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RESEARCH

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Application of the theory of planned behaviour to understand citrus stakeholders' intention to manage quarantine plant pest outbreaks

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Abstract

In the European Union (EU), after an outbreak of a quarantine plant pest, contingency plans help to mitigate its progression. However, opposition to their implementation limits their effectiveness and leads to social unrest, together with socio-economic and environmental losses for stakeholders and governments. Thus, stakeholders' decision making about contingency plans is a major issue for plant health authorities in the EU. In fact, a limited understanding of the factors influencing the adoption of plant health regulations by stakeholders has led to inadequate management of some quarantine plant pests. This study aims to better understand stakeholders' intentions to follow contingency plans. To this end, questionnaire data collected from a sample of 252 Spanish citrus stakeholders, using citrus Huanglongbing (HLB) disease as a case study, was analysed according to the Theory of Planned Behaviour (TPB) using structural equation modelling (SEM) for the model estimation. Results show that Intention (INT) to follow the contingency plan for HLB is primarily driven by Subjective Norm (SN) followed by Attitude (ATT) but not by Perceived Behavioural Control (PBC). We also observed that SN predicts ATT and PBC, as expected, and that age has a positive effect on INT. These results suggest that decision making programmes should encourage individuals who are relevant to the community to advocate for the adoption of the measures in case of an outbreak. Furthermore, to be effective, the implementation of contingency plans should take into account the stakeholders' views from the inception phase onwards. Our findings improve the understanding of variables influencing the intention to follow the contingency plan for HLB and support the use of TPB to explain stakeholders' intention to manage quarantine plant pest outbreaks.

Keywords: EU regulation, contingency plan, theory of planned behaviour (TPB), structural equation modelling (SEM), grower decision making, huanglongbing (HLB), outbreak

Introduction

Invasive plant pest outbreaks are threatening the sustainability of many social-ecological systems worldwide (Vilà *et al*., 2011; Rai and Singh, 2020). Invasive species are exotic (not native to a given habitat or ecosystem) species that have successfully established themselves in a new habitat and spread quickly within it (Wilson and Primack, 2019). According to the International Plant Protection Convention (IPPC), a quarantine plant pest is defined as a species that is invasive and not present or widely distributed in an area that can potentially cause severe economic losses and, for this reason, is officially controlled (Schrader and Unger, 2003). Following this definition, in this study, we will include inside the '*pest*' description any plant pathogen or arthropod to facilitate the reading. Also, we will use acronyms (dark blue marked) for the same purpose (see all the acronyms in Supplementary Materials: Appendix A).

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In the European Union (EU), the EU Plant Health Law (EU, 2016) has identified priority quarantine pests according to their potential socio-economic and environmental impacts. Special regulations apply to the EU priority pests, including the obligation of National Plant Protection Organisation (NPPO) in each of the EU Member States (MSs) to draw up contingency plans for them (EU, 2019a,b). A contingency plan is the basic roadmap to be adopted in case of a pest outbreak. It is specific for each pest and contains the regulations and steps to be followed for the control and eradication of the pest (see more details in section "Description of the contingency plan measures"). The development of contingency plans is an opportunity to evaluate, among others, the roles, responsibilities, budget and treatments needed in the case of an outbreak. In order to implement all the contingency plan measures successfully, there should be communication and trust between the government officials who will be responsible for the measures implementation and the other involved actors. Therefore, cooperating parties should be involved in the development of a contingency plan, and it is necessary to make them aware of their responsibilities if an outbreak occurs, as the IPPC contingency plan guide (IPPC, 2023) recommends. Nevertheless, NPPOs do not always consider the opinions and views of the people in the area affected by the outbreak and the same regulations are sometimes applied to all the EU MSs (Pavone, 2022; IPPC, 2023). In some cases, the application of top-down contingency plans was effective against specific plant pest outbreaks (Pavone, 2022). However, law and policy implementations have not always been successful in the control of some quarantine plant pests. Previous failures to execute them have demonstrated that public cooperation is fundamental for the effective implementation of outbreak management programmes (Abbott, 2019; Garcia-Figuera *et al*., 2021; Pavone, 2022).

Most studies on outbreak management for quarantine plant pests have focused on understanding how the pest will spread and how control measures will be performed (Duran-Vila *et al*., 2015; Aidoo *et al*., 2022). Others, like the one performed by Sulzbach *et al*. (2018), have focused on assessing the risk factors for the disease introduction by employing a structured questionnaire and an analytic hierarchy process to evaluate potential drivers. Only a few studies have emphasised the need to better understand stakeholders' responses to policy measures (Singerman *et al*., 2017; Milne *et al*., 2018; Garcia-Figuera *et al*., 2021; García-Figuera *et al*., 2022) and have included the level of adoption by farmers as a factor to assess the performance of outbreak management plans (Milne *et al*., 2020). Little is known about the attitudes, behaviour and willingness to adopt by key decision makers across different farming sectors. Traditionally, the focus has been on the economic aspects of farming adoption, particularly in practices like conservation measures, where financial incentives play a crucial role (Villamayor-Tomas *et al*., 2019; Pérez-Sánchez *et al*., 2024). However, recent studies have recognised that decision making processes are also deeply influenced by social and cognitive factors, underscoring the need to explore how intentions and behaviours are shaped not just by economic incentives but also by attitudes, social influences and perceived control over outcomes (Villamayor-Tomas *et al*., 2019).

Regulations for outbreak management are generally based on biological and epidemiological criteria, whereas stakeholder's decisions to comply with regulations are often driven by economic considerations (Despotović *et al*., 2019; Ribal *et al*., 2022; Ahmad *et al*., 2024). Nonetheless, it is essential to consider other critical factors, such as the perspectives and priorities of farmers and other key stakeholders regarding pest outbreaks (Borges and Lansink, 2015; Lanza-Castillo *et al*., 2021; Sarma, 2022). In this regard, the Theory of Planned Behaviour (TPB) presents a robust theoretical framework for understanding the impact of social and cognitive factors on stakeholder's decisions.

The TPB (Ajzen, 1991) is a widely used behavioural model that provides a theoretical framework for studying the factors influencing an individual's intention to follow, in our case, the contingency plan. This theory argues that a behaviour can be predicted via intention (INT) to perform a particular behaviour. Three socio-psychological constructs: Attitude (ATT), Subjective Norm (SN), and Perceived Behavioural Control (PBC), are related to INT. This theoretical model has been originally developed in social psychology. It makes it possible to explore and better understand the decision making process as regards behaviour under certain conditions. Previous studies have used TPB constructs to analyse a farmers' intention to predict the implementation of a fertilisation programme (Daxini *et al*., 2018, 2019) or integrated pest management plan (Despotović *et al*., 2019). Those studies provide evidence of the adequacy of this model to analyse stakeholder's behaviours, like in our case, their intention to adopt EU regulations against quarantine plant pests, such as those established by the contingency plans for outbreak management (Despotović *et al*., 2019; Ribal *et al*., 2022; Ahmad *et al*., 2024).

Breukers *et al*. (2012) used the TPB to conduct an innovative study aimed at understanding farmers' decisions in the Netherlands when dealing with invasive pathogens, in which they only considered aspects related to risk management. In our study, we have considered some controversial measures not just to explain the INT but as an object of the INT itself, aimed at putting certain practices into effect as part of the contingency plan. Also, we used Structural Equation Modelling (SEM), a proven versatile, powerful multivariate method to test models that contain latent and observed variables and, hence, can be used to explain the TPB results (Beran and Violato, 2010; Rhemtulla *et al*., 2012; Gunzler *et al*., 2013; Daxini *et al*., 2019).

Considering that compliance by stakeholders is of key importance for the successful implementation of outbreak management plans against quarantine pests, the main objective of this study is to characterise and better understand the underlying effect of the TPB constructs ATT, SN and PBC on INT to follow contingency plans in the EU. To this end, the TPB will test a constructed theory about stakeholders' intention to adopt the contingency plan, using citrus Huanglongbing (HLB) disease as an example.

HLB is a serious vector-borne disease caused by the Gram-negative bacterium *Candidatus* Liberibacter spp. ('*Ca. Liberibacter* spp.'), which leads to irreversible declines in tree health and fruit production (Bové, 2006; Duran-Vila *et al*., 2015; McCollum and Baldwin, 2016; Alquézar *et al*., 2022; Gasparoto *et al*., 2022). Our second objective is to identify the underlying relationship between the TPB constructs. Moreover, in an attempt to better understand the intention to follow the contingency plan, additional variables related to education, age or HLB knowledge, among others, were examined out of the principal SEM model through an ordered logistic regression. These results may be helpful to determine if other socio-economic characteristics of the individuals influence intentions towards the adoption of contingency plan measures. Additionally, these results may assist the design of future regulations and contingency plans as well as improving education programmes to increase society's awareness on quarantine plant pests and the measures needed for their control.

DESCRIPTION OF THE CONTINGENCY PLAN MEASURES

In the EU, plant health is managed at the national level by MSs in their territories (MacLeod *et al*., 2010; Ristaino *et al*., 2021), but common legislation is applied. According to Regulation (EU) 2016/2031, a series of protective measures, such as annual surveys, contingency plans, simulation exercises, and action plans for eradication, should be implemented for the priority quarantine pests in case of an outbreak (EU, 2016). From all these preparedness measures, in our study, we will focus on the contingency plan, which gathers the measures for eradication or containment of quarantine pest outbreaks.

A contingency plan is a set of guidelines that includes information about the pest, control measures, organisation and responsibilities of each actor involved, risk management measures to be taken in case of an outbreak as well as principles for area demarcation and timing for the actions to be implemented (EU, 2016; Wilson and Primack, 2019; Aragón *et al*., 2022). Each EU MSs has to design and implement its own contingency plan based on its own needs. However, the general framework for area demarcation, removal of affected plant hosts and restrictions on the movement of plant materials from affected areas are common to all EU MSs (Aragón *et al*., 2022; Pavone, 2022). Decision making and common regulations for all the EU MSs are generally designed by scientists and policy advisers in science-led government departments dealing with agriculture, food and the environment, with the aim to minimise the possible outbreak. Contingency plan measures aim to prevent or minimise damage from a given pest, but it is sometimes difficult for individuals to understand them due to the consequences of their implementation, such as the removal of affected trees (Pavone, 2022).

In the following sections, we will describe three contested measures of the contingency plan for HLB disease to contextualise why they were problematic in the implementation of contingency plans for pathogens with similar characteristics.

Tree removal

The EU Plant Health Law (EU, 2016) establishes that, when a quarantine plant pest outbreak is detected, a survey of the area around the positive finding must be performed to delimit the area with an infected zone surrounded by a buffer zone. In the infected zone, the host plants of the pest should be eliminated. The buffer zone is then subjected to intensive surveillance and control measures to keep it free from pest and avoid further spread (Amon-Armah *et al*., 2021; Ribal *et al*., 2022; Pavone, 2022).

In the case of HLB, the contingency plans in Spain and Portugal require the removal of the positive citrus trees (i.e. *Citrus* spp. and relative genera) (DGAV, 2021; MAPA, 2023). When a positive tree is detected, that infected tree is removed together with those within a radius that are likely to be infected but still asymptomatic. The destruction of these asymptomatically infected (but still productive) trees or landscape ancient trees (even if they are also symptomatically affected) is a measure that inhabitants and other stakeholders find difficult to understand and, hence, to support (Saponari *et al*., 2019; Pavone, 2022). Consequently, attempts to execute contingency plans have usually faced implementation problems. In some cases, they have been met with fierce public resistance, frequently resulting in delayed or discontinued interventions. A recent example of discrepancy between regulations and citizens' willingness to adopt them is the outbreaks of the quarantine plant pathogen *Xylella fastidiosa* in Spain and Italy. Since the success of a contingency plan also depends on the actions of stakeholders, it is crucial to study their behaviour to better understand it and encourage them to accept the measures of the contingency plan to reduce the risk of disease spread.

Coordinated insecticide treatments

Large-scale coordinated action is required to control certain plant diseases, especially those disseminated by highly mobile insect vectors. Area-Wide Management (AWM) is a strategy for dealing with plant pests, diseases or weeds where the actions are coordinated collaboratively across a large area, rather than implemented in individual fields (Singerman *et al*., 2017; García-Figuera *et al*., 2022; Schrader *et al*., 2024). EU regulations and current contingency plans do not specify how to organise treatments for the insect vector of a quarantine disease, such as HLB, in case of an outbreak. However, AWM has been demonstrated as the most effective form of management and control of HLB vectors and thus, disease spread (García-Figuera *et al*., 2022; Haynes, 2022; Lence and Singerman, 2023; Schrader *et al*., 2024). In case of detection of the HLB vectors, implementing a successful AWM strategy would require different actors to be involved and engaged with the insecticide treatments, for example, through existing farmers' organisations or neighbourhood groups (Galvañ *et al*., 2023).

Official inspection

Official inspection for HLB is a continuous, systematic process to collect, record, analyse and interpret data on the presence of vectors and symptoms. Trained and authorised inspectors of regional plant health authorities are often in charge of carrying out the monitoring and on-the-ground inspection process. These programs include systematic inspections to detect early HLB symptoms and/or vector population (DGAV, 2021; MAPA, 2023). Nevertheless, in previous experiences with outbreaks, when a pest was detected in the area, individuals usually oppose to official inspections because they do not want to face some measures such as tree removal. Others did not trust plant health authorities or other actors (i.e., crop advisors) or other farmers enough to report the presence of vectors, or diseased plants. This opposition makes inspection more difficult and delays outbreak control (Abbott, 2019; Pavone, 2022).

Additionally, to effectively control an outbreak, it is necessary to first report the presence of the pest to reliable actors (i.e neighbours, crop advisors from farmers organisations or the plant health authorities). However, this process requires individuals to trust the authorities, other crop advisors, or neighbours to allow them to enter their farms to see the unusual symptoms or insects. In this case, trust refers to the individual's belief that certain sources of information or entities (such as crop advisors, peers and institutions) are reliable, and thus, it is worth following their advice.

Trust can be, in such cases, a key factor to promote the belief in the relevance of the contingency plan measures. It could encourage stakeholders to communicate about unusual symptoms on their farms and promote the adoption of the measures necessary to keep their phytosanitary status (Maclean *et al*., 2019). In fact, previous works related to plant pest management have observed that the intention to stay informed and maintain communication with agricultural managers, crop advisors or plant health authorities had a favourable effect on the intention of adopting practices to prevent pest progression (Milne *et al*., 2018; Maclean *et al*., 2019; Garcia-Figuera *et al*., 2021).

THEORETICAL FRAMEWORK AND HYPOTHESES

Theory of planned behaviour

The TPB is a theoretical model developed by Ajzen (1991) based on a previous model: the Theory of Reasoned Action (TAR) (Ajzen and Fishbein, 1975, 1980). The TPB model assumes that individuals act based on considering the possible consequences of their actions. It also assumes that individuals carry on a deliberate process of reasoning about the consequences of a specific behaviour. In our study, we analysed the behaviour of compliance with the contingency plan for HLB.

The TPB is grounded on two basic principles: (a) People behave rationally, that is, they consider the available information and, consequently, evaluate the results of carrying out an action or not; (b) Actions are determined by the intention (INT) to carry them out or not, as they are under the voluntary control of the individual (see Fig. 1). Based on the empirical relationships contained in the TAR, the TPB aims to explain the influences on the intention of both individual and psychological factors (ATT) and the weight that social factors (SN) exert on individuals' decisions about how to behave. However, given that behaviours are under the voluntary control of the individual, which means that the individual has the capacity to decide whether or not to perform the behaviour, Ajzen (1991) reformulated the model and renamed it TPB, incorporating a third predictor: perceived behavioural control (PBC). In this way, it would be possible to explain both those behaviours that depend on the individual's own will (when control over the execution of their behaviour is high) (INT) from those behaviours that are carried out in response to personal or behavioural factors (PBC) and those that are produced in response to social pressure, based on acceptance and motivation to please other people (SN).

In the TPB, ATT refers to an individual's favourable or unfavourable evaluation of performing a behaviour and its perceived consequences. In this study, it is hypothesised that stakeholders who perceive the contingency plan as beneficial, useful and important are more likely to comply. SN reflects the social pressure or expectations from significant others, as well as the motivation to meet these actions and avoid social exclusion (Ajzen, 1991; Corral-Verdugo *et al*., 2019; Daxini *et al*., 2019). In our study, SN represents the influence of respected individuals or institutions endorsing the contingency plan and coordinated treatments, along with the fear of social exclusion for non-compliance. PBC is defined as the individual's perception of their capability to perform an action. In this study, it will correspond to the perception of how capable they are of implementing the measures of the contingency plan and how easy or difficult they perceive their application to be.

In our study, the stakeholders' INT to follow the measures of the contingency plan will be determined by their perception of being able to perform those measures (PBC), their favourable or unfavourable evaluation of following them in relation to their cost or difficulty (ATT) and the evaluation of the social consequences (SN) if they do not comply.

A systematic review focused on analysing stakeholders' belief patterns under the framework of expectancy-value models, including the TPB, suggested the need for accurate and principled measurement of compatibility between measures of TPB constructs (Sok *et al*., 2021). The recommendation of the original authors of the TPB is to adapt these measures by testing them (Ajzen, 1991). In our study, we have considered the results of a pilot study to construct our latent variables and measure the constructs. This pilot study was based on semi-structured interviews with citrus experts, scientists and plant health officers, which allowed us to gather information on the stakeholders' perceptions of positive and negative consequences that stakeholders perceive about the contingency plan action programme. This information was used to generate the items that would make up the final questionnaire. Fulfilling the recommendations for the use and measurement of the TPB constructs. This allowed us to become familiar with and understand the reflective and formative indicators of the latent theoretical variables centred around our study population. In this way, we sought to overcome the limitations levelled by Burton (2004) or more recently by Sok *et al*. (2021) regarding studies that have not followed the established principles and guidelines to ensure accurate theoretical conceptualisation and measurement (Ajzen, 2006; Fishbein and Ajzen, 2011).

Based on the TPB guides for questionnaire construction (Fishbein and Ajzen, 2011), INT can be predicted from ATT, SN and PBC, and no other predictors should have a direct impact on intentions (sufficiency assumption). Following other studies on agriculture-related topics that have used the TPB (Breukers *et al*., 2012; Daxini *et al*., 2018, 2019; Vaz *et al*., 2020; Lanza-Castillo *et al*., 2021), we formulate the following hypotheses related to the TPB constructs:

- H1: ATT positively influences the INT to follow the measures set by the contingency plan.
- H2: SN positively influences the INT to follow the measures set by the contingency plan.
- H3: PBC positively influences the INT to follow the measures set by the contingency plan.

Generally, the influence of the TPB constructs on intention varies depending on the behaviour and the context. Additionally, previous studies have shown that TPB constructs are correlated. We focused on two key causal relationships: the influence of SN on ATT and PBC (Daxini *et al*., 2019). Previous studies indicated that the influence of SN on ATT relies on an individual's fear of social exclusion if they do not follow the group actions and, therefore, it is the way to test whether their opinion or action will be validated by the group (Daxini *et al*., 2019). For the PBC, SN has proven to influence an individual's perception of the cost of performing a behaviour, which in turn proves that being socially supported encourages individuals to perform a particular behaviour (Daxini *et al*., 2019). Overall, this indicates that individual perceptions of how simple or challenging it is to act can be influenced by the external social pressure from what others perceive. Consequently, the model was expanded to include the following hypotheses:

- H4: SN has a positive influence on PBC.
- H5: SN has a positive influence on ATT.

The conceptual model with all the hypotheses to be tested is presented in Fig. 2.

Intention between the different types of respondents

According to the TPB, INT is influenced by socio-economic factors through ATT, SN, and PBC. However, the TPB has recently come into criticism for failing to account for these factors explicitly (Daxini *et al*., 2018). Therefore, in this study, we decided to test if there is any potential association between the respondent's socio-economic characteristics and their intention to adopt the contingency plan measures. The variables tested include farm size, citrus area, farmers organisation membership, age, formal (more than the

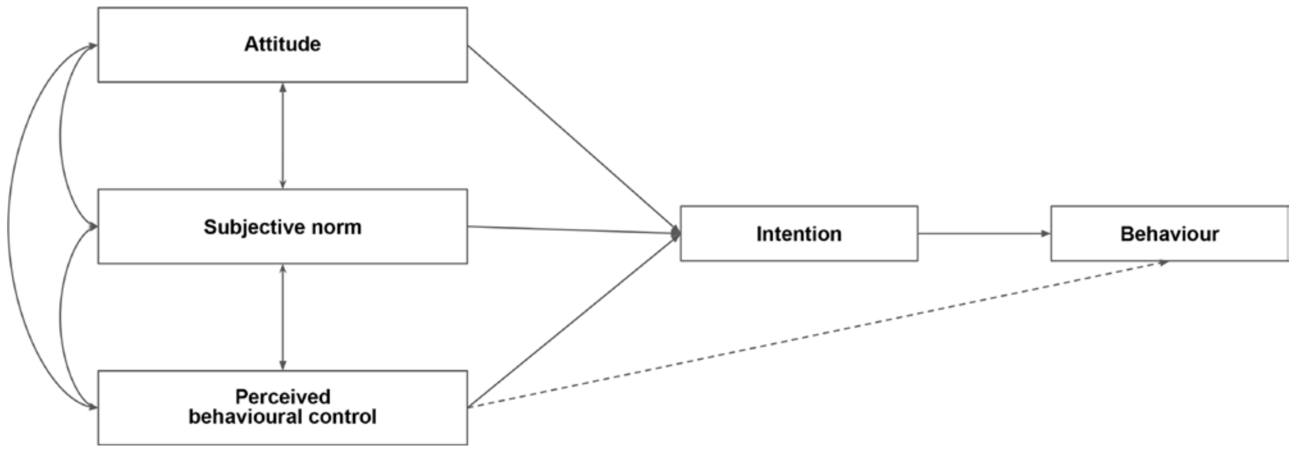

Fig. 1. Graphical representation of the original model of the *Theory of Planned Behaviour* (Adapted from Ajzen, 1991).

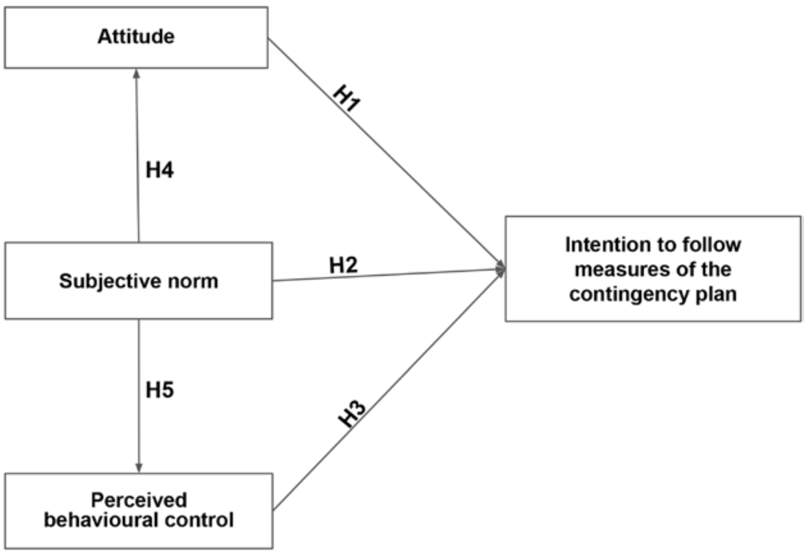

Fig. 2. Conceptual framework of our model based on the *Theory of Planned Behaviour* (Ajzen, 1991) model.

basic education studies) and agronomical education (education as vocational and degrees related to the agronomy), farm profitability, HLB knowledge and contingency plan knowledge. The analysis was performed out of the principal TPB model and, for this reason, is out of the model representation (Fig. 2).

Farm size has been frequently hypothesised to positively influence the decision to adopt some agronomical practices, such as soil testing, sustainable practices or recommended practices against HLB (Daxini *et al*., 2018; Despotović *et al*., 2019; Garcia-Figuera *et al*., 2021). Small farmers tend to be less willing to adopt new control measures or implement alternative agronomical practices due to the implementation costs that they may be unable to bear (Daxini *et al*., 2018). Therefore, to test if farm size affects the INT to adopt the contingency plan measures, we used responses from individuals with smaller farm sizes as a control group. Similarly, as HLB is a citrus disease, we added citrus area (i.e. percentage of the farm occupied by citrus) to test if this factor is determinant in individuals' INT. In contrast to farm size, for citrus area we used those with the largest citrus areas on their farms as a control group.

In Spain, due to the structural characteristics of farms, related to their small-scale ownership division (Galiana-Carballo *et al*., 2024), farmers usually form groups to concentrate financial resources, supplies, improve farm profitability and coordinate pest control (Martí *et al*., 2015). Some farmers are, therefore, grouped in farmers organisations (e.g. cooperatives, producers' associations, agricultural unions, etc.). These organisations are entities through which farmers' farms are managed by a common technical manager, who advises members on when or how to carry out pest management actions. Nevertheless, not all farmers are members of a farmers organisation. In this study, we added the farmers' organisation membership to verify if being a member of this kind of organisation could affect the intention to follow the contingency plan measures. The control group were those who were members of a farmers organisation.

We also decided to test if formal and agronomic education affects intention. Higher levels of formal and agricultural education have been shown to increase the likelihood of adopting nutrient management practices (Daxini *et al*., 2018). However, studies on the relationship between education and environmental conservation behaviour among farmers yielded mixed results, with some studies finding no significant correlation (Despotović *et al*., 2019; Lu *et al*., 2022). For a similar reason, we included knowledge of HLB and the contingency plan measures to control it, to see if it could affect. The control group was made up of those with formal and agronomic education and knowledge of HLB and the contingency plan measures to control it.

In previous works, age has been hypothesised to negatively influence the adoption of different agronomical practices, because older farmers tend to be more conservative (Daxini *et al*., 2018). In some studies, the oldest were the most likely to adopt certain management measures, and in others age was not significantly related to the level of adoption (Paniagua-Mazorra, 2000; Beltrán-Esteve *et al*., 2012; Garcia-Figuera *et al*., 2021; Pérez-Sánchez *et al*., 2024). As Spanish farmers are generally elderly (Paniagua-Mazorra, 2000; Beltrán-Esteve *et al*., 2012), we added this variable to assess whether it significantly affects intention, with the control group being the oldest individuals (> 65 years old).

Lastly, we added farm profitability because is also generally found that profit-making farmers are usually more likely to adopt measures that will keep their crops healthy (Daxini *et al*., 2018). Thus, we used highly profitable farms as the control group.

Methods

CASE OF STUDY

Our case study, HLB, is one of the most devastating citrus diseases that has put this crop at risk worldwide (Duran-Vila *et al*., 2015; McCollum and Baldwin, 2016). The causal agent of HLB is transmitted by two psyllid vectors: the Asian citrus psyllid *Diaphorina citri* and the African citrus psyllid *Trioza erytreae* (Bovè, 2006). The disease can also spread by propagating infected material, such as buds and plants for planting. Currently, there are no curative treatments or any citrus cultivar resistant to HLB (McCollum and Baldwin, 2016; Hendrichs *et al*., 2021). The disease is widespread in the main citrus-growing areas worldwide, including the USA, South Africa, Argentina, Brazil, China, Uruguay and India (Das *et al*., 2014; Shimwela *et al*., 2016; Zheng *et al*., 2018; Graham *et al*., 2020; Alquézar *et al*., 2022; DGSA, 2023). Only the citrus-growing areas in the Mediterranean Basin, Australia and New Zealand are still free of the disease (Bassanezi *et al*., 2013; Alquézar *et al*., 2022). Nevertheless, in the Mediterranean Basin, both vectors are present and spreading, *T. erytreae* on the the Iberian Peninsula and *D. citri* in Cyprus and Israel (EPPO, 2022, 2023).

In the EU, '*Ca. Liberibacter* spp.' causing HLB are quarantine priority pests, for which particular phytosanitary measures are enforced

(EU, 2016; Aragón *et al*., 2022), including the implementation of a contingency plan in case of an outbreak (EU, 2019a).

STUDY AREA AND QUESTIONNAIRE DESIGN

As stated above, the Mediterranean Basin is still free of HLB, with Spain being the largest citrus-growing area, representing around 23% of the total EU citrus area (Siverio *et al*., 2017). The population of interest in our study consists of the citrus stakeholders in the main citrus-growing area in Spain: the Valencian Autonomous Community. This region is divided into three provinces, Alicante, Valencia and Castellón, which together represent 54% of the total Spanish citrus areas (Ortiz *et al*., 2022). Although the study area is focused on the Valencian Autonomous Community, responses to the questionnaire from other citrus-growing areas in Spain, such as the Region of Murcia and Andalusia, were also considered, in the category "other" (see subsection "Respondent rate and socio-economic description of the sample", Supplementary Materials: Appendices B and C for additional details). All the participants are, therefore, from areas where the HLB or its vectors have not yet been detected.

The questionnaire was developed based on the literature on HLB and its vectors, regulations and the official contingency plan in Spain (Singerman *et al*., 2017; Milne *et al*., 2018; McRoberts *et al*., 2019; García-Figuera *et al*., 2022; MAPA, 2023), after consultation with the plant health authority of the Valencian Autonomous Community and scientific experts. It was divided into three sections:

- Questions in the first section were used to collect data on the socio-economic variables (e.g. 'What is your age?' 'farm size' or 'farm location').
- Questions in the second section were aimed at assessing the respondents' knowledge on HLB disease, the contingency to be implemented in the event of an outbreak and their risk perception about the disease.
- Questions in the third section were based on the TPB. In this section, respondents were asked to assess a variety of statements designed to capture their attitudes, subjective norms and perceived behavioural control to follow the measures of the contingency plan to address HLB and its vectors.

All the questions are available in Supplementary Materials: Appendix F, and the questions used in the theoretical model are shown in Table 1.

DATA COLLECTION

The total active population in the agricultural sector in the Valencian Autonomous Community is estimated to be about 64,000 people (GVA, 2022). However, there is no reliable census on those related to the citrus crop and, some stakeholders, such as part-time farmers, are not considered in the official statistics. In order to reach as many respondents as possible, the questionnaire was launched in two different ways:

A web-based questionnaire, using the Arslan (2018) `R` package on the `R` software version 4.0.3 (https://www.R-project.org) and the `formR` (Arslan *et al*., 2019) platform to develop a shareable website with the questionnaire. A paper questionnaire was designed in LaTeX using the Saalbach (2020) packages and templates for face-to-face data collection. The questionnaire and the LaTeX template are available in Supplementary Materials: Appendices F.1 and F.2.

The web-based questionnaire was launched by web link through the `Formr` webpage (Available at: https://prehlb.formr.org/) from 20 March to 20 June 2023. Several announcements were made in public and private media with the link to the web questionnaire in order to encourage participation. The paper questionnaires were administered during the same period through passes in citrus extension courses and interviews with local citrus farmers, crop advisors or other stakeholders with the first author (A. Galvañ) as the interviewer. In both cases, web-based and paper questionnaires, participation was voluntary and the responses were anonymous.

VARIABLES

TPB variables

The TPB constructs are considered as latent constructs or variables and they were obtained using multiple items to measure each construct in order to minimise the measurement error of a specific variable (Borges and Lansink, 2015; Aldas-Manzano and Uriel-Jimenez, 2017; Daxini *et al*., 2019).

Due to a lack of validated measurement instruments related to this field, the TPB statements used to evaluate each item were based on the suggestions published by Ajzen (2006). A total of 17 items were used to measure the TPB constructs: attitude, subjective norm, perceived behavioural control and intention. The ATT, PBC and SN items were scored on a seven-point Likert scale, with −3 being the most unfavourable response, 0 as the neutral response and +3 representing the most favourable one (Rhemtulla *et al*., 2012; Robitzsch, 2020).

For the INT, in order to understand the willingness to follow controversial contingency plan measures for HLB (MAPA, 2023), individuals were asked to answer a total of 8 items (i.e 'radius of citrus tree removal', 'inform the technical staff of the plant health authority about the presence of HLB or its vectors' and 'perform coordinated insecticide treatments together with their neighbours or farmers organisations') measured as intervals on a seven-point Likert scale from 'Totally unwilling' (1) to 'Totally willing' (7). Scores between 1 and 3 were referred to as negative, while scores between 5 and 7 were referred to as positive. A score of 4 was considered neutral. (Rhemtulla *et al*., 2012; Robitzsch, 2020). As these items (questions 24 and 25 on the questionnaire, Supplementary Materials: Appendix F.1) measure the same construct ('willingnness to remove affected trees'), due to collinearity issues, we combined them into a single composite score (I2 in Table 1) (Brown, 2015). We did the same with the willingness to perform coordinated treatments (questions 30, 31 and 32 on the questionnaire and I1 in Table 1). In the items related to the willingness to inform about the disease presence on the farm, there was a linearity problem with one of the items, and we decided to remove this item. Then we did as before and combined them (questions 27 and 28 on the questionnaire and I4 in Table 1).

In order to facilitate the subsequent analysis, the TPB and willingness scales were aligned with each other by changing the −3 to +3 scale to the 1 to 7 scale. For the analysis, Likert variables were treated as ordinal data.

Socio-economic variables

The socio-economic variables consisted of age, farm location, farm size and number of plots, proportion of citrus plots per farm, profitability, and pest management strategies, among others. The variables were measured as categorical data with three different types: the binary items, with two options (1 = Yes, 0 = No); the ordinal items, where higher numbers indicated higher categories ($1 < 2 < 3$) and the nominal items, where numbers only reflect a category without a specific order ($1 \nless 2 \nless 3$).

For the variables used to analyse the potential association between the respondent's socio-economic characteristics and their INT to adopt the contingency plan measures (see section "Intention between the different types of respondents"), the variables used as referent groups were classified as 1 and the others as 0. All the variables related to the latent items of the theoretical model are shown in Table 1 and those of the socio-economic, in Supplementary Materials: Appendix C.

DATA ANALYSIS

Structural equation modelling (SEM)

Structural Equation Modelling (SEM) with latent constructs was used to analyse the proposed research hypotheses. The analysis was performed using `R` software version 4.0.3 (https://www.R-project.org). Ordinal data were analysed using the diagonally weighted least squares (WLSMVS) estimator (Flora and Curran, 2004; Bandalos, 2014; DiStefano and Morgan, 2014). According to the two-step model building process, first, a Confirmatory Factor Analysis (CFA) was implemented to determine both the measurement model and the component validity and reliability of the constructs, as well as the model fit. The second step consisted in identifying a structural model (SEM) to examine the relationship in the hypothesised constructs (Rezaei *et al*., 2019; Lanza-Castillo *et al*., 2021).

Before conducting the SEM analysis, the data were checked to verify normality and multicollinearity, as well as the fact that linear and error terms were independent. Moreover, the construct's reliability (composite reliability, CR) was assessed by Cronbach's Alpha (CA). To confirm that the data were not affected by multicollinearity, the Variance Inflation Factor (VIF) was estimated through the `R` packages `car` and `performance` (Fox and Weisberg, 2019; Lüdecke *et al*., 2021). The normality of the data was verified through the Mardia Skewness and kurtosis tests via the `MVN` package (Korkmaz *et al*., 2014). To test linearity, the Rainbow test (Utts, 1982; Kraemer and Sonnberger, 2012) was performed with the `lmtest` (Zeileis and Hothorn, 2002) package. Lastly, to verify that the theorised variables can be used as independent variables in the SEM instead of the original items, the Kaiser Meyer Olkin (KMO) and the Barlett test were used for the TPB variables (see Supplementary Materials: Appendix E.1). The Barlett test for all the variables was $p = 0.00$

The convergent and discriminant validity (CV, DV) were also checked before CFA and SEM. To asses the CV, Average Variance Extracted (AVE) were calculated. To be considered acceptable, AVE estimates should be 0.5 or greater, and CR estimates should be 0.6 or greater (Muhamad Safiih and Azreen, 2016). DV was examined as in Rezaei *et al*. (2019) and, for that purpose, ASV and MSV were calculated. For an acceptable DV, each AVE construct should be higher than the ASV and the MSV among all the constructs (see Supplementary Materials: Appendix E.1 and E.2 for further details).

To assess how well the specified CFA model reproduces the observed relationships, different overall goodness of fit indices were used in the present research, including the Chi-square (χ^2), the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI) and the Standardised Root Mean Square residuals (SRMR). If the χ^2 value of a model exceeds the critical value from the χ^2 distribution, then the null hypothesis of adequate model fit must be rejected. As χ^2 has some limitations, including the fact that it is overly sensitive to sample size, it is generally recommended to report the χ^2, but focus more on the other fit indices when evaluating model fit (Aldas-Manzano and Uriel-Jimenez, 2017; Stone, 2021). The values of the RMSEA, CFI, TLI and SRMR range from 0 to 1. Better model fit is indicated by values close to 0 for the SRMR and RMSEA and close to 1 for the CFI and TLI. A model is considered satisfactory if the CFI and TLI indices are higher than 0.9, and excellent if the values are higher than 0.95 for both indices. For RMSEA and SRMR values below 0.08 the model is acceptable, and below 0.06 it is considered perfect (Rezaei *et al*., 2019; Lanza-Castillo *et al*., 2021; Elahi *et al*., 2021).

After establishing a satisfactory measurement model, the SEM was specified. The SEM was used to explain the hypothesised model relationships beyond the primary associations specified by the CFA. The same fit index was used in the SEM specification. All the model fit estimations for CFA and SEM were performed using the `R` package `lavaan` (Rosseel, 2012). The CFA and SEM model estimator outputs can be found in Tables 1 and 2.

Intention between the different types of respondents

This analysis was performed out of the SEM model. An ordered regression model was used to examine the potential associations between respondents' INT to follow the contingency plan measures and their socio-economic characteristics. First, a new item called 'intention' was created and measured as the explanatory variable. With a CA of 0.88, the internal consistency of 'intention' was deemed sufficient, indicating that the items are adequately correlated and can be treated as a single variable (Daxini *et al*., 2018). The `R` package `MASS` (Venables and Ripley, 2002) was then used to determine the possible associations.

Results

RESPONDENT RATE AND SOCIO-ECONOMIC DESCRIPTION OF THE SAMPLE

A total of 860 people clicked on the web-based URL link to the questionnaire, 363 started the questionnaire and 209 answered all the questions, which corresponds to a response rate of 57.6%. Additionally, 43 respondents completed the face-to-face questionnaire. Altogether, considering both the web and the face-to-face questionnaire, there were 252 respondents who completed all the questions (see Supplementary Materials: Appendix C for further details). We recognise that our sample may not be fully representative. However, it captures the conditions of many smallholder citrus farms in Spain and across South-east and Southern Europe.

The highest number of responses were from Valencia Province (62.30%). Of them, more than half belonged to a farmers' organisation (56.75%) and most of them were males (83.33%). The category that best defined the respondents was farm owner (69.84%), with a farm size between 1 and 10 ha (32.14%). The rest of the responses were distributed equally between the other farm size categories. As regards profitability, 46.03% of the respondents answered that their farm did not yield a profit, followed by 29.37% who answered that it operated at a loss, and 24.60% answered that they made a profit. Most of the respondents followed conventional pest management (68.25%), and they applied the pest control treatments themselves (46.65%), whereas only 3.17% answered that they do not perform any pest management.

The level of education of the respondents was primarily agriculture-related higher educational studies (36.90%), and only 1.59% marked 'without studies'. The age of the respondents ranged from less than 35 years (5.95%) to more than 65 years old (15.87%), with the highest proportion of respondents (48.02%) between 51 and 65 years old. Most of the respondents answered that they know what HLB is and how it spreads (53.17%). Nevertheless, the majority of them said that they do not know the contingency plan measures against HLB and its vectors (68.65%).

MEASUREMENT MODEL

Verification of the model assumption showed that the data did not violate any assumptions of linearity (Rainbow test p-value = 0.31) and correlation (Durbin-Watson test, 2.02 p-value = 0.53). The VIF values were between 1.32 and 3.10, meaning the data had a non-problematic correlation level, and thus the assumption of multicollinearity was not violated (see Supplementary Materials: Appendix D2). Nevertheless, all the normality tests performed had a significant p-value, which means that the data violated the multivariate normality assumption (see Suplementary Materials: Appendix D1).

Table 1. Statements and scales used for the latent variables and confirmatory factor analysis results.

Code	Statement	Mean	SD	IL	CR	AVE	R^2
Intention (I)		5.7	1.3		0.88	0.64	
I1	Would you be willing to cooperate to apply coordinated insecticide treatments?			0.86***			0.75
I2	Would you be willing to remove affected citrus trees and those in a radius around them?			0.62***			0.38
I3	Would you be willing to allow the technical staff of the plant health authority to inspect your farm to detect the HLB disease and its insect vectors?			0.87***			0.75
I4	Would you be willing to inform about the presence of HLB or its vectors on your farm?			0.82***			0.68
Attitude (A)		5.6	1.5		0.87	0.79	
A2	By implementing the measures established in the contingency plan I will help to reduce the spread of the disease in my area			0.96***			0.91
A3	For me, adopting the contingency plan would be: Not Important/Very Important			0.85***			0.72
A4	I will make an effort to implement the measures of the contingency plan on my farm			0.86***			0.75
Perceived behavioural control (PBC)		5.7	1.2		0.81	0.64	
PBC1	I understand why the measures of the contingency plan are necessary			0.80***			0.63
PBC2	I have all the information I need to implement the measures established by the contingency plan			0.98***			0.96
PBC3	I would be able to implement the measures established by the contingency plan			0.56***			0.31
Subjective norm control (SNC)		5.5	1.3		0.67	0.43	
SN_CT1	Please mark the degree to which your reference people (family, friends, partner, colleagues at work and agricultural society, etc.) would approve or disapprove of you carrying out the coordinated insecticide treatments in your area			0.68***			0.47
SN_CP1	Please mark the degree to which your reference people (family, friends, partner, colleagues at work and agricultural society, etc.) would approve or disapprove of you following the measures of the contingency plan			0.79***			0.63
SN_CP2	Would you be willing to allow the technical staff of the farmers' organisation to apply insecticide treatments in coordination with the neighbouring farms?			0.44***			0.19

Notes: M = Mean; SD = Standard deviation; IL = Item loading; CR = Composite Reliability; AVE = Average Variance Extracted.
***= $p < 0.001$.

All latent constructs were assessed for reliability and validity. The reliability test of the CFA (Table 1) showed acceptable results with CA values higher than 0.6 for all the variables (Cronbach, 1951; Daud *et al*., 2018; Taber, 2018). Except for the SN variable (0.43), all the AVE values were higher than 0.5. However, based on Fornell and Larcker (1981), if AVE is less than 0.5 and CR is higher than 0.6, the convergent validity of the construct is still tolerable, and these variables can be used in the model (Muhamad Safiih and Azreen, 2016; Thiam *et al*., 2024). Therefore, it was decided to leave the SN construction unchanged. The DV was confirmed (Supplementary Materials: Appendix E2) as the AVE values were greater than the MSV and ASV for all the constructs of the model (Rezaei *et al*., 2019; Daxini *et al*., 2019).

The CFA results (Table 1) showed that the standardised factor loading for all the items was higher than 0.4 (Table 1). The R^2 value was over 0.1 and statistically significant ($p < 0.001$), indicating acceptable reliability of the observed variables (Stevens, 2012; Cheung *et al*., 2023; Ozili, 2023). The model fit was assessed by examining the Chi-square (χ^2). Given the over-sensitivity of the chi-square test, we use the 90% confidence interval for the RMSEA, the CFI, the TLI and the SRMR, as they are more reliable in large samples (Daxini *et al*., 2019). The results of the CFI (0.962), TLI (0.985), RMSEA (0.075) and SRMR (0.049) indicated a good model fit (Borges and Lansink, 2015; Aldas-Manzano and Uriel-Jimenez, 2017), although this was not the case for χ^2 (0.001).

STRUCTURAL MODEL

Goodness of fit indices of the structural model, namely CFI (0.964), TLI (0.984), RMSEA (0.077) and SRMR (0.051), indicated suitable model fit (Daxini *et al*., 2019). Standardised estimates were used to indicate the strength of the hypothesised relationship between variables. According to the SEM analysis, the TPB constructs explained 65% of the variance in the INT to follow the measures of the contingency plan. Table 2 shows the results of the path analysis of the hypothesis testing. The standardised path coefficients of the direct effect of each construct (ATT, SN and PBC) on INT concluded that ATT and SN constructs have a positive and significant influence on INT, but not PBC; therefore H1 and H2 were accepted and H3 rejected. In addition, the coefficients also demonstrated that SN had a greater effect on INT (0.517) than ATT (0.337). As expected, the coefficients revealed that SN was positively and significantly associated with ATT (0.668, $p = 0.00$) and PBC (0.537, $p = 0.00$). Therefore, H4 and H5 were also accepted.

IMPACTS OF SOCIO-ECONOMIC FEATURE ON STAKEHOLDERS' INTENTION

As shown in Table 3, the analysis to test if the socio-economic characteristics of the stakeholders influence the INT to adopt the contingency plan measures showed that only the age of the individuals' had a statistically significant effect on INT to adopt the contingency plan measures. Older individuals answered to be more willing to adopt contingency plan measures in case of an HLB outbreak.

Table 2. Coefficients of the structural equation model path.

Hypothesis	Path	Std. estimate	*p* (>|Z|)	S.E	Result
H1	ATT → INT	0.337	0.004	0.108	SU
H2	SN → INT	0.517	0.002	0.213	SU
H3	PBC → INT	0.037	0.640	0.089	NS
H4	SN → ATT	0.686	0.000	0.112	SU
H5	SN → PBC	0.517	0.000	0.104	SU

Notes: SU = Supported; NS = Not supported; S.E = Standard error; Std. estimate = Standard estimate.

Table 3. Effect of the socio-economic characteristics on stakeholders' intention.

	Value	Std. error	*t*-value	*p*-value
Farm size	−0.14	0.27	−0.53	0.60
Citrus area	0.33	0.27	1.22	0.22
Profitability	−0.14	0.30	−0.45	0.65
Formal and agronomic education	0.30	0.29	1.02	0.31
Age	1.07	0.34	3.12	0.00
HLB knowledge	0.16	0.29	0.56	0.57
Farmers organization membership	−0.01	0.24	−0.05	0.96
Contingency plan knowledge	0.28	0.31	0.92	0.36

Discussion

To encourage the adoption of the measures established by contingency plans for quarantine plant pests, it is essential to understand the psychological factors underlying the stakeholders' decision making processes, as demonstrated by previous implementations of contingency plans in the EU. Thus, it is crucial to know the effects of ATT, SN and PBC on INT to adopt the measures of the contingency plan. This can facilitate changes in the contingency plan and supporting regulations and contribute to the development of effective awareness campaigns to enhance stakeholders' acceptance and the effective implementation of the measures.

This study used the TPB to explore the INT of Spanish stakeholders to embrace the measures of the contingency plan against HLB as an example of a priority quarantine plant disease not present in the EU territory. Moreover, the possible correlation between the socio-economic characteristics of the individuals and their INT to adopt the measures was also examined. The sample of stakeholders in this study came from the most important citrus area of Spain (Ortiz *et al*., 2022). The socio-economic profile of the respondents was mainly male citrus farmers, owners of their farms, following conventional management practices and obtaining low profits, with agricultural education and knowledge of HLB disease but not of the contingency plan. Our study shows that the TPB can be used as a research framework to explain stakeholders' INT to follow the measures in the contingency plan. Additionally, the TPB helps integrate the analysis of stakeholder's preferences for measures that are both relevant and contentious in addressing pest management challenges, such as coordination and tree removal. The complementary ordered logistic regression analysis sheds light on the factors influencing the INT to adopt the contingency plan measures.

Our results show that SN is the most relevant determinant of the INT to follow the measures of the contingency plan against HLB, which implies that perceived social pressure determines the individuals' final behaviour in following the contingency plan measures. This may be due to the nature of the farms, which are typically small, and the farmers' social structure, where the knowledge and management of a plant pest are commented and transmitted between the individuals, and the information on measures to be implemented comes from the local plant health authorities and scientists. It may also be due to the mandatory nature of the measures. A fear of social and economical penalties may increase the social pressure on stakeholders to adopt the measures in a way that is perceived as socially and legally acceptable (Daxini *et al*., 2019; Laksono *et al*., 2022). Previous studies on other topics have also observed that SN plays a significant role in determining INT to adopt certain agronomic practices, such as improved irrigation technologies (Lanza-Castillo *et al*., 2021), response to invasive forest pests (Holt *et al*., 2021), grassland adoption (Martínez-García *et al*., 2013), or accept agro-environmental schemes (Villamayor-Tomas *et al*., 2019). The results of these studies suggest that the individuals' perceptions and concerns are affected if they do not follow the group's behaviour, as they might be socially excluded, or economically sanctioned (Cheng, 2022), a finding that aligns with our results. Therefore, governments should consider promoting participatory groups led by the plant health authorities, and including a reference person that stakeholders could trust to engage them in crop management practices, specifically those related to plant health. These participatory groups could provide interactive platforms for citizens, farmers, and other stakeholders, encouraging trust in the actions needed to preserve the plant health status of the area. Moreover, it would also be advisable that plant health authorities gather insights from stakeholders after implementing the measures in case of an outbreak, paying attention to the stakeholders' concerns, making them feel heard and supported. Consequently, subjective norms can encourage more positive participation, rather than exerting legal enforcement for involuntary implementation; an issue that has already been observed (Cheng, 2022; Pavone, 2022).

In this study, ATT had the second-highest direct effect on stakeholders' INT to follow the contingency plan against HLB, which implies that stakeholders with more favourable opinions on the consequences of adopting the contingency plan will be more likely to follow it. Indeed, previous studies have found that ATT is the most important determinant of individual's INT (Wauters *et al*., 2010; Rossi-Borges *et al*., 2016; Despotović *et al*., 2019). Therefore, bearing in mind its positive and high effect over INT, it would be advisable for governments to promote positive attitudes towards detecting HLB disease and its vectors. They should apply contingency plan measures to preserve the phytosanitary status of crops and the environment. This can be achieved through more public awareness campaigns and by educating people how to implement these measures. In contrast to previous studies on the individual's decision making process (Daxini *et al*., 2019; Laksono *et al*., 2022; Lind *et al*., 2023; Omulo *et al*., 2024), in our case, the PBC had no direct effect on INT. This suggests that the stakeholders' perceptions of the level of complexity, self-confidence and degree of control over the contingency plan do not determine the final INT to adopt it. No PBC influence could probably be attributed to variations in perceived difficulty, not only the ease of performing actions but also the control one has in performing them. This could mean that a stakeholder might feel compelled to adopt phytosanitary measures due to social pressure and beliefs in their benefits, regardless of their perception of control. The strong social pressure from other farmers, neighbours, and community leaders can be a determining factor, as farmers may feel obligated to meet the expectations of their community for fear of economic or social sanctions, making their own perception insignificant compared to social pressure (Cheng, 2022).

This is confirmed by our findings on the significant influence of SN over PBC and ATT, which suggests that the stakeholders' evaluation of the importance of implementing the contingency plan and their self-perception about their competence to follow these measures was influenced by the group opinions. These results agree with previous studies on other agricultural topics, which have shown that individuals were usually more influenced by social pressures than by their own opinions and/or self-perception about their behaviour (Daxini *et al*., 2019). In fact, in the case of the quarantine plant pathogen *X. fastidiosa*, individuals left aside the rational consideration of the outbreak management plan (e.g tree felling, vector control, etc.) as a consequence of the opinions and information released by people who were relevant to them (Pavone, 2022). This may be because individuals usually consider others' behaviour to assess if taking that behaviour would be beneficial to them and, thus, SN influence their opinion about that action (Daxini *et al*., 2019). Our study results are, therefore, in line with Daxini *et al*. (2019), suggesting that in the case of outbreak management for quarantine pests, the individuals' ATT and PBC will be influenced by their social links. Hence, it would be important for the competent authorities to raise awareness and engage relevant individuals, who will positively influence the stakeholders' confidence and trust to follow the contingency plan.

Regarding the socio-economic characteristics, surprisingly, knowledge of the contingency plan did not significantly affect stakeholders' INT to adopt its measures. This result may be attributed to the superficial understanding that many stakeholders seem to have regarding HLB. It is probable that while individuals might claim to know about HLB because they recognise it as a citrus disease, this self-reported knowledge lacks depth because many stakeholders may not fully grasp the challenges of the disease, the severity and rapidity of its impacts, and, therefore, the need for their control. Thus, the general and broad questions from the current study regarding HLB knowledge, its dissemination, severity, and associated management measures (especially those outlined in the contingency plan) may suggest a lack of more profound formulation of these questions and, therefore, an inadequate collection of respondents' real awareness.

It is plausible to believe that if we had asked more specific questions, these could have revealed a closer relationship between clear knowledge of the HLB, the need for its control through EU regulation, and the intention of stakeholders to follow the measures in the contingency plan. Addressing this gap in future studies through more targeted questions could uncover the true impact of knowledge on stakeholders' intentions.

Age was the only one of the socio-economic variables with a significant and positive association with INT. Older farmers often have more experience and tend to be more focussed on the long-term sustainability and productivity of their farms, considering them as a legacy to the next generation that makes them more aware and have a better understanding of the risks and consequences of not adopting phytosanitary measures (Burton, 2014; Rizzo *et al*., 2024). Considering the advanced age of farmers and other stakeholders related to agriculture and the relevant effect of SN over INT, policy implementation measures should align with the social contexts of the area and encourage community support. Therefore, stakeholders' SN towards the contingency plan should be considered when designing educational and awareness campaigns for quarantine pest outbreaks and facilitating further interventions. Future studies in this area should focus on additional factors that may influence stakeholders' SN, which can be critical to the social pressure that stakeholders may experience when following certain behaviours.

STUDY LIMITATIONS

This study has several limitations that should be considered to be able to interpret the results properly.

First, this study evaluated the INT to follow the contingency plan for a specific group of stakeholders in the main citrus production region in Spain. Therefore, the results are limited to this type of stakeholders and geographic area and cannot be extrapolated to other regions and types of stakeholders, such as home-growers and citizens in residential areas, who may also influence the overall response against the disease.

Second, respondents participated in this study on a voluntary basis, mostly using the online questionnaire. Therefore, the sample did not include those potential respondents who were not willing to participate in the study and could be less interested in implementing the contingency plan. This potential optimism bias of the study may limit a quantitative assessment of the results in relation to the chances of successfully implementing the contingency plan.

Third, the study was based only on the TPB model, which incorporates different controversial items of a contingency plan to measure the INT to adopt them. Furthermore, regarding the TPB, the study only focused on INT and did not consider actual behaviour. Although INT is considered the best predictor of behaviour, it might not always translate into actual behaviour, and other variables might be responsible for the relationships observed (Damalas, 2021; Irwin *et al*., 2023). Therefore, future research to validate the results might incorporate complementary constructs, such as the actual behaviour, and address the limitations of psycho-social factors by including other variables that are relevant to the model and a larger study area.

Fourth, this is an ex ante study, meaning that the questionnaire was conducted when the HLB disease and its vectors were still not present in the commercial citrus-producing areas under study and, therefore, measures of the contingency plan have not yet been implemented. For instance, the respondents showed a relatively high degree of knowledge and awareness about the disease, but not of the measures of the contingency plan, such as tree removal, performing collaborative treatments, and notifying the authorities. Consequently, longitudinal studies will be needed once the disease is eventually introduced and the contingency plan is implemented to explore the variations in the INT of the population sample.

CONCLUSIONS

Plant pest outbreaks are a major cause of losses in agriculture, natural ecosystems, services and biodiversity. The EU Plant

Health Law aims to protect the EU territory against the introduction and spread of new quarantine plant pests and mandates the development of a contingency plan for a group of priority pests (EU, 2016, 2019a). Barriers to entry, early detection, and eradication are some of the measures necessary to avoid major socio-economic impacts by plant pest outbreaks. Nevertheless, contingency plans need public cooperation in order to be truly effective. Hence, one of the challenges in promoting plant health is to actively involve stakeholders in the necessary actions to preserve the status of agricultural crops and natural ecosystems.

The findings of this study indicate that the combined TPB constructs can explain stakeholders' INT to follow the contingency plans for priority pests such as HLB.

The results of this study indicate the relevance of the SN, which has the greatest influence on the willingness to follow the contingency plan, followed by ATT. Although PBC was not found to have a significant influence, it is advisable that education about the scientific basis and rationale behind the regulations to control plant pest outbreaks, such as those set out in the contingency plan, may be relevant for stakeholders to understand and adopt these measures.

The results of the SN showed that this construct has a direct effect on the INT but also on the ATT and perceptions on adopting the contingency plan measures. These results suggest that the opinions of others considered as relevant by the stakeholders play a crucial role in their INT to follow the contingency plan, either because they fear social exclusion or because they feel encouraged by those relevant peers.

Our results have practical implications for plant health regulators and authorities in relation to plant pest outbreak management and the involvement of stakeholders. Appropriate methods need to be identified to expand the plant health regulatory framework in the EU beyond the implementation of control measures, to engage stakeholders and the population in general so they understand the scientific basis of the measures and are willing to implement them.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ETHICS STATEMENT

The authors confirm that the research meets any required ethical guidelines, including adherence to the legal requirements of the study country.

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AUTHOR CONTRIBUTIONS

AG, SG, NM, SV, AV and MA conceptulised the study; AG, SG, NM, AV and MA contributed in methodology; AG took care of data curation; AG performed formal analysis. AV contributed in funding acquisition . AG, MA and AV contributed in original draft writing; AG, MA, SG, NM, SV and AV took care of final draft and AG, SG, SV and AV contributed in review & editing.

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DATA AVAILABILITY

Data curation and formal analysis was implemented with *R* statistical programming Team (2021) and the code is open-source and available at: https://doi.org/10.5281/zenodo.14592067.

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