The manuscript contains nothing that is abusive, defamatory, libelous, obscene, fraudulent, or illegal.

ETHICAL STATEMENT

In conducting the research and administering the questionnaire, we strictly adhered to all ethical standards, ensuring that the data collected and analyzed from respondents were respectful and in compliance with all applicable guidelines.

DATA AVAILABILITY

Data will be made available on request.

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