ISSN: 18158129 E-ISSN: 18151027
Volume 17, Issue 11, November, 2021

# Farmers' behavior and intention to adopt integrated pest management in fruit: Case study in Vietnam

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**ABSTRACT**— Vietnam has introduced Integrated Pest Management (IPM) for more than thirty years. However, it has not been adopted and diffused widely. Thus, both the government and non-government extension programs have promoted the practice of IPM or integrated IPM with other programs such as Vietnamese Good Agricultural Practice (VietGAP) recently in Vietnam to help farmers pursue sustainable agriculture with market-oriented. This research aims to identify the significant factors affecting farmers' decision and intention to apply IPM in the case of longan in the Mekong Delta, Vietnam. This research applied theory of planned behavior (TPB) to build the models to examine factors influencing farmers' behavior and intention to adopt IPM using binary logistic regression. The results show that farmers perceived the benefits of applying IPM to help them to reduce the production cost, increase productivity, reduce health risks to sprayers, community and end consumers, and ecological functions to the soil, animals, and aquatic environment. The importance of the belief on the effectiveness of IPM leads to the close relationship between farmers' intention to adopt IPM and the community-based IPM programs. Economic benefits of adopting hypothetical IPM programs are the most significant factors controlling farmers' intention to practice IPM. The success of previous extension programs would generate the best belief to farmers to disseminate agricultural technologies in Vietnam.

**KEYWORDS:** theory of planned behavior, adoption, IPM, integrated pest management, Vietnamese Standard of Good Agricultural Practice, VietGAP.

## 1. INTRODUCTION

Integrated Pest Management (IPM) has been disseminated in Vietnam for more than 30 years in rice, fruit, and other crops by the international, national and local extension programs [26], [7], [35], [25]. However, pesticide use in Vietnam is still very high compared to other agricultural countries [18], [13], [27], [34]. The consequences are both generating high production costs and environmental impacts and do not meet the requirements of residues in both the strict domestic and export markets [14], [24], [8]. Thus, the Mekong Delta, the largest region in rice and fruit production in Vietnam, continues to introduce many programs on IPM or integrated IPM into other programs such as VietGAP (Vietnamese Good Agricultural Practice) to diffuse IPM in Vietnam (Vietnam News, 2020; Southern Fruit Research Institute, 2019). How to convince farmers to adopt IPM and diffuse IPM widely in the Mekong Delta, Vietnam, especially in areas where IPM programs have not been introduced or demonstrated. Besides, how farmers who participated in IPM programs, will continue to apply IPM after these IPM programs are over. These are important questions that both policymakers and extension specialists in Vietnam and other countries need to disseminate IPM widely in Vietnam and the world. Thus, this study on farmers' behavior and intention to adopt integrated pest management in fruit, a case study in Vietnam will identify important factors for adopters and non-adopters to practice IPM in Vietnam. The case study of Idor longan, one of the tropical fruits chosen to apply IPM and VietGAP in the Mekong Delta, Vietnam recently will be demonstrated in this article. The following part will introduce a case study of Idor longan in the Mekong Delta, Vietnam. Idor longan, also known as E-dor, E-

daw, or Ido (*Dimocarpus longan Lour*.) has advantages such as small seeds, thick and crispy edible white-fleshed with less water content, moderate sweetness [28], [16]. Idor longan has less pest infestation than other longan species in the Mekong Delta Vietnam, especially witches' broom disease, caused by longan gall mite (*Eriophyes dimocarpi*), one of the most affected pests in the Mekong Delta in the last 5 years [15]. As a result, Idor longan has been recommended to grow in the Mekong Delta provinces [11], [3], [2]. However, like other fruits and vegetables produced in the Mekong Delta, Idor longan also face many difficulties in both production and consumption. Most farmers do farming on a small and scattered production scale. Besides, they are afraid to apply new techniques; thus, the production cost is high and logan quality does not meet consumption requirements in high-value markets at home and abroad [20], [37], [23].

## 2. MATERIAL AND METHODS

### *2.1 Literature review*

The theory of planned behavior [1] is a basic theory that helps to understand and predict the behavior of farmers applying IPM of both groups of farmers who have not and are adopting IPM. This theory applied the theory of reasoned action, which is also the theory to explain the relationship between actions and attitudes and social norms [5], [12]. The highlight of the theory of planned behavior proposes groups of behaviors that influence both the respondent's behavior or decisions and the respondent's intentions in the future. Attitudes towards behavior, social norms or influence, factors outside the object of analysis, and perceived behavioral controls are three components of the theory of planned behavior. Of which, perceived behavioral control is the main difference to the theory of rational behavior. In addition, the model applies the extended planned behavior to add background information characteristics of respondents and longan growers [4]. The KAP model (Knowledge, Attitudes, and Practice) is also a popular research model on the behavior of farmers applying for new technology transfer programs in agriculture [33], [22], [19], [26], [7], [35]. This model modified the theory of rational behavior that explains the relationship between knowledge, attitude, and behavior. How knowledge shapes attitudes and perceptions, then they influence behavior. However, the model does not separate the groups of cognitive factors as in the theory of planned behavior model.

This study also partially applies the theory of norm action behavior [32]. This model emphasizes the role of altruism and environmentally friendly behavior affecting respondents' behavior or intention to apply IPM. The application of IPM brings direct benefits to farmers such as reducing production costs, improving incomes and profits, and many benefits to the community. Besides, indirect benefits of IPM on the environment and communities positively affect respondents' behavior and intention to adopt IPM. The detail of these factors is seldom found in the theory of planned behaviors [32], [4]. Based on the review, the model is built on four groups of factors affecting the behavior and the intention to apply IPM of respondents [33], [22], [21], [31], [32], [4], [10], [9], [19], [26], [7], [35]. The first group of factors are attitudes toward behaviors affecting the behavior and intention to IPM. A positive understanding of the respondents on the effectiveness of the IPM leads to better IPM applications (direct and indirect benefits of IPM). The expected results or effectiveness of the technology (expectancy-value model) is a significant factor when participating in the IPM program. Background knowledge on IPM of the related crops can both lead or restraint the acceptance of respondents to adopt IPM. The IPM program on rice was very famous and widely implemented in Vietnam from 1992 to 1994. Besides, many new local and government extension programs have continued to transfer IPM knowledge and skills to farmers in Vietnam recently to reduce the use of pesticides that are harmful to the environment [7], [29], [30]. Even private sectors that provide agrochemicals and pesticides in Vietnam have shifted to more environmentally friendly or biochemical substances with less persistence to the environment and low residues in products to suit the market demand.

Theory of rational behavior emphasized the roles of social influence [4], [12]. Social norms, such as respondents adopt IPM practice depending on the wishes and preferences of family members, the judgment of surrounding households or local authorities, and the efficiency of previous IPM or agricultural programs or innovation [21], [31]. This group of factors depends on the external factors, those pressure the respondents' decision or intention to adopt new techniques. In addition, the motivation on the effectiveness of IPM is also a significant factor to speed up IPM adoption.

Perceived behavioral control is a new component in the theory of planned behavior while rational behavior theory consists of only two components, namely attitudes and social norms. The perceived behavior control applied the theory of self-efficacy [21], [31]. They are the judgments of respondents on the ease or difficulty to adopt IPM technologies. Besides, they are the necessary conditions for applying new technology (controllability) [10], [32], [9]. IPM is difficult to adopt because it requires farmers' knowledge in different methods of pest management. In addition, farmers also need to understand the concept of pesticide toxicity in terms of persistence to the environment and accumulation through the food chains [33], [22], [19], [26], [7]. The factors controlling the behavior of applying new technology include both internal conditions (production scale and resources) and external conditions (market requirements, output, and input prices) [26], [7].

### *2.2 Data collection*

Secondary data includes data on the status of Idor longan cultivation and implementation of the VietGAP and IPM program of Idor longan in the Mekong Delta. This is the basis for selecting the research area and understanding the characteristics of growing Idor longan in the Mekong Delta. In addition, published studies on actual and planned behavior to adopt the agricultural technologies, especially on IPM in rice and other crops were also collected to construct and review the models of the behavior and intention to adopt IPM of respondents of Idor longan.


**Figure 1.** Study sites

Primary data mainly based on 180 households growing Idor longan in three provinces of Vinh Long, Tien Giang and Dong Thap, including 90 households with and 90 households not participating in the VietGAP program in the Mekong Delta. In which, households participating in VietGAP in Vinh Long and Tien Giang also participate in the IPM program implemented by the Southern Fruit Institute (SOFRI). The number of interviewed households participating in VietGAP and IPM accounted for 80% of the total households participating in the two VietGAP and IPM programs in the three study sites. Details of the interview sites are

presented in Table 1 and Figure 1.

**Table 1.** Study sites and sampling size

| Study sites | Apdopted VietGAP/IPM | | No. of respondents | |
|---|---|---|---|---|
| | Area (ha) | No. HHs | VietGAP /IPM | Non-VietGAP/ IPM |
| 1. An Nhon commune, Chau Thanh district, Dong Thap province | 56 | 34 | 30 | 30 |
| 2. Tan Phong commune, Cai Lay district, Tien Giang province | 23 | 34 | 30 | 30 |
| 3. Hoa Ninh commune, Long Ho district, Vinh Long province | 20 | 44 | 30 | 30 |
| **Total** | **99** | **112** | **90** | **90** |

### *2.3 Data analysis*

Figure 2 present the diagraphic model of factors affecting the decision and intention to apply IPM. It adopted the model of the theory of planned behavior, which includes four components, namely attitudes toward behaviors, subject norms, perceived behavior control, and background information of respondents and their orchards. Part 4.1 of the results will present the descriptions of four groups of factors. The actual behavior or the decision to adopt IPM has relied on the two groups of adopters and non-adopters IPM, who directly participated in VietGAP and IPM programs in three provinces of the Mekong Delta. Interviewees introduced hypothetical scenarios to respondents to identify their responses to intend to adopt IPM from both adopters and non-adopters (part 4.2 of the results). The binary logistic regressions were applied in all three models and the result is in part 4.3.

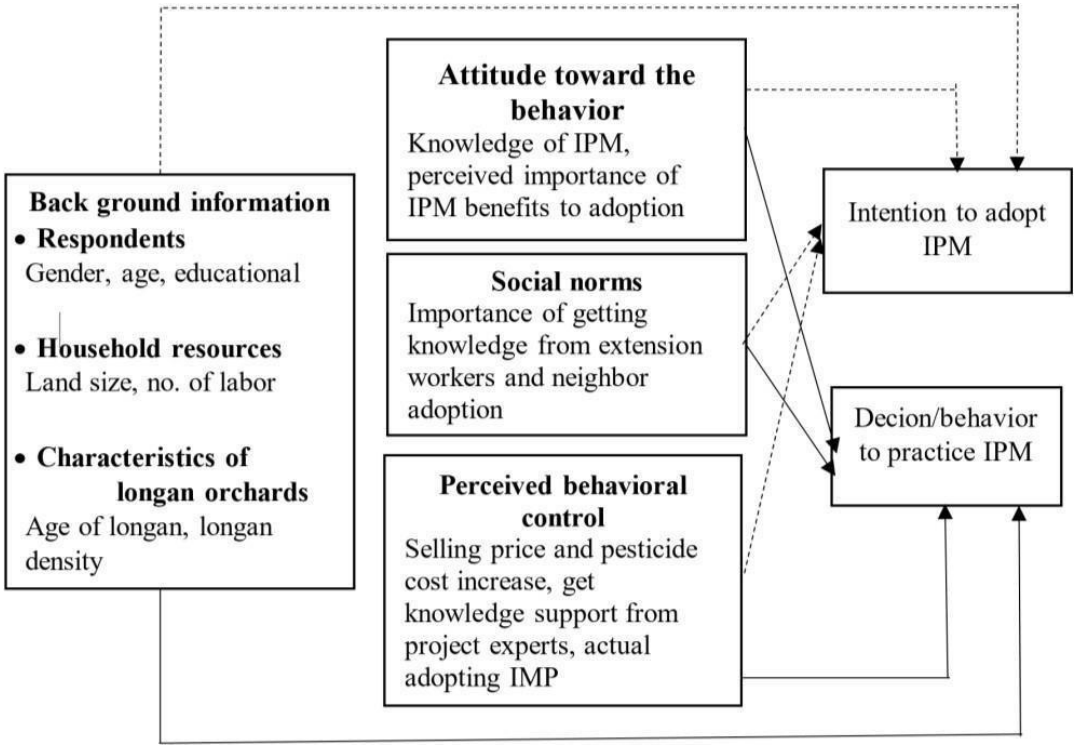


**Figure 2.** Conceptual framework adapted from the theory of planned behavior

## 3. RESULTS

### *3.1 Description of variables affecting IPM adoption and intention applying the theory of planned behavior*

#### *3.1.1 Characteristics of variables related to knowledge, attitude, and perception of respondents to IPM benefits*

Thirty percent of the respondents reported that they knew about IPM before the VietGAP and IPM were introduced to their sites in Vinh Long, Tien Giang, and Dong Thap province. The Likert scale of 1 – 5 (least import – very important) was applied in 17 statements to evaluate respondents' perception of the importance of IPM benefits. Then, these statements were merged into five similar groups of IPM benefits and converted to scale (0, 1 – Least important and very important). These five groups of benefits will be tested in the logit models later. The respondents perceived that it is very important that IPM can help to reduce production costs including labor, fertilizers, and pesticides ($X_{2,1}$, 0.85/1). This factor is the most important benefit that respondents expect from IPM. The next benefit of IPM that respondents consider very important is that IPM can help increase productivity, selling price, and profit for IPM adopters ($X_{2,2}$, 0.82/1). In addition, the adoption of IPM helps respondents feel confident, knowledgeable, and creative in pest management for their longan orchard (0.68/1 – important). Applying IPM also helps to reduce health impacts for sprayers, communities, and consumers ($X_{2,4}$, 0.8/1 – important). Finally, applying IPM can reduce pesticide resistance, improve the ecological environment, protect useful enemies, and poison aquatic species and animals ($X_{2,5}$, 0.73 – Important) (Table 2).

**Table 2.** Respondents' knowledge, attitude and perception on integrated pest management

| Var. | Variable description - Attitude toward the behavior | Ave. | SD | Ranking |
|---|---|---|---|---|
| $X_1$ | Respondents knew about IPM before the VietGAP/IPM programs transferred to farmers ($X_1$=1: Knew) | 30.0 | | |
| $X_{2,1}$ | Respondents perceived that IPM can help to reduce productioncosts including labor, fertilizers and pesticides[1] (merged three statements) | 0.85 | 0.13 | Very important |
| $X_{2,2}$ | Respondents perceived that IPM can help to increase productivity, selling price and profits of adopters[2] (merged three statements) | 0.82 | 0.13 | Very important |
| $X_{2,3}$ | Respondents perceived that IPM can help to increase farmers' confidence, knowledge, options and creativity to pest management[3] (merged four statements) | 0.68 | 0.15 | Important |
| $X_{2,4}$ | Respondents perceived that adopting IPM can help to reduce harmful health effects sprayers, community and consumers[4](merged three statements) | 0.80 | 0.17 | Important |
| $X_{2,5}$ | Respondents perceived that adopting IPM can help to reduce pesticide resistance, improve the ecological environment, protect useful enemies and poison aquatic species and animals[5] (merged four statements) | 0.73 | 0.16 | Important |

Notes: 1,2,3,4,5: statements about the benefits of IPM and how important they affect to the decision to apply IPM, Likert scale of 5. The variables $X_{2,1}$, $X_{2,2}$, $X_{2,3}$, $X_{2,4}$ merged three statements and $X_{2,3}$ and $X_{2,5}$ merged four statements by getting the average scores of three or four statements, then divided by 5. The values of variables $X_{2,j}$ varies from 0 to 1. Of which, 0 – 0.2 =very not important, 0,21 – 0.4 = not important, 0.41 – 0.6 = neutral, 0.61 – 0.8 = important and 0.81 – 1.0 = Very important

***3.1.2 Social norms or external factors affecting respondents' behavior and intention to adopt IPM***

Respondents identify social factors, external factors that influence the decision or intention of respondents to adopt IPM. Specifically, 26% of respondents said that they learn IPM experience and knowledge from the extension workers and members of the cooperatives and they greatly influence the decision to apply IPM. In addition, IPM practice requires the decisions to reduce the use of pesticides persistent or difficult to decompose in the environment or reduce the use of inorganic fertilizers. These requirements make farmers worry that the longan yield and skin color affect the longan yield and quality. Therefore, respondents reported that if their neighbors accept to apply IPM, they will practice IPM (Table 3). The survey results showed that 41% of respondents agree to practice IPM if more than 20% of their neighborsadopt IPM (Table 3). Many studies had similar results related to neighbor behaviors [4], [36], [12], [29].

**Table 3.** Influence social norms to respondents' perception on integrated pest management

| Var. | Variable description - social norms | Percentage |
|---|---|---|
| $X_3$ | Got IPM knowledge from extension workers and cooperatives members ($X_3$=1: Yes) | 26.1 |
| $X_4$ | Neighbor adopting IPM affect respondents' intention or continuing to apply IPM ($X_4$=1: agree to apply IPM if at least 20% of their neighbor agree to adopt) | 41.1 |

***3.1.3 Characteristics of variables related to belief controlling respondents' behavior and intension to adopt IPM***

Table 4 describes the perceived behavioral control variables of respondents related to IPM application. Farmers required the selling price of longan at the farm gate would be higher when applying IPM and expected to sell certified VietGAP or IPM longan. This desire belongs to the direct benefits of IPM. For example, respondents intended to apply IPM if certified VietGAP and IPM longan prices increase by at least 20% compared to normal longan prices. Thus, with an average longan price of 20 thousand VND/kg, the price of longan when applying IPM should vary in 22 – 25 thousand VND/kg. The price of longan at the farm gate depends much on good time selling longan and the size and quality of longan. The analysis shows that the selling price of longan at the farm gate of IPM adopters was significantly higher than non-IPM adopters about 500 – 600 VND/kg. The high price of longan is due to the better quality of the longan, the better skin color of the longan when properly applied disease prevention measures according to the IPM guidelines.

**Table 4.** Variables of perceived behavior control to respondents' perception on integrated pest management

| Var. | Variable description - Perceived behavioral control | Percentage |
|---|---|---|
| $X_{5,1}$ | Selling price at farm gate affect respondents' intention or continuing to apply IPM ($X_{5,1}$=1 agree to apply IPM if selling price increase at least 10% of the current price) | 30.6 |
| $X_{5,2}$ | Respondents required support knowledge, fertilizers or staff to visit their gardens regularly ($X_{5,2}$=1 agree to apply IPM if receiving supports) | 44.4 |
| $X_6$ | Reducing production costs affect respondents' intention or continuing to apply IPM ($X_6$=1 agree to apply IPM if production costs reduce at least 10% of the annual investment) | 34.4 |
| $X_{7,1}$ | Longan growers is practicing IPM/VietGAP | 50.0 |
| $X_{7,2}$ | Price of pesticides increase affect respondents' intention or continuing to apply IPM ($X_{7,2}$=1 agree to apply IPM if price of pesticide increase at least 10% of the current price) | 35.0 |

In addition,adopting IPM should help reduce the annual investment cost of longan by at least 10%. With the annual investment cost of longan about 8.5 million VND/year/1,000m$^2$, farmers expected that applying IPM could reduce by 850 – 1 million VND. Farmers could achieve this requirement by reducing the cost of inorganic fertilizers and add more organic fertilizers. The increase of pesticide price at the market is a significant factorleading respondents to decide and intend to apply IPM.

### *3.1.4 Characteristics of repondents and their farms*

The characteristics of respondents and their longan production are presented in Table 5. In detail, the educational attainment of respondents was grade 7 (secondary school). The average density of the longan gardens is 25 trees/ 1,000m2 (±20 longan trees). The average area of longan is 5.2 ± 6.4 thousand m$^2$ and the average age of the tree is 8.8 years ± 3.8 years. In addition, the number of interviewed households in each province is the same. These characteristics will be tested their influence on the decision and intention to apply IPM of longan growers.

**Table 5.** Characteristics of respondents and longan farms

| Var. | **Background factors of respondents and farms** | Average | Standard deviation |
|---|---|---|---|
| $X_8$ | Number of schooling years attainment (years) | 7.3 | 3.1 |
| $X_9$ | Longan density (trees/1,000m$^2$) | 24.7 | 19.8 |
| $X_{10}$ | Longan area (1,000m$^2$/household) | 5.2 | 6.4 |
| $X_{11}$ | Longan age (years) | 8.8 | 3.8 |
| $X_{12}$ | Dong Thap study site ($X_{15}$=1: Yes) | 33.3 | |
| $X_{13}$ | Vinh Long study site ($X_{15}$=1: Yes) | 33.3 | |

### *3.2 Respondents' intention to adopt IPM*

The hypothetical scenarios are that the IPM program would continue to transfer in the area that has and has not implemented the IPM/VietGAP program. Hypothetical scenarios of incentives include the price of longan in the garden increases, production costs decrease, pesticide price increase and longan adopters agree to adopt the new IPM program. Among scenarios, increased selling prices of longan is the most attractive incentive to respondents with 56% of respondents intending to participate in the IPM. Then production costs decrease (54%), neighbors adopt IPM (53%), and increase the price of pesticides (47%) are significant incentives to attract farmers' intention to adopt IPM (Table 6).

**Table 6.** Respondents' intention to adopt IPM in the hypothetical scenarios

| **Intention to adopt IPM with incentives** | **Adopters of IPM/VietGAP** | | **Total (n=180)** |
|---|---|---|---|
| | **Yes (n=90)** | **No (n=90)** | |
| **Agree to adopt IPM if longan selling price at farm gate increase** | | | |
| Price increase <=20% | 53 | 36 | 44 |
| Price increase <=30% | 59 | 46 | 52 |
| Price increase > 40% | 62 | 49 | 56 |
| Do not agree to adopt IPM | 38 | 51 | 44 |
| **Agree to adopt IPM if production cost decrease** | | | |
| Decrease less than10% | 44 | 24 | 34 |
| Decrease more than 40% | 63 | 47 | 54 |
| Do not agree to adopt IPM | 37 | 53 | 46 |

| | | | |
|---|---|---|---|
| **Agree to adopt IPM if price of pesticides increase** | | | |
| Increase by 10% | 46 | 24,4 | 35 |
| Increase more than 40% | 55 | 40 | 47 |
| Do not agree to adopt IPM | 45 | 60 | 53 |
| **Agree to adopt IPM if neighbors would adopt IPM** | | | |
| <=20% neigbors adopt IPM | 48 | 35 | 41 |
| <=30% neigbors adopt IPM | 57 | 40 | 48 |
| >40% neigbors adopt IPM | 68 | 48 | 53 |
| Do not agree to adopt IPM | 42 | 52 | 47 |

Respondents predicted that about 48% of farmers would agree to adopt the new IPM program and it is not much different response between IPM adopters and non-adopters (Table 7). To participate in the new IPM program, respondents expect the project staff would visit their orchards regularly to give them proper and up-to-date technical advice (43%). Respondents also needed more knowledge about IPM (36%) and got subsidies from qualified fertilizers and pesticides (17%).

**Table 7.** Predict the ratio of farmers agree to adopt new IPM program and their expectation

| **Parameters** | **Adopters of IPM/VietGAP** | | **Total (n=180)** |
|---|---|---|---|
| | **Yes (n=90)** | **No (n=90)** | |
| **Predict the ratio of farmers agree to adopt new IPM program** | | | |
| Mean | 49 | 47 | 48 |
| Standard deviation | (15) | (14) | (14) |
| **Expectation from the new IPM program (% of respondents)** | | | |
| Technical staff visit the longan orchards regularly for up-to-date advice | 43 | 43 | 43 |
| Provide fertilizers and insecticides | 21 | 12 | 17 |
| Provide knowledge related to IPM | 38 | 33 | 36 |

Respondents presented the most constraints of IPM and VietGAP adoption are they cannot sell longan with certified VietGAP and IPM (62%, Table 8). In the setup of the VietGAP program, farmers would sell longan with certified VietGAP to the cooperatives at a better price than the middlemen or traders. However, the cooperatives were not very active, so farmers sold their longan to the middlemen. Even the longan selling price with VietGAP certified was higher than the non-certified VietGAP longan, respondents were disappointed about this outcome. Respondents also showed their reluctance to apply IPM because the effects of IPM are slow and more focused on the indirect benefits (24%). They do not have many options to choose the bio-plant protection products (14%).

**Table 8.** Constraints in IPM adoption perceived by respondents

| **Constraints of IPM adoption** | **Percentage** |
|---|---|
| There are not many options to choose bio-plant protection products | 14 |
| It takes long time to see the effects of IPM | 24 |
| No differentiation between IPM/VietGAP and non-IPM/ VietGAP products (longan sold at the markets) | 62 |

### *3.3. Factors affecting respondents'decision and intention to apply IPM*

**Table 9.** Factors affecting respondents 'decision and intention to apply IPM

| Var | Variable description | Y1 | | Y2 | | Y3 | |
|---|---|---|---|---|---|---|---|
| | | Coef. | SE | Coef. | SE | Coef. | SE |
| **Attitude toward the behavior** | | | | | | | |
| $X_{1,1}$ | Respondents knew about IPM before the VietGAP/IPM programs transferred to farmers ($X_1$=1: Knew) | 1.57* | 0.82 | -0.52ns | 1.12 | 2.26* | 1.35 |
| $X_{2,1}$ | Respondents perceived that IPM can help to reduce production costs including labor, fertilizers and pesticides ($X_{2,1}$=1: Yes) | 5.92*** | 2.08 | -6.19** | 2.63 | 5.37** | 2.73 |
| $X_{2,4}$ | Respondents perceived that adopting IPM can help to reduce harmful health effects sprayers, community and consumers ($X_{2,4}$=1: Yes) | -3.88*** | 1.50 | 1.73ns | 2.42 | -1.55ns | 2.66 |
| **Social norms** | | | | | | | |
| $X_3$ | Respondent got IPM knowledge from extension workers and cooperatives members ($X_3$=1: Yes) | 1.18ns | 0.84 | 0.62ns | 1.17 | -0.53ns | 1.40 |
| $X_4$ | Neighbor adopting IPM affect respondents' intention or continuing to apply IPM ($X_4$=1: agree to apply IPM if at least 20% of their neighbor agree to adopt) | -0.45ns | 0.52 | 1.97** | 0.85 | 1.22ns | 0.75 |
| **Perceived behavioral control** | | | | | | | |
| $X_{5,1}$ | Selling price at farm gate affect respondents' intention or continuing to apply IPM ($X_{5,1}$=1 agree to apply IPM if selling price increase at least 10% of the current price) | -1.23ns | 0.75 | 3.77*** | 0.94 | | |
| $X_{5,2}$ | Respondents required support knowledge, fertilizers or staff to visit their gardens regularly ($X_{5,2}$=1 agree to apply IPM if receiving supports) | | | | | 1.50** | 0.75 |
| $X_6$ | Reducing production costs affect respondents' intention or continuing to apply IPM ($X_6$=1 agree to apply IPM if production costs reduce at least 10% of the annual investment) | 0.32 ns | 0.74 | 2.95*** | 0.75 | 2.63*** | 0.92 |
| $X_{7,1}$ | Households applied IPM/VietGAP ($X_{7,1}$=1 = Yes) | | | 1.26 ns | 0.85 | -0.45ns | 0.74 |
| $X_{7,2}$ | Price of pesticides increase affect respondents' intention or continuing to apply IPM ($X_{7,2}$=1 agree to apply IPM if price of pesticide increase at least 10% of the current price) | 1.33* | 0.76 | | | 5.07*** | 1.21 |
| **Background information** | | | | | | | |
| $X_8$ | Number of schooling years attainment (years) | 0.11* | 0.06 | 0.04ns | 0.11 | 0.08ns | 0,14 |
| $X_9$ | Longan density (trees/1,000m$^2$) | 0.0ns | 0.01 | -0.02ns | 0.02 | 0.01ns | 0,02 |
| $X_{10}$ | Longan area (1,000m$^2$/household) | 0.20*** | 0.07 | -0.04ns | 0.10 | 0.06ns | 0,05 |
| $X_{11}$ | Longan age (years) | -0.05ns | 0.05 | 0.08ns | 0.11 | -0.07ns | 0,10 |
| $X_{12}$ | Dong Thap study site ($X_{12}$=1: Yes) | 0.11ns | 0.46 | 1.10ns | 0.94 | -0.61ns | 1,07 |
| $X_{13}$ | Vinh Long study site ($X_{13}$=1: Yes) | 0.30ns | 0.49 | -0.85ns | 0.94 | 3.22*** | 0,99 |
| | Constant | -4.26*** | 1.62 | -4.03*** | -1.41 | -8.89*** | 3.24 |

| Var | Variable description | Y1 | | Y2 | | Y3 | |
|---|---|---|---|---|---|---|---|
| | | Coef. | SE | Coef. | Coef. | SE | Coef. |
| | No. of observations | 180 | | 180 | | 180 | |
| | Ratio of $Y_j$=1(%) | 50 | | 35 | | 44 | |
| | Log Likelihood | -92.75 | | -35.51 | | -32.54 | |
| | LR $Chi^2$ | 64.03 | | 162.06 | | 182.23 | |
| | Prob > $Chi^2$ | 0.00 | | 0.00 | | 0.00 | |
| | Pseudo $R^2$ | 0.26 | | 0.70 | | 0.74 | |

Note: Coef. is coeficient of the logit regression, SE is standard error,

*, **, *** is significantly at α = 10%, 5% and 1% respectively and ns is not significant at α = 10%,

$Y_1$=1: households are practicing IPM/VietGAP

$Y_2$=1: respondents intend to apply IPM if the price of pesticides increased by 10%

$Y_3$=1: respondents intend to apply IPM if the selling price of longan at farm gate increased by 20%

To analyze the factors affecting the decision and intention to apply IPM of the respondents, three models of the decision and intention to apply IPM were analyzed using the Binary Logit model (Table 7). Model 1 analyzes the factors affecting the respondents' decision to apply IPM/VietGAP ($Y_1$=1 = 50%). The analysis results show that three variables of attitudes towards behaviors all affect the decision to apply IPM. In which, respondents perceived that applied IPM can help to reduce harmful health effects sprayers, community, and consumers ($X_{2,4}$) has a negative influence on the decision to adopt IPM. Farmers know the effects of pesticides on the health of sprayers, the environment, and consumers. However, due to the increasing number of pests in longan orchards, the growers got significant economic losses if they would not spray insecticides. "Pesticides are the fastest way to kill pests and insects" farmers presented. They have not believed the effects of biological and physical controls in IPM. The initial decision of the household when participating in the IPM/VietGAP programs were to learn new knowledge, improve longan the garden, receive subsidies from the program, and got convinced by the project staff to participate in the program. The households with a larger area of longan cultivation and respondents with higher educational attainment would increase the probability to practice IPM. This result is consistent with the criteria to choose households that participated in IPM and VietGAP programs and many studies on the behavior or decision to apply IPM in fruit and other crops in Vietnam and other agricultural producing countries [6], [5], [8], [26], [7].

The factors affecting the intention of respondents to apply IPM relied on two models that the new IPM program introduced with the assumption the price of pesticides increases by 10% and the selling price of longan at the farm gate in the crease by 20%. An increase in the selling price of longan is substantial for longan growers because it would improve their income and profit. In addition, the application of IPM directlyreduces the use of pesticides, especially those that are highly persistent and are not allowed or regulated residues in exporting countries. Therefore, when pesticide prices increase, it increases the production costs oflongan growers, so it directly affects the intention to apply IPM.

The two models $Y_2$ and $Y_3$ have high Pseudo $R^2$ (70 and 74% respectively), thus the variables included in the models are better explained than model 1 ($Y_1$). Like in the $Y_1$ model, if respondents knew about IPM in advance, it would influence respondents' intention to adopt IPM (Table 7). For those expected to reduce the production costs such as labor cost, fertilizers, and pesticides, would most affect intention to adopt IPM. This result is similar to other research related to IPM adoption in the last two decades [26], [7]. Regardless of the new production techniques applied, the increase of production costs, especially labor costs, would not be supportive or the most constraints for diffusion in Vietnam [35], [25]. Regarding the group of social norm

factors, neighbors' participation in IPM is the most significant factor for respondents to decide to apply IPM. Vietnamese farmers imitate fast when they see their neighbors apply new techniques or new crops efficiently. In addition, farmers do not much believe in the effectiveness of the introduced technology or feel shy if they fail when trying the technology, so they want to see their neighbors also apply or apply first. Farmers often said that "to see is to believe" or "I only have this land for household livelihood, so I cannot take a risk." Farmers who adopt IPM expected the technical staff to visit their orchards regularly to exchange knowledge and give them appropriate technical advice. However, the variable about learning IPM from technicians and members of cooperatives is not significant ($X_3$). The reason is that both of them were not very active and have not created a trust for the respondents in both IPM and VietGAP programs. The social factors have not separated from the attitude and perception in the knowledge, attitude, and practice (KAP) [26], [7]. However, later, especially in the in-depth studies on adoption, researchers in psychology, anthropology, agricultural extension have studied in more detail the influence of social norms in the theory of planned behavior on intention and decided to adopt IPM [21], [31], [4], [12].

In the factors related to perceived behavioral control, the respondent perceived the requirements or the outcomes of IPM. They also understand the hypothetical scenarios and the significant factors in the decision to adopt IPM. Respondents realized that the increased selling price of longan, reduced production costs, increased pesticide use ($X_{5,1}$ and $X_6$). Besides, respondents required technical staff to visit their orchards regularly and give up-to-date advice ($X_{5,2}$). This result is consistent with the actual observation and many previous studies [10], [32], [9], [26], [7]. Regarding the characteristics of respondents and households included in the model $Y_2$ and $Y_3$ are not significant with the intention to apply IPM of the respondents. This result is different from the result of model 1. However, respondents in Vinh Long do not much interested in this hypothetical IPM program because the outcomes of the previous IPM and VietGAP did not satisfy them. Particularly, the slow promotion to sell certified VietGAP and IPM longan lead IPM adopters reluctant to join in the new IPM program. This result reconfirms the role of previous programs in influencing farmers' willingness to participate in the new extension programs. In addition, the fact that farmers receive free agricultural extension services would not actively participate and keep on practicing IPM after the demonstration ended [26], [7]. Self-advocacy to learn new technologies and private extension services should promote widely in Vietnam.

## 4. CONCLUSIONS

The results of the models showed the importance of background knowledge of IPM and respondents' judgment of the previous programs implemented. The perception of respondents on IPM benefits is significantly influenced respondents' intention to adopt IPM. Besides, the importance of the social factors, especially respondents' neighbors and technical staff of extension programs. These factors emphasized how belief and trust in the effectiveness and efficiency of the technologies influencing respondents' decision and acceptance to adopt the IPM. Perception of the condition or control behavior is also significant. IPM is a difficult technique, acquires adopters' knowledge in integrated pest management and results in slow effects. They are the most constraints of IPM. Whereas economic inventives are the most acttractive factors that govern adopters' behavior.

At the study sites, more programs that integrate IPM continue to transfer to farmers from different sources of funds from the government, private sector, and international funds. The community-based IPM programs will be effective to transfer IPM. More economic incentives will speed up the IPM diffusion. It is essential to involve the private sector in transferring IPM and market information to farmers (longan quality and agrochemical residues to specific markets). Besides, the contracted selling price of the longan farm gate will contribute to the faster IPM diffusion in the Mekong Delta, Vietnam.

**5. ACKNOWLEDGEMENT**
This article is part of the research Including gender to develop the sustainbale value chain of Idor Longan in the Mekong Delta, Vietnam (B2019-TCT-07), supported by Ministry of Education and Training of Vietnam.

**6. REFERENCES**

[1] Ajzen, I. (1991). The theory of planned behavior. Organizational behavior and human decision processes, 50(2), 179-211.

[2] Anh, N. (2018). Australia ready to get its teeth into Vietnamese longans in 2019. https://e.vnexpress.net/news/business/markets/australia-ready-to-get-its-teeth-into-vietnamese-longans-in-2019- 3717416.html, retrieved in July 19, 2021.

[3] Ataei, P., Gholamrezai, S., Movahedi, R. and Aliabadi, V. (2021). An analysis of farmers' intention to use green pesticides: The application of the extended theory of planned behavior and health belief model. Journal of Rural Studies, 81, 374-384.

[4] Bagheri, A., Bondori, A., Allahyari, M. S. and Damalas, C. A. (2019a). Modeling farmers' intentionto use pesticides: An expanded version of the theory of planned behavior. Journal of Environmental Management, 248, 109291.

[5] Bagheri, A., Bondori, A. and Damalas, C. A. (2019b). Modeling cereal farmers' intended and actual adoption of integrated crop management (ICM) practices. Journal of Rural Studies, 70, 58-65.

[6] Bagheri, A., Emami, N. and Damalas, C. A. (2021). Farmers' behavior in reading and using risk information displayed on pesticide labels: a test with the theory of planned behavior. Pest Management Science, 77(6), 2903-2913.

[7] Chi, T. T. N., Hossain, M. and Palis, F. (2004). Impact of integrated pest management-farmer field school (IPM- FFS) on farmers' insect pest management belief, attitude and practices (KAP) in Vietnam. Omonrice, 12, 109-119.

[8] Dang, H. V., Nguyen, L. T., Tran, H. T., Nguyen, H. T., Dang, A. K., Ly, V. D. and Frazzoli, C. (2017). Risk factors for non-communicable diseases in vietnam: a focus on pesticides. Frontiers in Environmental Science, 5, 58.

[9] Daxini, A., Ryan, M., O'Donoghue, C. and Barnes, A. P. (2019). Understanding farmers' intentions to follow a nutrient management plan using the theory of planned behaviour. Land Use Policy, 85, 428-437.

[10] Despotović, J., Rodić, V. and Caracciolo, F. (2019). Factors affecting farmers' adoption of integrated pest management in Serbia: an application of the theory of planned behavior. Journal of Cleaner Production, 228, 1196- 1205.

[11] Duc, H. and Dam, M. (2021). Mekong Delta farmers restructuring crop cultivation to better respond to climate change. https://vietnamagriculture.nongnghiep.vn/mekong-delta-farmers-restructuring-crop-cultivation-to-better- respond-to-climate-change-d296686.html, retrieved in July 19, 2021.

[12] Ghane, F., Samah, B. A., Ahmad, A. and Idris, K. (2011). The role of social influence and innovation characteristics in the adoption of Integrated Pest Management (IPM) practices by paddy farmers in Iran. In International Conference on Social Science and Humanity-IPEDR Singapore, 2, 217 – 220.

[13] Giao, N. T. (2021). The use of pesticides in triple-rice crop in the coastal district, Tra Vinh, Vietnam." Journal of tourism, hospitality and environment management, 6 (22), 32-40. DOI 10/35631/JTHEM.622004.

[14] Giao, N.T., Cong, D. C., Tuong, P.T.L., Dan, T.H. & Trinh, L. T. K. (2021). The use and managementof pesticides in paddy rice and durian cultivation in Phong Dien District, Can Tho city, Vietnam. NIPES Journal of Science and Technology Research, 3(3), 1 – 10. https://doi.org/10.37933/nipes/3.3.2021.1

[15] Hanh, T.T.M, Hieu, N. T, Bay, D. T. B., Hoa, N. V. & Hoat, T. X. (2016). Evaluation of Susceptibilityto Witches' Broom of Longan Varieties Growth in Mekong Delta. Vietnam Journal of Agricultural Science, Vol. 14, No. 6: 843-851.

[16] Hau, T. V. and Huan, D. M. (2011). Investigating characteristics of shoot flushing, flowering and fruit development of "E-Dor" longan (Dimocarpus longan Lour.) in Chau Thanh district, Dong Thap province. Can Tho University Journal of Science. 20b. 129-138.

[17] Hoang, H.G. (2020). Exploring farmers' adoption of VietGAP from systemic perspective: implication for developing agri-food systems. British Food Journal, Vol. 122 No. 12, pp. 3641-3661. https://doi.org/10.1108/BFJ-09- 2019-0724.

[18] Hughes, D., Thongkum, W., Tudpor, K., Turnbull, N., Yukalang, N., Sychareun, V., Vo, T.V., Win, L.L, Watkins, A. and Jordan, S. (2021). Pesticides use and health impacts on farmers in Thailand, Vietnam, and Lao PDR: Protocol for a survey of knowledge, behaviours and blood acetyl cholinesterase concentrations. Plos one, 16(9), e0258134.

[19] Jørs, E., Lander, F., Huici, O., Morant, R. C., Gulis, G. and Konradsen, F. (2014). Do Bolivian small holder farmers improve and retain knowledge to reduce occupational pesticide poisonings after training on Integrated Pest Management?. Environmental health, 13(1), 1-9.

[20] Komorek, C. (2020). New standards impact Vietnamese fruit exports. http://www.fruitnet.com/asiafruit/article/183037/new-standards-impact-vietnamese-fruit-exports, retrievedin July 19, 2021.

[21] Lue, J. C. and Frankowski, S. D. (2020). High Need for Drama Individuals May Interpret Their Manipulative and Impulsive Behaviors as Self-Efficacy. North American Journal of Psychology, 22(3), 499-519.

[22] Maddah, D., Ghach, W., Abi Farraj, N., Yehya, M., Al Khatib, J. and Alami, N. H. (2020). The first community- based intervention to promote safe pesticide use by developing knowledge, attitudes, and practices among Lebanese farmers. Human and Ecological Risk Assessment: An International Journal, 26(10), 2824-2835.

[23] Massmann, O. (2017). Vietnam – Agriculture Sector – Current Issues and Solutions for Investment and Outlook on Major Trade Deals TPP 11 and EUVNFTA.

https://blogs.duanemorris.com/vietnam/2017/12/20/vietnam-agriculture- sector-current-issues-and-solutions-for-investment-and-outlook-on-major-trade-deals-tpp-11-and-euvnfta/, retrieved in July 19, 2021.

[24] Migheli, M. (2020). Do trained farmers protect themselves when using pesticides? Evidence from rural Vietnam. Environmental Monitoring and Assessment, 192(7), 1-13.

[25] Nelson, R., Orrego, R., Ortiz, O., Tenorio, J., Mundt, C., Fredrix, M. and Vien, N. V. (2001). Working with resource-poor farmers to manage plant diseases. Plant Disease, 85(7), 684-695.

[26] Nicetic, O., Van de Fliert, E., Ho Van Chien, R., O'Leary, Z. and Rae, D. (2009). Learning by doing: Designing and conducting impact assessment studies for citrus Farmer Field Schools in Vietnam. Integrated Assessment of Agriculture and Sustainable Development, 512.

[27] Normile, D., 2013. Vietnam Turns Back a 'Tsunami of Pesticides'. Journal of Science (341(6147), 737-738. DOI: 10.1126/science.341.6147.737

[28] Oanh, N. (2016). Growing Ido Longan in Thoi An. https://vietnam.vnanet.vn/english/growing-ido-longan-in-thoi- an/264643.html, retrieved in July 19, 2021.

[29] Palis, F. G. 2006. The role of culture in farmer learning and technology adoption: a case study of farmer field schools among rice farmers in central Luzon, Philippines. Agriculture and Human Values, 23(4),491-500.

[30] Pontius, J. and Lestari, A. S. (2004). In 1998 the FAO programme was given a new name: the FAO. Silent Invaders: Pesticides, Livelihoods, and Women's Health, 292.

[31] Rezaei, R., Safa, L. and Ganjkhanloo, M. M. (2020). Understanding farmers' ecological conservation behavior regarding the use of integrated pest management-an application of the technology acceptance model. Global Ecology and Conservation, 22, e00941.

[32] Rezaei, R., Safa, L., Damalas, C. A. and Ganjkhanloo, M. M. (2019). Drivers of farmers' intention to use integrated pest management: Integrating theory of planned behavior and norm activation model. Journal of environmental management, 236, 328-339.

[33] Sharifzadeh, Mohammad Sharif, and Gholamhossein Abdollahzadeh. "The impact of different education strategies on rice farmers' knowledge, attitude and practice (KAP) about pesticide use." Journal of the Saudi Society of Agricultural Sciences (2021).

[34] Thuy, P. T., Van Geluwe, S., Nguyen, V. A. and Van der Bruggen, B. (2012). Current pesticide practices and environmental issues in Vietnam: management challenges for sustainable use of pesticides for tropical crops in (South- East) Asia to avoid environmental pollution. Journal of Material Cycles and Waste Management, 14(4), 379-387.

[35] Van Mele, P., Cuc, N. T. T. and Van Huis, A. (2001). Farmers' knowledge, perceptions and practicesin mango pest management in the Mekong Delta, Vietnam. International Journal of Pest Management, 47(1),7-16.

[36] Veisi, H. 2012. Exploring the determinants of adoption behaviour of clean technologies in agriculture: a case

of integrated pest management. Asian Journal of Technology Innovation, 20(1), 67-82. https://doi.org/10.1080/19761597.2012.681435

[37] Vietnam News (2018). Việt Nam struggles to export fruit to demanding markets. https://vietnamnews.vn/economy/463812/viet-nam-struggles-to-export-fruit-to-demanding-markets.html, retrieved in July 19, 2021.