Protecting Walnut Orchards against Frost: A Test of Extended Theory of Planned Behavior

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ABSTRACT

Cold stress is a major environmental constraint that limits nut productivity worldwide. Late spring frost is identified as a yield-reducing factor in Persian walnut production as well. Despite significant improvements in cold and freezing tolerance methods, orchardists have not taken advantage of these recommended protection methods. This study examined determinants of walnut orchardists' frost-protection behavior, using the extended theory of planned behavior (TPB) as a conceptual framework. Based on TPB assumptions, frost-protection behavior is mediated by a series of constructs. The purpose of this research was to examine the role of TPB variables (extended by orchard-system profile) in meeting the necessities of performing active and passive methods of frost protection. A total of 91 orchardists completed a baseline questionnaire that included the TPB constructs. The present investigation was carried out in the major walnut growing site of Sepidan County, western Fars Province, Iran. The results from the hierarchical multiple regression showed that the behavioral attitude, perceived behavioral control (PBC), intention, orchard-system profile, and interaction of orchard-system features and PBC were significant predictors of frost-protection behavior in the prospective sample. Results of the present study provided evidence that the extended TPB is a useful framework for understanding orchardists' frost-protection behavior.

1. Introduction

The protection of permanent cold-sensitive species, like nut trees, against frost damage is an annual challenge in many growing regions (Battany 2012) like Iran. According to field observations, this challenge results in annual yield losses and other side effects (Bakhshinejad 2014; Agri-Jihad Ministry Stat 2017, unpublished report). It appears that orchardists' adaptive misbeliefs regarding frost are particularly a response to perceptions and economic fatalism to justify their farming style. Studies on the late spring frost damage to the Persian walnut (*Juglans regia L.*) are largely focused on the mechanisms, quantifications, technical procedures, and practices to alleviate plant stress (Beineke 1978; Lindow 1983) and neglect the social dimension of farmers' behavioral change. It should come as no surprise then that frost-protection technologies and methods have had limited practical application for local-level users.

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Reviews of research on determinants of farmers' frost-protection behavior resulted in a number of factors based on local availability and costs (Webb and Snyder 2013) and risk perceptions or beliefs about the existence and characteristics of a natural hazard (Nigg and Mileti 2002; Arbuckle et al. 2015). Indeed, the focus of research so far has been more on the technical and economic factors and less on the underlying psychological constructs (e.g., intention, perceptions, and beliefs) associated with farmers' decisions and behavior (Borges et al. 2014a). Among theoretical models that explain human behavior (attribution theory, bureaucracy theory, cognitive dissonance theory, technology acceptance model, theory of reasoned action, etc.; Lee 2006), this paper uses sociobehavioral constructs from the theory of planned behavior (TPB) to analyze factors affecting the orchardists' frost-protection behavior. However, the main rationale behind choosing the TPB was to gain an understanding of the predictable nature of frost-protection behavior by moving away from a broad generalization of common rational cost–benefit beliefs, perceptions, and tacit or instinctive behavior (Lee 2006). TPB constructs—as opposed

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to other available leading behavioral theories that may help explain farmers' behavior—are perceptions that focus on a specific set of context-based conditions (Ajzen 1991). It seems that the influence of different contextual situations (farm size, soil structure, access to resources, etc.) has been found to be important in changing farmers' practices (Karami and Mansoorabadi 2008). TPB considers not only the farmers' own abilities (Taylor and Todd 1995) and locus of control, but also the outside influences—orchard systems' inputs—associated with their beliefs and decisions (Lamb 2015) to practice frost-protection methods. However, the TPB's openness to expanding its structure and hosting external variables and additional constructs readily discloses specific behavioral causes and reasons with a cross-sectional design (Rhodes 2015). Most of these factors are critical mediators of behavioral change (Rhodes and Pfaeffli 2010) that spurred a series of exorbitant model tests. This is while other behavioral theories are exactly more sacrosanct, in that their model structures are less open to testing with additional variables (Rhodes 2015). Further, the simple TPB and extended structures have gained some support in climate change research and other proenvironmental farming behavior in Iran (Sharifzadeh et al. 2012, 2014; Monfared et al. 2015; Rahmati Ghofrani et al. 2017; Rezaei et al. 2018), albeit not in particular, absolute relationships between the antecedent variables and constructs (Yazdanpanah et al. 2014).

The starting point of this paper is a review of the literature. During this review, we propose a reconceptualization on shortcomings of current studies, particularly regarding the determinants of adoption and application of frost-protection methods and devices. The study is the first of its kind in examining the frost-protection behavior in Iran. The authors hope that the outcome of the current study can benefit smallholders as well as large-scale woody plant gardeners, policy-makers, researchers, technology developers, and agribusinesses and will be of significant value in filling in the gaps that exist in the literature to date. The remainder of this paper is organized as follows. Section 3 presents the methodology used within this study, followed by the key findings and the discussion. The paper concludes by considering the implications of the study for policy and practice.

2. Theoretical base

A growing body of literature considers the intrinsic and extrinsic agronomic, sociocultural, psychological, and economic factors that may influence farming decisions in different contexts (e.g., Feola et al. 2015; Meijer et al. 2015; Öztekịn 2011; Burton 2004; Siebert et al. 2006). These studies have employed both descriptive and prescriptive approaches to identifying various aspects of farmers' behavior (e.g., innovation studies, conservation agriculture, and rural studies). However, descriptive studies mostly focus on the analysis of determinants of farming behavior (Mase et al. 2017; Arbuckle et al. 2015; Burton 2004; Siebert et al. 2006; Stewart et al. 1984), whereas prescriptive studies specify the reasons underlying such behavior. So, they focus on how to counter one or more causes of farming behavior (Sharifzadeh et al. 2014). However, there are few reports on context-based determinants of farming behavior under severe climatic conditions like frost (Stewart et al. 1984; Miller and Downton 1993; Rimal and Schmitz 1999). The potential of sociopsychological models to contribute to individual preferences of orchard-/farming-system users is clear in diverse fields of agriculture (e.g., conservation, animal welfare, diversification, organic farming, and proenvironmental agricultural practices; Beedell and Rehman 2000; Wauters et al. 2010; de Lauwere et al. 2012; Bruijnis et al. 2013; Läpple and Kelley 2013; Price and Leviston 2014). This study invokes the growing body of literature concerned with frost-protection behavior (Wisniewski et al. 2003; Rihan et al. 2017; Ahmed et al. 2015). However, there are few studies on passive and active methods of adaptation and tolerance to spring frost in walnuts (Aslamarz et al. 2011). Passive methods (e.g., plant selection; site selection; appropriate use of cultural and management practices, like canopy trees; plant nutritional management; proper pruning; plant covers; and modification of the physical environment of the crop, like avoiding soil cultivation, irrigation, removing cover crops, soil covers, trunk painting, and bacteria control) are usually less costly than active methods (e.g., wind machines, sprinkling irrigation, foam insulation, and open air heating). Often, the benefits of implementing passive methods outweigh the advantages of the need for active practices (Ghaemi et al. 2009; Webb and Snyder 2013). However, active methods are implemented just before or during a frost night to prevent ice formation within sensitive plant tissue (Ribeiro et al. 2006). It seems that the overall aim of both types of strategies is to maintain plant temperatures high enough to minimize extracellular ice formation (Webb and Snyder 2013). Frost prevention can be achieved by performing methods that are believed to avert or minimize the damage when frost is expected, although these methods are often inadequate for protecting crops under severe frost conditions (Skrīvele et al. 2008).

Whereas scientific understanding of frost-protection techniques (devices and procedures) is firmly established, public understanding of the phenomenon varies widely (Chowdhury and Haque 2008). In particular, farmers' adaptation to and mitigation of frost threat is characterized by their subjective interpretations and observations of their last experiences with frost. This descriptive paper contributes to the existing literature on the determinants of frost-protection behavior in orchard systems by using psychological constructs from the TPB to explore the factors that influence orchardists' decisions in a dynamic context of climatic events to gain improved orchard yield. The theory of planned behavior (Ajzen 1985) posits that beliefs provide the cognitive basis upon which attitudes toward objects and actions are shaped, and those attitudes can be highly predictive of the intention toward behavior (Arbuckle et al. 2015). Three kinds of factors are likely to affect frost-protection behavior as depicted in the TPB model (Ajzen 1985): 1) attitudes reflecting expectancies and values associated with frost-protection methods, 2) social expectations of local norms concerning the frost protection, and 3) perceived control over orchardists' frost-protection behavior (e.g., orchardists' self-perceived ability, self-concept, and self-efficacy to use frost-protection means and methods).

Furthermore, this study assumes that frost-protection behavior is proenvironmental in that it concerns both environmental sustainability and individual preferences. Perhaps the effectiveness of such behavior depends on addressing the factors, experiences, and support that give rise to it and potentially sustain it over time (MacTavish 2011).

This section does not intend to provide a comprehensive survey of the TPB debate, but rather profiles the parameters with significant contributions to the research. According to the purpose of this research, the model we constructed consists of three main factors: behavioral attitude, perceived subjective norms, and perceived behavioral control (PBC). All three factors (H1, H2, and H3, respectively) influence the intention toward performing frost-protection methods directly. To acquire more information, the behavioral attitude factor is split into cognitive (perceived ease of use and usefulness) components. Based on TPB, any human action is guided by behavioral intention (H4) and PBC (H5). However, different scholars present alternative theoretical frameworks for analyzing drivers of readiness or desire to perform a given behavior among farmers. According to the models presented in these studies, other variables could mediate the intention–behavior relationship (Reuter et al. 2010; Schwarzer 2008). Sometimes, volitional processes that link goal-directed responses to situational cues mediate the intention–behavior relation (Sniehotta et al. 2005; Caudroit et al. 2011). Perhaps these frameworks incorporate agronomic relationships between farming-system features into the model (H6) (Negri and Brooks 1990; Hennessy and Rehman 2007).

3. Method

a. Study area

The population of interest consists of the walnut orchardists who reside in Sepidan County, Fars Province. The study area is located at elevations of 3000 m above mean sea level. Mean annual rainfall of the region is about 678.3 mm (Fars Meteorological Bureau 2015). The average annual temperature is about 14.8°C (and a range of −15.5° to 36.4°C). Of the 69 308 ha of cultivated land in Sepidan County, 19 959 ha of the orchard area consists mainly of walnuts, pears, and apples. Walnut orchards make up only 15% of the total geographical orchard area with annual production of 14 250 tons. The farm size is different—small farms with orchard areas consisting of 1–10 walnut trees form about 55% of the total orchard area. About 45% of the area is made up of farms with 10–15-ha orchards and over 15 trees. The dominant farming system in the region relies on small, family-based mixed farms or landless farmers, as do much of the rest of the Iranian farming systems. Therefore, those who practice integrated subsistence agriculture and livestock breeding with orchards' production (the holders of 10–15 walnut trees) are considered rich, large-scale farmers in the study area. This is because most of the walnuts produced in the region are marketable due to their high quality. By selling these marketable walnuts, the annual income earned would be 550 000 000 Iranian rials [equal to almost $13 100 (U.S. dollars)] per garden in the study area. Compared to the annual farming income in the region, which is almost 200 000 000 Iranian rials per farm (equal to almost $4760), it would be rational to categorize the owners of 10–15 walnut trees as rich, large-scale farmers.

b. Data collection

To determine the sample size that represents the population of medium- and large-sized holders, Cochran's formula was used (Cochran 1977):

$$n = \frac{\frac{z^2pq}{d^2}}{1 + \frac{1}{N}\left(\frac{z^2pq}{d^2} - 1\right)} = \frac{\frac{(1.96)^2(0.5)(0.5)}{0.0025}}{1 + \frac{1}{112}\left[\frac{(1.96)^2(0.5)(0.5)}{0.0025} - 1\right]} = 87 \approx 91\,, \qquad (1)$$

where n is the sample size; z is the tabular value of the standardized normal variate corresponding to the level of significance desired ($z = 1.96$ for the confidence level of 95%); p is the estimated proportion of an unknown attribute in the population (the maximum variability of 0.5 is adopted); q is the precision equal to $1 - p$; and d is the desired level of absolute precision required on either side of the proportion (the adopted value for precision is ±5%). Finally, the target sample size was increased to 91 subjects to account for an anticipated 5% rate of subject withdrawal.

Using a simple random sampling technique, 91 out of approximately 112 orchardists were selected as our respondents. Based on the socioeconomic features of the study area, respondents were representatives of large-scale orchard owners whose main source of income was their annual walnut production; most of them were owners of 10–15 walnut trees. It is important to note that high levels of walnut orchard income tend to be associated with high quality and production capacity, and the nut's price provides a rationale for responding to the environmental stress.

A household survey was used to elicit information on respondents' attitudes, perceptions, beliefs, and behavior with respect to frost protection. Because very little is known about the extent and the way orchardists actually operate frost-protection methods and the underlying beliefs, attitudes, normative referents, and control factors affecting frost-protection behavior, we conducted field observations, informal interviews, and an exploratory survey in the study area. Respondents were asked about their experiences and viewpoints on frost protection in these interviews. The information was used to develop the final questionnaire. A pilot study involving 27 semistructured interviews was then undertaken in the Homayejan District of Sepidan County. During this presurvey, a complete list of all accessible outcomes regarding orchardists' behavioral, normative, and control beliefs was determined. Homayejan District was chosen because the area has undoubtedly suffered from frost.

c. Variables and scaling

The approach used by Wauters et al. (2010) is adopted to measure frost-protection behavior. Therefore, the dependent variable was measured by means of 10 dummy variables. Each of these dichotomous variables was equal to 1 when the particular frost-protection practice was applied and was 0 otherwise. The dummy codes are then multiplied with the efficiency weights to produce values corresponding to each behavior and summed. Weighted behavior scores ranged from 4.22 to 12.20. The practices considered are dropped irrigation, surface irrigation, furrow irrigation, wind machines, sprinkling irrigation, fogging, open air heating, burning fuel and tires, foaming insulation, and covering trees with insulating materials (e.g., polyethylene cages, plastic, cloth tents, canvas, and gunnies). The abovementioned practices were among the active and passive methods of frost protection in orchards that were determined by subject matter specialists, experts, and field observations during the presurvey phase.

The remainder of the questionnaire involved five-point Likert-scale assessments of "ease of use" and "usefulness" components of attitude conducted by means of questions on a scale from "1 = extremely disagree" to "5 = extremely agree." The injunctive subjective norms affecting use of frost-protection methods were probed with expectancy and belief components suggested by the TPB. The general approach used by Artikov et al. (2006) and Hu et al. (2006) is adopted to measure the subjective (social) norm variables. The higher the norm components (expectancies and values) are, the more encouraging or discouraging influence they will have on orchardists' use of active and passive frost-protection methods. Similarly, the more value an orchardist places on the view of a certain individual/group, the more influence that particular individual/group will have on frost-protection methods.

Behavioral control belief includes both internal and external control mechanisms. The same general approach (five-point Likert-type scale) was used to measure the PBC components. PBC variable was then developed by multiplying the two external and internal control variables.

The intention scales were composed of three elements: (i) an action (e.g., performing frost control), (ii) target (a frost-protection device), and (iii) context (at their gardens) in the time frame of the next spring season (Ajzen and Fishbein 1977). To decrease the time interval between intention and behavioral measures, the questionnaires were distributed during winter. The last part of the questionnaire consisted of orchardists' individual (age, education, region, etc.) and orchard-system profile questions concerning farm characteristics: the size of the orchard; types and amount of fertilizers, poisons, and pesticides; income; costs; and land tenure system. Table 1 presents a summary of different scales

TABLE 1. Scales for measuring determinants of frost-protection behavior among walnut orchardists.

Scale (No. of items)	Description
Attitude	
Ease of use (7)	How easy is it to perform frost-protection methods in a garden on a scale from "1 = extremely difficult" to "5 = extremely easy."
Usefulness (7)	The degree to which an orchardist believes that using a particular frost-protection method would enhance his or her performance.
Subjective norms	
Expectancies and values (5)	How likely it is that various emotional, public community, peer group, expert, and landlords and other orchardists' relationships with persons/groups believe that frost-protection methods should be performed in gardens.
Motivation to comply (5)	Measured from answers to the question "How much do you value the views of these others on this matter?" from options of "1 = low value" to "5 = very high value."
PBC	
External control beliefs (9)	Orchardists' estimates of how the influence of frost-protection methods on their gardens is limited by 1) access to frost-protection devices, 2) external support (credits, insurance, and education), 3) markets, 4) price, and 5) inputs on the 1–5 scale.
Internal control beliefs (8)	Focusing on (e.g.,) technical and economical ability, self-concept, and self-efficacy, internal control is measured by orchardists' estimates of how the influence of frost-protection methods on their gardens is limited by 1) how important is it to enhance your ability to apply the frost-protection method and 2) promote self-concept of using a particular device on the scale from "1 = extremely unimportant to me" to "5 = extremely important to me." Answers reflect the desire for operational control over behavior.
Intention	
Action (4)	Orchardists' intention to perform frost-protection method: "I intend to equip my garden with frost-protection devices for spring" on a five-point scale from 1 (strongly disagree) to 5 (strongly agree).
Target (6)	I plan to install a frost-controller device at the garden to attain a higher income, livelihood security, to help my garden continue to thrive, etc.
Context (6)	I want to perform frost-protection method given the impact and presence of contextual barriers (institutional support, etc.)

related to the development of the questionnaire for this research. Table 2 provides the reliability and validity values.[1] In this study, analysis was performed using IBM SPSS version 21.

[1] The convergent validity was assessed using factor loadings. Applying confirmatory factor analysis, the initial validity of the theoretical framework was assessed. From the findings, despite an adequate model fit [χ^2/df = 1.65, where df = degrees of freedom; confirmatory fit index (CFI) = 0.87; normed fit index (NFI) = 0.91; root-mean-square error of approximation (RMSEA) = 0.05], two items from "Ease of use" (Ease5 and Ease6), three items from "Usefulness" (Use5, Use6, and Use7), and two items from "External control beliefs" (Exc6 and Exc8) were removed from the analysis due to low factor loadings. All other items provide evidence for convergent validity regarding their significant loadings higher than or very close to 0.50 on their corresponding factors. So, based on the modified theoretical framework, a better model fit is achieved (χ^2/df = 2.52, NFI = 0.92, CFI = 0.96, RMSEA = 0.06). The internal consistency among items was also measured using Cronbach's alpha. The Cronbach's alphas were higher than the minimum cutoff score of 0.65 (Lee and Kim 1999). Further, the values of average variance extracted (AVE) for all of the constructs were higher than thresholds (Fornell and Larcker 1981). AVE is calculated as follows: Σsquared multiple correlation (SMC) between the constructs SMC/(ΣSMC+ Σstandard measurement error).

4. Results

a. *What are the features of walnut orchard systems confronting late spring frost?*

There was a bias in the sample toward males (100%), low-income class (71.7%), and low education levels (primary school; 33.3%). This may have been due to a number of reasons; namely, the study specified that the orchardists who filled out the questionnaires must be the head of household in the observation period or representative of the walnut growers' population in the region (e.g., planting 10–15 walnut trees in their orchard). The average age of the orchardists was 49.2 years. The number of respondents with low levels of education in this sample was 60% (2.2% illiterate, 33.3% primary school, and 24.4% secondary school attendants). It can be concluded that orchardists received a lower education than the average Iranian society. We found a significant negative correlation between age and education ($r = -0.5$, $p < 0.1$). The huge discrepancy between income resulting from walnut products and nonfarm income reflects that there seems to be a challenge with regard to agricultural sector activities.

TABLE 2. Measurement model: validity and reliability. Two items from ''Ease of use'' (Ease5 and Ease6), three items from ''Usefulness'' (Use5, Use6, and Use7), and two items from ''External control beliefs'' (Exc6 and Exc8) were removed from the analysis due to low factor loadings. SMC is squared multiple correlation (described in footnote 1) and CR is composite reliability.

	Constructs	Factor loadings	SMC	Cronbach's α	CR	AVE
		Behavioral attitude				
Ease of use	Ease1	0.755	0.570	0.78	0.637	0.577
	Ease2	0.815	0.664			
	Ease3	0.798	0.637			
	Ease4	0.906	0.821			
	Ease7	0.442	0.195			
Usefulness	Use1	0.843	0.710	0.82	0.716	0.677
	Use2	0.949	0.900			
	Use3	0.843	0.710			
	Use4	0.625	0.390			
		Perceived subjective norms				
Expectancies and values	Exp1	0.604	0.365	0.69	0.630	0.562
	Exp2	0.773	0.597			
	Exp3	0.850	0.723			
	Exp4	0.757	0.573			
	Exp5	0.746	0.556			
Motivation to comply	Mot1	0.729	0.532	0.85	0.657	0.598
	Mot2	0.856	0.734			
	Mot3	0.800	0.640			
	Mot4	0.729	0.532			
	Mot5	0.744	0.553			
		PBC				
External control beliefs	Exc1	0.706	0.498	0.82	0.602	0.523
	Exc2	0.696	0.485			
	Exc3	0.729	0.531			
	Exc4	0.806	0.650			
	Exc5	0.690	0.475			
	Exc7	0.756	0.571			
	Exc9	0.675	0.456			
Internal control beliefs	Inc1	0.794	0.630	0.79	0.749	0.717
	Inc2	0.783	0.613			
	Inc3	0.853	0.727			
	Inc4	0.868	0.754			
	Inc5	0.883	0.780			
	Inc6	0.803	0.644			
	Inc7	0.917	0.841			
	Inc8	0.868	0.754			
		Intention				
Action	Act1	0.893	0.797	0.69	0.870	0.861
	Act2	0.935	0.874			
	Act3	0.929	0.863			
	Act4	0.956	0.913			
Target	Tgt1	0.682	0.465	0.85	0.751	0.721
	Tgt2	0.837	0.701			
	Tgt3	0.818	0.669			
	Tgt4	0.901	0.813			
	Tgt5	0.909	0.827			
	Tgt6	0.922	0.851			
Context	Conx1	0.849	0.721	0.80	0.812	0.794
	Conx2	0.875	0.767			
	Conx3	0.892	0.795			
	Conx4	0.909	0.827			
	Conx5	0.889	0.790			
	Conx6	0.931	0.868			

Using the *k*-means algorithm, orchardists were clustered into two groups based on their orchard-system portfolio in response to a late spring frost. Accordingly, the less-risk-oriented orchard systems, named ''process-oriented systems,'' consisted of 51 small-holders regarding the orchard size and cost of fertilizers and pesticides, while at the same time achieving a satisfactory economic return (e.g., yield, price, and profitability and marketability). Compared to the less-risky systems, the so-called ''product-oriented systems'' contained 38 risk-oriented orchards (42.7%) with considerable reliance on external inputs (e.g., fertilizers and pesticides). A lower supply of products and even a lower price level, versus the larger size of the orchard, was the prominent feature of this cluster.

b. *Are orchardists interested in using frost-protection methods?*

Table 3 shows the numbers of orchardists who reported that various frost-protection methods were applied in their orchards during the last spring frost in 2014. In this table, we show the percentages of the orchardists' population that performed both active and passive methods of frost protection. These results suggest that in total, 91 farmers (out of 91) reported having adopted frost-protection practices (Table 3). The most common frost-protection strategies were ''burning fuel and tires'' (100.0%), ''surface irrigation'' (78.9%), ''furrow irrigation'' (70.0%), and ''covering trees with insulating materials'' (26.9%). The ''0'' is set to indicate ''nonusers'' of a particular frost-protection method. Boldface entries indicate maximum usage of a particular frost-protection method. As the efficiency of operating the particular frost-protection method was important, the experts' viewpoints regarding the issue were determined. Analytical hierarchy methodology was used generate the efficiency weights from pairwise comparison judgment matrices. Column 3 in Table 3 indicates the efficiency weights of applying frost-protection methods from walnut experts' viewpoints. The opinions of walnut experts were elicited for comparing the elements. Elements were compared pairwise, and judgments on comparative attractiveness of elements were captured using a rating scale. Higher rating shows superior attractiveness, compared to lower ones (Ramanathan 2006). The final weights represent the rating of the frost-protection alternatives in achieving the goal. As shown in the table, open air heating, burning fuel and tires, and fogging are the most efficient frost-protection methods in the region. This is while the results obtained by Ribeiro et al. (2006) and Battany (2012) had shown that wind machines were more effective under conditions of strong thermal inversions in the apple orchards. However, field observations reveal that open air heating is hindered by two factors: 1) the significant cost of equipping orchards with canals to circulate warm air from the source to the cooled ends and 2) the limited stock of fossil fuels presented to farmers and orchardists and the fixed quota of subsidies. The canals are expensive to install, and their proper design and maintenance requires technical skills. It is important to note that based on the experts' viewpoints, the active and passive protection behaviors mentioned in this study are complementary rather than competitive with each other when assessing their effects on performances of trees facing frosts. Thereby, given the differential efficiency ratings of these different protection practices, the dummy codes are multiplied by the efficiency weights before adding them up.

TABLE 3. Percentage of orchardists reporting different degrees of use of frost-protection methods in the last spring frost (2014). Boldface indicates maximum usage of a particular frost-protection method.

Frost-protection methods	Users (frequency/%)	Weight
Dropped irrigation	8/8.9	1
Surface irrigation	71/78.9	1.22
Furrow irrigation	63/70.0	1.11
Wind machines	1/1.1	1.56
Sprinkling irrigation	15/16.7	2.22
Fogging	0/0.0	2.44
Open air heating	2/2.2	3.67
Burning fuel and tires	**90**/100.0	2.44
Foaming insulation	4/4.4	1.22
Covering trees with insulating materials	38/42.2	1.78

c. *What determinants are the major contributors to applying frost-protection methods?*

The results in Table 4 display the means, standard deviations, and correlations between regression variables. As expected, almost all of the zero-order correlations were significant. The strong correlation between PBC and intention suggests that the higher the ability, self-concept, and confidence to control and protect orchards from frost damage, the stronger the intention to learn these practices for the future. This is perhaps unsurprising, as additional variables mediate the intention–behavior relationship (Armitage and Conner 2000). As it seems that the future structure of farming remains a function of the number of new entrants (Hennessy and Rehman 2007), farming-system characteristics and features are among the factors held to mediate the

TABLE 4. Descriptive data for measures included in regression analysis. The first variable values range from 0 to1, variables 2 to 5 were measured on scales that ranged from 1 to 5, and the Y variable was measured on a scale from 0 to 18.66. Note that * refers to $p < 0.05$ and ** refers to $p < 0.01$.

Variable	M/std dev (n = 90)	1	2	3	4	5	6
Orchard-system profile	—	1					
Behavioral attitude	2.66/0.51	−0.08	1				
Perceived subjective norms	3.64/1.31	−0.24*	0.40**	1			
PBC	2.97/1.07	−0.15	0.64**	0.70**	1		
Intention	3.26/1.06	−0.04	0.54**	0.67**	0.83**	1	
Frost-protection behavior	7.38/1.81	−0.22*	0.24**	0.54**	0.66**	0.64**	1

interactions of intention with behavior (Latruffe et al. 2013) in this study.

To be consistent with the approach taken by Povey et al. (2000) and Wenzel (2002), a hierarchical multiple regression analysis was then carried out in three stages, using frost-protection behavior as the dependent variable. To reduce multicollinearity effects, all variables were mean centered, except that of the orchard-system profile, which was as a dummy variable. The independent variables were the behavioral attitude, perceived injunctive norms, and PBC in the first block; intention, PBC, and the orchard-system profile in the second block; and interaction terms of orchard-system profile × PBC and orchard-system profile × intention in the third block. The interaction terms (e.g., orchard-system profile × PBC and orchard-system profile × intention) were calculated by multiplying each pair of variables. Using the variance inflation factor's (VIFs) typical threshold value, variables with VIF values greater than 10 (i.e., tolerance >0.1) were discarded. So, the interaction term between orchard-system profile and intention exceeded the multicollinearity threshold of 10 (Hair et al. 1998) and thus was not included in the model. The VIFs of all other variables reported in Table 5 were lower than the commonly accepted multicollinearity threshold. The VIFs for behavioral attitude, subjective norms, PBC, intentions, orchard-system profile, and the interaction term between orchard-system profile × PBC were 1.74, 2.26, 5.94, 3.74, 9.59, and 9.42, respectively, in predicting frost-protection behavior, which provides evidence against multicollinearity.

All independent variables were entered into the equation in the first and second blocks using enter regression procedure. However, stepwise procedure was used in the third step to analyze the exploratory nature of the interaction term. It is evident from Table 5 that behavioral attitudes and PBC accounted for a significant proportion of the variability in frost-protection behavior in the first block ($R^2 = 0.50$). Therefore, H1 and H3 are confirmed by the results. Limited evidence is found for the second hypothesis that subjective norms are

TABLE 5. Hierarchical multiple regression analysis predicting frost-protection behavioral intention. Note * refers to $p < 0.05$ and ** refers to $p < 0.01$.

Predictor	R^2	R^2 change	F change	df	Significance	Step 1β	Step 2β	Step 3β
Block 1	0.50	0.50	28.92	85	$p < 0.001$			
Behavioral attitude						−0.29**		
Perceived subjective norms						0.13		
PBC						0.76**		
Block 2	0.54	0.04	3.68	83	$p < 0.05$			
Behavioral attitude							−0.30**	
Perceived subjective norms							0.03	
PBC							0.53**	
Intention							0.32*	
Orchard-system profile							−0.14	
Block 3	0.58	0.03	7.19	82	$p < 0.001$			
Behavioral attitude								−0.28**
Perceived subjective norms								−0.005
PBC								0.32
Intention								0.36*
Orchard-system profile								−0.70**
Orchard-system profile* PBC								0.58**

important for orchardists' intention to perform frost-protection methods (H2). Godin and Shephard (1990) had shown that subjective norms were generally not associated with intention. Niles et al. (2016) also stated that little evidence was available to confirm the subjective norms–intention relation in the context of climate change adaptation among New Zealand farmers. Similarly, it parallels the results of a meta-analysis by Armitage and Conner (2001), who found the weakest role for subjective norms as a predictor of intention in comparison to attitude and PBC. As Willnat et al. (2002) indicated, social norms may inhibit the individual's willingness and motivation to perform in public settings. Detert and Edmondson's (2007) and Young's (2014) research revealed that in order to minimize the probability of losing face, individuals often remained inactive in public interactions. In sum, to further our understanding, several factors (e.g., descriptive norms as the perceptions of what peers and other farmers do; trust in peers, experts, and the community at large; and the tendency toward self-scrutiny in order to avoid making mistakes) needed to be investigated. PBC was found to be the strongest predictor of frost-protection behaviors, whereas the behavioral attitude was found to be negatively, directly and indirectly, related to frost-protection behaviors. This finding could be interpreted as follows: when an orchardist desires to perform a protection behavior, the attitude becomes a pressure instead of a motivator. Although behavioral attitude was assigned a positive weight when used alone, it seems that it is given a negative weight when the behavioral attitude and PBC predictors are all used together. This would suggest that orchardists with a more positive attitude, who believe that frost-protection methods are easy and useful enough to combat freeze damage and cold injuries, would be less likely to perform the related method when perceiving their abilities and confidence to use such methods. The presence of such an interaction would indicate the operating role of PBC in determining the impact that attitudes might have on frost-protection behavior. However, this result has received support in the literature (Eagly and Chaiken 1993).

In the second block, PBC, intention, and the orchard-system profile as a dummy variable were entered, and a similar regression was conducted. As predicted, these variables significantly increased the variance accounted for (R^2 change = 0.04), and H4 and H5 are confirmed by this result. The main effect of orchard-system features was entered, but it was not a significant predictor of the behavior. Using a stepwise procedure, the

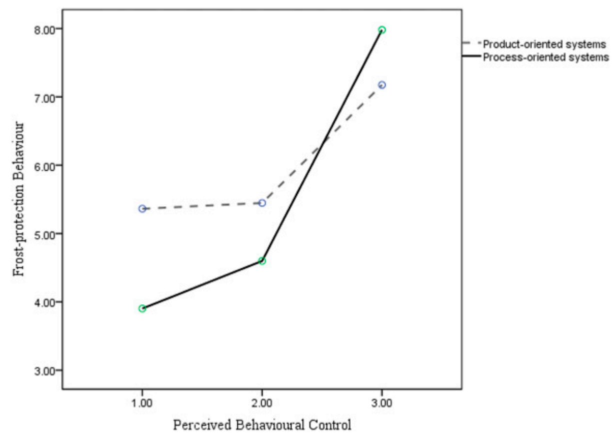

FIG. 1. Simple regression slopes show regression of frost-protection behavior on PBC for orchardists with product-oriented orchard systems and process-oriented orchard systems.

interaction term was added to the equation[2] in the third block. Therefore, frost-protection behavior was regressed on interaction between PBC and orchard-system profile and found to significantly increase the amount of variance explained (R^2 change = 0.03; F change = 7.19, $p < 0.001$). The results indicated a significant beta weight for the orchard-system profile × PBC ($\beta = 0.58$, $p < 0.001$) and orchard-system features ($\beta = -0.70$, $p < 0.001$).

Adopting from Povey et al.'s (2000) and Wenzel's (2002) statistical approaches, the interaction effect was further examined using the simple effects method by examining the regression lines at levels of the hypothesized moderator (i.e., product-oriented systems and process-oriented systems). Simple slope analyses results demonstrate how the relationship between PBC and frost-protection behavior changes as a function of orchard-system profile (Fig. 1). It is apparent that PBC

[2] The structural equation modeling was conducted to assess the fit of the naïve model. Maximum likelihood estimation revealed that the chi-square (χ^2) value of the naive measurement model was 39.94 (df = 3, $p < 0.001$, χ^2/df = 19.97), even though other goodness-of-fit indices revealed that the measurement model provides an acceptable fit to the data (CFI = 0.85, NFI = 0.84, RMSEA = 0.46). The extended-TPB model was then compared with the naïve model by including the added "orchard-system profile" construct. Considering the goodness-of-fit indices for the extended model [the chi-square (χ^2) value was 6.79 (df = 6, χ^2/df = 1.13), and the CFI, NFI, and RMSEA were 0.99, 0.98, and 0.03, respectively], the extended model fit the data well. Indeed, predictors of frost-protection behavior in the extended TPB explained about 33% of the variance in the dependent variable, whereas antecedent variables in the naïve model explained approximately 41% of the total variance. Therefore, it could be concluded that the extended model provides better explanatory power than the naïve TPB model.

predicts frost-protection behavior for product-oriented orchard systems ($\beta = 0.65$, $p < 0.001$) and process-oriented orchard systems ($\beta = 0.67$, $p < 0.001$). As significant interaction effect suggests, the orchard-system profile indeed moderates the frost-protection behavior–PBC relationship (H6). Simple effects analysis also showed that at high levels of PBC, however, process-oriented systems achieved higher levels of protection behavior. Post hoc analysis also revealed that performing the protection behavior under higher levels of PBC was significantly greater than the low and moderate levels of PBC. Several studies have found support for this interaction effect (Jones et al. 2000; Karami and Mansoorabadi 2008; Bruijnis et al. 2013; Borges et al. 2014b). Jones et al. (2000) proved that costs were the moderators of the intention of customers in the marketing context. Farm size and farm income are two main determinants of farmers' decisions on the adoption of innovations (Borges et al. 2014b). Farming-system factors that were considered as potential predictors of attitude toward behavior in other studies took place in the same context of the Iranian farms (Karami and Mansoorabadi 2008). However, Bruijnis et al. (2013) found no differences in farm variables between farmers with different levels of intention to improve the food health of dairy cows in the Netherlands.

5. Discussion

a. *Which factors contribute to the practice of frost-protection methods in walnut production?*

Frost-protection behavior is an example of the dynamic complex process in which many factors interact and contribute to mitigating the negative effects of environmental stress. What varies in moving from a risky status to a nonrisky controlled one is the way the effective actions are considered. As this study illustrates, different factors interact to result in performance improvements in frost-prone environments. Starting from the assumption that contextual status would force orchardists to manage their orchards facing frost damage differently, this study used an extended model of TPB to capture how contextual and sociopsychological factors influence frost-protection behavior among walnut orchardists. The hierarchical regression analysis in this study indicates that behavioral attitude, PBC, orchard-system features, intention, and the interaction between PBC and orchard-system profile were all significant predictors of orchardists' frost-protection behavior. It reveals that orchard-system profile—size of the orchard, access to external outputs (e.g., pesticides, fertilizers, and credits), and economic return (e.g., yield, price, and profitability and marketability)—is a panacea for walnut orchardists facing late spring frosts. However, the interaction between this factor and PBC was found to significantly increase the amount of variance explained. This is one of the first studies to include sociopsychological measures of TPB in the frost science area. The results would appear to indicate that the findings for this frost-protection behavior are, perhaps, comparable with those reported for drought-management behaviors (Sharifzadeh et al. 2012). Orchard-system features, although of high importance to walnut growers' management operations, have already been largely incorporated into frost-management schemes. Rimal and Schmitz (1999) also revealed that more than 65% of the Californian farmers who adopted the antifreeze technology were from medium and large farms that constituted more than 95% of the area under antifreeze technology. This result is consistent with the findings of other researchers elsewhere. Sprinklers, wind machines, and heaters were among the antifreeze technologies that the orange growers chose.

When averaging over various predictors, we found that orchardists' behavioral attitudes fell on the low end of the given scale. These low levels of attitudes resulted primarily from the low perceived ease of use of frost-protection methods (which had means ranging over 2–3 on the 1–5 scale) rather than low perceived usefulness (which were rated more highly), suggesting that orchardists see such methods as only moderately likely to contribute to better frost controllability. Further research is needed to investigate whether these results contribute to better understanding of the limitation of frost-protection methods to achieve better outcomes.

Among the factors that ultimately determine frost-protection behavior, the presence or absence of requisite contextual facilitating resources may be based in part on environmental factors, but it is usually also influenced by orchardists' economical capital (size of the orchard, soil structure, water resources, availability and access to devices, etc.) and by other social capital (trust in knowledge sources and/or respect to their warnings, perceived adaptive capacity, avoiding fatalism, etc.) that increases or reduces the perceived difficulty of performing the behavior in question. Perhaps access to objective resources to perform active and passive frost-protection actions and subjective perceptions of these resources correspond with each other (Grothmann and Patt 2005). It is apparent that the more facilitating context (e.g., resources, abilities, and self-confidence) orchardists believe they possess, and the fewer obstacles or impediments they anticipate, the greater the expectancy of the frost-control behavioral engagement should be. These results are in line with the findings obtained by Sharifzadeh et al. (2012) in the context of drought-protection behavior.

b. *What factors impede orchardists from practicing frost-protection methods?*

Indeed, most of the frost-protection methods identified by orchardists were used under experimental conditions. So, there is no precise result of when and under which frost status (radiation frosts, convective frosts, etc.) the method is applied to control frost. Besides, the accountability of different methods to modify temperature varies with crop, cultivars, and stage of blossom development (Ghaemi et al. 2009). Because of some equipment failure, decision-making is made more difficult for farmers, especially when considering all the factors found to be related to the pattern of protecting walnut trees from frost. Results showed significant temperature control had taken place, especially in the central part of the orchard, but how is it possible to protect the block margins, where the risk of low temperature is higher due to the wind drift effects? It seems that among different ways of facilitating orchardists' engagement into frost-protection practice, gathering detailed information and setting guidelines and incentives through education and awareness programs could potentially benefit them. As the exact solution has not been provided yet, perhaps joint definition of issues and development of solutions would be needed to combine scientific and local knowledge/resources to run further along these lines.

6. Conclusions

The purpose of this study was to investigate variables relevant to the process of frost protection through an application of the TPB. Overall, our findings support the potential applications of a behavior-oriented approach: in particular, farming under risky environmental conditions. Furthermore, the extended TPB framework shows great promise in enhancing our understanding of orchardists' behavior under frost stress.

This study has major implications for policy-makers, Agri-Jihad organization experts, walnut orchardists, and other stakeholders (technology developers, agribusinesses, etc.). The prevalent frost-protection methods used by orchardists that emerge from our findings suggest important implications for experts, technology developers, and agribusinesses aiming to promote alternative methods regarding orchardists' mentalities. As the results show, "burning fuel and tires," "surface irrigation," "furrow irrigation," and "covering trees with insulating materials" were the most applicable methods used by orchardists. This suggests the infeasibility of using other frost-protection methods in terms of limitations for real orchard systems. On the other hand, the obstacles apparent in the evidence, which does not seem to be localized, open up the possibility that not only the orchard-system features, but also orchardists' perception, would determine the rational choice of engagement in frost-protection actions. These results have some implications for social scientists and policy investigators who are interested in the causes of orchardists' actions.

As such, the regional understanding of ease of use and usefulness features of these methods could help policy-makers mobilize the formation of positive intentions toward these methods in the region. However, results revealed that perceived injunctive norms include emotional, public community, peer groups, experts, and landlords and other orchardists could not affect frost-protection practices. This finding has potentially important implications for frost-protection behavior. Regarding the regional socioeconomic context, we suggest that perceived descriptive social norms could also serve as one important measure by which policy-makers can improve regional levels of practicing the protection methods, as these groups seem to be an important factor for determining future intention of farmers. Therefore, future research is needed to examine both the actual and the perceived descriptive norms (i.e., perceptions of what others do). In other words, future research should evaluate the actual descriptive norms (e.g., the prevalence, quantity, and frequency of active and passive protection practices), as well as the perceived descriptive ones (e.g., how often orchardists perceive others to engage in protection activities). Furthermore, peer groups' knowledge of frost-protection devices and methods and factors that facilitate trust building and respect between orchardists and the public community, experts, and peer groups should be identified. This requires collective (policy) efforts and social learning to take place in different institutional contexts, particularly the mass media and Agri-Jihad Organization actors' joint collaboration with Water Organization actors. Perhaps part of this legitimacy rests on orchardists' perceived behavioral control (abilities, self-concepts, and confidence) to help their orchards continue to thrive. However, our findings reveal conditions that must be obtained in order for such frost-protection devices and methods to be effective. It is worth mentioning the important effects that would have any meaningful pricing policy and funding mechanisms (subsidies, loans, etc.) on the applications of these devices. This would create an environment that politically approves the contextual support in order to strengthen the poor orchardists' perceived ability, self-concepts, and confidence to run these methods under adverse climatic conditions in their orchards.

We acknowledge that the limited number of interviewees is the main limitation in the current study. However, it was presumed that studying only a limited number of cases (large-scale walnut owners) could help us make some logical generalizations. In other words, if frost-protection devices and methods are not perceived to be in line with the needs of these orchardists, then the small-holders will not follow through on them. For future research, we propose the possibility of expanding the number of participants, including not only the walnut orchardists, which could have very specific characteristics, but also a representative sample of the cold-climate fruit producers.

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