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RESEARCH ARTICLE

Farmers' intention to reduce pesticide use: the role of perceived risk of loss in the model of the planned behavior theory

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Abstract

Numerous studies have examined how farmers are involved and behave in the use of pesticides, but what drives farmers' intention to diminish pesticide applications is mostly unknown. This study explored farmers' intention to minimize pesticide use, through the theory of planned behavior (TPB) and an adjusted form of the TPB, with perceived risk of loss as an additional variable to the original model. On a scale from 1 to 5, intention to reduce pesticide use had the lowest score of all variables (2.36), indicating that most farmers did not show intention to reduce pesticide use. Only 15.2% of the farmers were willing to reduce pesticide use, while 8.3% were undecided. Moreover, 58.2% of the farmers had high levels of perceived risk of loss by the reduction of pesticide use, which explained 37.3% of farmers' intention. From the three variables of the TPB, attitudes had the highest score (3.34), indicating slightly favorable attitudes toward pesticide reduction, while perceived behavior control had the lowest score (2.70), indicating poor control of pesticide reduction. Also, the three basic variables of the TPB were positively correlated ($P < 0.01$) with farmers' intention to reduce pesticides, while a negative correlation ($P < 0.01$) was noted between intention to reduce pesticides and perceived risk of loss. The three basic variables of the TPB were significant predictors of intention, capturing 54.7% of the variation in farmers' intention. Adding perceived risk of loss as a construct to the TPB improved the predictive ability of the original model. Poor control of pesticide reduction (high-perceived barriers) and high perceived risk of loss drive farmers' intention to reduce the use of pesticides. Advancing alternative crop protection methods focusing on agro-ecology and integrated pest management should be included in the work of extension services.

Keywords Pesticide use · Perceived risk of loss · Theory of planned behavior

Introduction

Intensive farming systems of conventional agriculture are dominated by external inputs (i.e., fertilizers and plant protection products) to safeguard and enhance production (Pretty 2018). In such farming systems, pesticides play an essential role because of their wide use in crop protection (Damalas 2009; Damalas and Eleftherohorinos 2011; Monfared et al. 2015). Farmers consider these chemicals as a guarantee of security over unpredictable pathogenic vectors in farming systems, but intensive use has created environmental concerns worldwide. Moreover, farmers are routinely exposed to high levels of pesticides due the nature of their job (Damalas and Koutroubas 2016). Major adverse effects on non-target organisms and other costs pertaining to contamination of the environment (air, soil, drinking water, and food) and human health have been reported (Jayaraj et al. 2016; Nicolopoulou-Stamati et al. 2016; Damalas and Koutroubas 2017). These costs create a necessity for a shift towards more environmentally friendly pest control. Assuming that pro-environmental behavior is a protective way of acting for a healthy environment, understanding how farmers decide to use pesticides in their farms is crucial (Damalas and Koutroubas 2018). However, factors influencing farmers' intention to reduce pesticide use remain poorly understood.

The ultimate goal should be to manage pests in a way that allows sustainable crop production, without adverse effects on environment and human health. However, adoption of alternative methods of pest control, which are less dependent on pesticides, is generally lagging. Thus, despite the large promotion of alternative methods, pest control based on synthetic

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pesticides remains the most popular method of crop protection in modern agriculture (Pretty 2018). Farmers in developing countries continue using pesticides as the most common pest control method despite the multiple negative effects of pesticides (Monfared et al. 2015; Abdollahzadeh et al. 2016; Bagheri et al. 2018; Abadi 2018). Such heavy use is not justified, because according to a recent study, the total use of pesticides could be diminished by 42% without affecting productivity and profitability with the use of agricultural inputs in the majority of the farms studied (Lechenet et al. 2017). However, several farmers, not only in developing countries, use pesticides in excess and in an unsafe manner (Damalas and Khan 2017; Rezaei et al. 2017; Damalas et al. 2019; Sharifzadeh et al. 2019).

Examining cases where reduction of pesticide use can be achieved without sacrificing production or profit is a worthy research topic (Frisvold 2019). However, multicriteria support systems along with pest monitoring programs are required to develop sustainable pest control strategies (Meissle et al. 2010). Several barriers have been reported to affect pest control decisions, so there is not a consensus on what drives farmers to diminish pesticide applications. Farmers' perceptions were reported to influence farmers' behavior in the adoption of alternative methods of pest control besides pesticides (Hashemi and Damalas 2010). Common barriers to the reduction of pesticide applications include economic dependence of farmers by previously chosen inferior standards (Wilson and Tisdell 2001), call of the markets for flawless products (Skevas and Oude Lansink 2014), insufficient information services on the correct pesticide use (Jin et al. 2015), poor adoption of knowledge and technologies of IPM (Sherman and Gent 2014; Lamichhane et al. 2016), absence of non-chemical alternatives (Khan and Damalas 2015a), and poor knowledge about pesticide use, safety issues, and non-chemical alternatives (Khan and Damalas 2015b; Allahyari et al. 2017; Damalas and Koutroubas 2017). In addition, the risk of yield loss due to pests often prevents farmers from diminishing pesticide use (Chèze et al. 2020). Recently, it has been reported that farmers' intention to diminish pesticide use was influenced by the behavior of other farmers (Bakker et al. 2021).

Exploring factors driving farmers' decision-making is necessary for interventions to reduce the use of pesticides (Damalas and Koutroubas 2018). Various theories have been tested in the literature to explain farmers' motive to use pesticides, of which the theory of planned behavior (TPB) is a popular model (Ajzen 1991). According to the TPB, behavior is largely defined by the intention of an individual to get involved in the specific behavior (Ajzen 1991). Moreover, attitudes, subjective norms, and perceived behavioral control (PBC) are the main stimuli of an individual to complete the behavior and then the behavior is regulated by intention and PBC (Yazdanpanah et al. 2014). Attitude reflects the evaluation of the behavior in question as favorable or unfavorable (Ajzen 1991). Subjective norms reflect the degree of social pressure that an individual feels by engaging in a behavior or not (Ajzen 1991). PBC reflects the level of difficulty that an individual feels by carrying out the behavior of interest (Ajzen 1991).

The TPB has been reported to predict well a behavior in the agricultural domain (Borges et al. 2014; Senger et al. 2017; Daxini et al. 2019; Despotović et al. 2019; Bagheri et al. 2021). However, the theory can be improved by additional variables that can improve the predictive ability of the model (Monfared et al. 2015; Bagheri et al. 2019; Rezaei et al. 2019; Savari and Gharechaee 2020). The objective of this study was to identify factors determining farmers' intention to reduce pesticide application, through the TPB, and test the explanatory ability of the model by adding a new construct, i.e., perceived risk of loss (Fig. 1).

Methodology

The study was based on a face-to-face survey of a random sample of 230 farmers from four municipal units of Pieria Prefecture, Greece. A multi-stage sampling plan was employed for selection of respondents. In the first stage, the municipal units of interest were purposively selected based on convenience allowing easy collection of data. In the second stage, three communities within each municipal unit were selected randomly. In the third stage, a simple random sampling was used to select farmers from each community within each municipal unit. For this purpose, farmers' lists offered by the local authorities were used. All random selections were performed using a random number generator application in MS Excel. Sample size was determined according to Krejcie and Morgan (1970). The number of individuals in the sample was defined by the size of the population of each community within each municipal unit. Overall, the survey had a margin error ±5% at a confidence level of 90%, which was considered acceptable (Fink 2015). Participants were mainly involved in the cultivation of cereal grains, cotton, and tobacco. Farmers were surveyed from December 2018 until January 2020 using a structured questionnaire (Table 1). Farmers were asked to

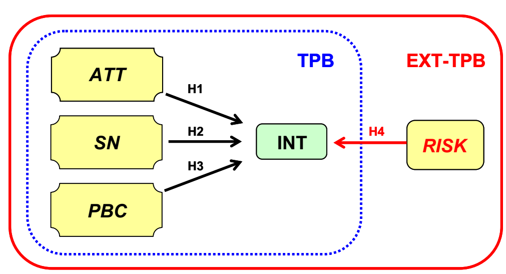

Fig. 1 The TPB framework (Ajzen 1991) and the extended version used in the study. *INT* intention, *ATT* attitudes, *SN* subjective norms, *PBC* perceived behavioral control

Table 1 Items examined in each construct of the TPB model

Statement	Mean
Attitudes (alpha = 0.834)	3.34
It is important for human health to produce without pesticides.	4.17
It is important for the environment to produce without pesticides.	4.22
It is important for my income to produce without pesticides.	2.32
In my opinion, biological control of pests is a good idea.	2.63
Subjective norms (alpha = 0.982)	2.85
My close friends think I should not use pesticides in my crops.	2.45
My peer farmers support crop production free of pesticides.	2.73
My family pushes me to limit pesticide use in my crops.	3.00
I feel morally obliged to produce pesticide-free products.	3.23
Perceived behavioral control (alpha = 0.707)	2.70
If I wanted, I could easily cultivate my crops without pesticides.	2.48
I believe I have the resources to cultivate my crops without pesticides.	2.58
I would not have problems in succeeding to non-chemical pest control.	3.01
For me, switching to non-chemical pest control would be possible.	2.73
Risk of loss (alpha = 0.942)	3.40
I am afraid that less pesticide use will lead to serious yield losses.	3.50
I am afraid that less pesticide use will lead to serious income losses.	3.30
Intention (alpha = 0.981)	2.36
I intend to use fewer pesticides in my crops in the near future.	2.60
I plan to replace pesticides with non-chemical options of pest control.	2.54
I predict that I will engage to biological pest control in the near future.	2.40
I see myself seeking out non-chemical options of pest control in the future.	1.90

On a scale from 1 = totally disagree to 5 = totally agree

answer questions focusing on their attitudes, subjective norms, PBC, perceived risk of loss, and intention to the reduction of pesticide use, based on a five-point scale from totally disagree to totally agree to capture the extent of respondents agreement with the statements of the questionnaire. Statements of each construct of the questionnaire were created by the authors. The final score for each construct is the mean of the scores for all statements involved in each construct. Before the study, the validity of the questionnaire was checked by crop protection experts and was pre-tested in a pilot study with 30 farmers out of the main sample. The questionnaire's internal reliability was tested using Cronbach's alpha. All constructs indicated acceptable-to-excellent reliability (Table 1). Data were analyzed using the statistical package SPSS. Univariate analysis (frequencies and mean scores) and multivariate analysis (linear regression) were used to assess the relative influence of the factors on farmers' intention to diminish pesticide applications. Multiple linear regression examines the possibility of a linear relationship between a combination of independent variables and a dependent variable. Before performing the regression models, assumption testing was conducted to check for linearity, normality, homoscedasticity, and multicollinearity (variance inflation factor). Visual inspection of scatter plots and residuals analysis confirmed the linearity and homoscedasticity of the data. The Kolmogorov-Smirnov test confirmed the normality of data distribution. Values of variance inflation factors below 5 showed no significant problems of multicollinearity. Finally, data checking revealed no outliers. Differences were considered significant at $P < 0.05$ or $P < 0.01$

Results

The age of the farmers ranged from 18 to 72 years, with an average of 45.95 years (SD = 14.97). Most participants (59.6%) had some years of secondary school or less, while the remaining (40.4%) had completed secondary school or higher levels of education. Intention to reduce pesticide use had the lowest score of all variables of the TPB (2.36), indicating that most farmers did not show intention to reduce pesticide use (Table 1). All items tested in this variable showed scores below the average value of the scale (< 3). Only 15.2% of the farmers were willing to reduce pesticide use, while 8.3% were undecided (Fig. 2). Moreover, 58.2% of the farmers had high levels of perceived risk of loss by the reduction of pesticide use (Fig. 2), which explained 37.3% of farmers' intention. From the three variables of the TPB,

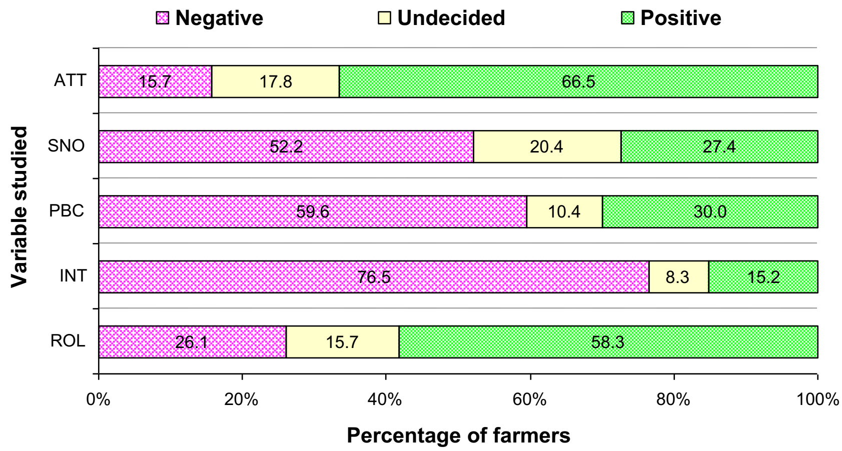

Fig. 2 Farmers' level of agreement in all variables studied. *INT* intention, *ATT* attitudes, *SNO* subjective norms, *PBC* perceived behavioral control, *ROL* risk of loss

attitudes had the highest score (3.34), indicating slightly favorable attitudes toward pesticide reduction, while perceived behavior control had the lowest score (2.70), indicating poor control of pesticide reduction (Table 1).

The three basic variables of the TPB were positively correlated ($P < 0.01$) with farmers' intention to reduce pesticides, while a negative correlation ($P < 0.01$) was noted between intention to reduce pesticides and perceived risk of loss (Table 2). Moreover, intention, attitudes, subjective norms, and PBC were negatively correlated with age, while risk of loss was correlated positively with this variable (Table 3). This relationship indicates that elderly farmers showed high levels of risk loss, but poor intention to reduce pesticide use. On the contrary, intention, attitudes, and subjective norms were positively correlated with education, while risk of loss was correlated negatively with this variable (Table 3). This relationship indicates that well-educated farmers showed low levels of risk loss, but high intention to reduce pesticide use. Farm size did not show any correlation with any of the variables of the TPB model.

The first regression model revealed that attitudes, subjective norms, and PBC predicted well farmers' intention, explaining 55.5% of the variation in farmers' intention (F = 94.14, $P < 0.01$) (Table 4). The second regression model pointed out that attitudes, subjective norms, PBC, and risk of loss were significant predictors of farmers' intention, explaining 64.2% of the variation in farmers' intention (F = 100.05, $P < 0.01$) (Table 4). For the revised TPB model, the predictive validity was even higher than the original model, so that it can be concluded that risk of loss as a new variable in the model can efficiently improve the predictive ability of the TPB.

Discussion

The first goal of the present study was to shed light on the factors explaining farmers' intention to reduce pesticide use by applying the TPB framework. The three basic variables of the TPB explained 55.5% of the variance in farmers' intention to reduce pesticide use and were positive predictors of intention, fully confirming the applicability of the TPB framework. As confirmed by the first regression model, findings provide theoretical support for using the TPB in exploring farmers' intention to reduce pesticide use. Thus, the study adds to the literature on the suitability of the TPB framework in the area of pesticide reduction, as already confirmed in a large range of behaviors, with promising results (Armitage and Conner

Table 2 Pearson's correlation test between all variables of the model studied

Variables	INT	ATT	SNO	PBC
INT	1			
ATT	0.493**	1		
SNO	0.654**	0.541**	1	
PBC	0.538**	0.271**	0.428**	1
ROL	−0.611**	−0.360**	−0.445**	−0.273**

INT intention, *ATT* attitudes, *SNO* subjective norms, *PBC* perceived behavioral control, *ROL* risk of loss

**Significant at $P < 0.01$

Table 3 Pearson's correlation test between demographic variables and all variables of the model studied

Variable	Age		Education		Farm size	
INT	−0.531	**	0.252	**	0.025	ns
ATT	−0.308	**	0.103	*	0.076	ns
SNO	−0.419	**	0.144	*	0.114	ns
PBC	−0.202	*	0.127	ns	0.068	ns
ROL	0.715	**	−0.243	**	0.045	ns

INT intention, *ATT* attitudes, *SNO* subjective norms, *PBC* perceived behavioral control, *ROL* risk of loss, *ns* not significant

**Significant at $P < 0.01$; *Significant at $P < 0.05$

Table 4 Regression analysis for intention to reduce pesticide use

	B	SE	*t* test	*P* value	R^2	VIF
Model 1						
Constant	−0.554	0.201	−2.759	0.006	0.555	
ATT	0.182	0.068	2.693	0.008		1.46
SNO	0.555	0.067	8.321	0.000		1.67
PBC	0.267	0.045	5.926	0.000		1.23
$F = 94.14^{**}$						
Model 2						
Constant	0.848	0.262	3.231	0.001	0.642	
ATT	0.123	0.061	1.998	0.047		1.49
SNO	0.419	0.063	6.670	0.000		1.83
PBC	0.242	0.041	5.927	0.000		1.24
ROL	−0.218	0.030	−7.373	0.000		1.31
$F = 100.05^{**}$						

INT intention, *ATT* attitudes, *SNO* subjective norms, *PBC* perceived behavioral control, *ROL* risk of loss, *VIF* variance inflation factor

**Significant at $P < 0.01$.

2001). In addition, findings offer useful information regarding the TPB factors to be taken in consideration in efforts to minimize pesticide use among farmers. Previous studies in the same or different domains, which used similar theoretical frameworks, found that the TPB constructs could explain 40 to 75% of the variance in farmers' intention (Senger et al. 2017; Bagheri et al. 2019; Rezaei et al. 2019).

The second objective of the study was to test whether the addition of perceived risk of yield losses to the model would upgrade the predictive power of the model concerning farmers' intention to diminish pesticide use. The addition of perceived risk of loss to the model explained 64.2% of the variance in farmers' intention to diminish pesticide use and was a negative predictor of intention. Previous research on farmers' perceptions of weather risks to apple production found that farmers who were more risk averse tended to perceive greater probabilities of farm losses (Menapace et al. 2013). Similarly, Lechenet et al. (2017) reported that shifting to low-pesticide farming is difficult due to uncertainty and risk aversion. A recent study on farmers' hesitation to lessen pesticide use showed that farmers disliked risk of production losses because yield was a primary target and, therefore, the risk of production losses by pest infestation hampered the reduction in pesticide use (Chèze et al. 2020). In Denmark, an important proportion of farms were sprayed with pesticides to ensure high yield, rather than profit (Pedersen et al. 2012). The variable of perceived risk of loss is rooted in utilitarianism, a normative ethical theory that determines right from wrong by focusing on outcomes (Mulgan 2014). The basic idea behind utilitarianism is to maximize utility, which is often defined in terms of well-being or related concepts. In this context, most farmers think only about the benefits of using pesticides and, therefore, apply them on their farms, while they pay less attention to financial and environmental costs. Thus, perceived benefits of using pesticides outweigh their costs. Both models in the current study showed that subjective norms and PBC predicted well farmers' intention. Therefore, the social pressure and the perceived easiness with which farmers could adopt pesticide reduction influenced intentions.

Participants reported a poor intention to minimize pesticide use, despite relatively positive attitudes that were expressed toward that behavior. This finding may be attributed to the low scores of subjective norms and perceived behavior control among participants, which indicated that farmers did not pay attention to the social pressure to engage in reduction of pesticide use and had poor control of pesticide reduction. It was also noted that elderly farmers showed poor intention to reduce pesticide use compared with their young counterparts. Similarly, less educated farmers showed poor intention to reduce pesticide use compared with their well-educated counterparts. Based on the above findings, efforts to reduce pesticide use should target at improving the levels of subjective norms and PBC, especially among elderly and less educated farmers. Thus, this paper contributes to the TPB model by identifying significant effects of certain demographic variables (e.g., age and education).

Given the significant impact of subjective norms on predicting farmers' intention in both models of the current study, it is reasonable to assume that highlighting the environmentally oriented behavior of important people that farmers value and identify themselves with would be effective in terms of using social influence for shaping a positive intention. This can refer to education programs featuring peer farmers and pesticide experts (e.g., crop consultants and pesticide retailers). According to Armitage and Conner (2001), subjective norms were found as the least influential variable in the TPB model. Nevertheless, social norms always influence intentions to some extent, because people normally shape intentions and reach decisions driven by important reference groups (Burton 2004).

Given the important role of PBC in predicting farmers' intention in both models of the current study, it is reasonable to assume that higher beliefs about farmers' own abilities and skills to reduce pesticide use would increase their entrepreneurial intention. PBC refers to people's expectations by the performance of a given behavior, considering the requisite resources they have and the obstacles they feel they may encounter (Ajzen 2002). Therefore, when people feel that they possess the required resources to perform a behavior with few or no significant obstacles, they show high PBC (Ajzen 2002). Relevant recommendations could include education to enable farmers to develop their own competencies for prudent use of pesticides allowing farmers to take responsibility for their current situation.

The results of the present study also showed that several characteristics could affect farmers' intention to diminish pesticide use. Young age of farmers was associated with high willingness to reduce pesticide use. Previous studies also showed that young farmers were more willing to adopt certain best management practices (Rahelizatovo and Gillespie 2004). This finding probably reflects a greater environmental awareness and better information of the benefits of pesticide reduction by young farmers, through the more diverse range of information sources used, which may encourage intention to reduce pesticide use. Moreover, good education of farmers was associated with high willingness to reduce pesticide use. A previous study showed a positive association between education and adoption of nutrient management practices (Lambert et al. 2006), as also observed in the present study. This finding could be attributed to the increased levels of farmers' awareness of the benefits of pesticide reduction and the increased ability to overcome obstacles in the implementation of non-chemical pest control with high levels of education, which in turn may encourage intention to reduce pesticide use.

Findings of this study might be important for future interventions concerning reduction of pesticide use. Appealing to farmers' subjective norms toward risky pesticide use and their control over non-chemical pest control practices might be a good strategy when designing prevention safety campaigns dealing with farmers' use of pesticides. Findings add to the current literature the important role of subjective norms in farmers' intention to reduce pesticides. From this point of view, future studies in this area should focus on additional measures of subjective norms that can capture different dimensions of social pressure that farmers may experience when following certain behaviors.

The present study has several limitations that must be taken into account for better interpretation of findings. First, the study assessed farmers' intention to reduce pesticide use by exploiting one specific method, i.e., the TPB model, while different methodologies (e.g., focus groups, agent-based models, role-playing games, farmers' willingness to pay, and discrete choice experiments) have been used to examine farmers' behavior in the adoption of environmentally friendly practices of production. For example, approaches from the economics discipline could provide useful tools to quantify the relative influence of different drivers on farmers' decisions, or to assess the role of different drivers in actual decisions. Therefore, complementary methodologies could be employed in future research to validate or refine findings. Second, the study focused on the main variables of the TPB plus one additional construct, while other potentially relevant factors (e.g., knowledge of pesticide risks, environmental concerns, incentives) were not included in the research model. Future research could address this limitation by including additional exogenous variables to the model. Third, the cross-sectional nature of this study gives a rather limited snapshot of conditions at a single point in time. Therefore, longitudinal studies beyond a single moment in time are needed to explore changes in the characteristics of the target population. Finally, considering the overall research according to the TPB model, this study focused on intention and did not capture actual behavior. Although intention is the strongest predictor of behavior (Armitage and Conner 2001), consistency in correlation relationships between intention and behavior cannot rule out that other variables are responsible for the noted relationships (Webb and Sheeran 2006). For example, intentions may affect to a lesser extent behavior when social reaction to the behavior is possible, when there is lack of control over the behavior, and when habit formation is involved (Webb and Sheeran 2006). Moreover, people's motivation varies over time, so that best intentions do not always translate into behavior (Sheeran and Webb 2016). Actual behavior is affected by a second act of willing based on a specific if-then plan that promotes goal realization (implementation intentions) (Gollwitzer and Sheeran 2006). Whatever the case may be, this limitation of the current study needs to be studied in future research.

Conclusions

This study attempted to determine factors affecting farmers' intention to diminish pesticide use. The objective of the study was twofold: (i) to examine the use and efficacy of the TPB in terms of the intention to avoid pesticide application among farmers and (ii) to improve the predictive ability of the TPB by inserting perceived risk of loss as a new construct to the model. Three major findings can be summarized. First, the TPB is an effective framework to predict farmers' intention to diminish pesticide applications, as it captured a substantial part of the variation in farmers' intention. Second, the results support for the usefulness of inserting perceived risk of loss into the TPB framework. The construct of perceived risk of loss seemed to be useful in predicting farmers' intention toward diminishing pesticide applications. Third, our findings revealed that poor control of pesticide reduction (high-perceived barriers) and high perceived risk of loss drive farmers' intention to reduce the use of pesticides. Extending the findings beyond the TPB domain, future efforts should encourage farmers to obtain and engage with technical support that advances alternative methods of crop protection focusing on agro-ecology and integrated pest management. Such support on alternative methods of crop protection could help farmers to increase their confidence of successfully applying non-chemical methods of pest control. Highlighting the benefits of using non-chemical pest control methods will reinforce attitudes that are more positive toward pesticide use reduction. To this end, stimulating farmers to join group learning with platforms of farmer-led knowledge exchange that focuses on pesticide use is essential. Methodologically, future research could apply more extensive measures of the TPB or perhaps different methodologies (e.g., economics approaches) with respect to farmers' intentions, to replicate or challenge observations of the current study.

Author contribution CAD: conceptualization, methodology, field data collection, statistical data analysis, validation, writing, reviewing and editing, and preparing final draft

Data availability All data generated or analyzed during this study are available from the corresponding author on reasonable request.

Declarations

Ethical approval A research article following the ethical standard of the institution.

Consent to participate Not applicable.

Consent to publish Not applicable.

Conflict of interest The author declares that they have no conflict of interest.

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