Which factors lead tomato growers to implement integrated pest management? Evidence from Turkey

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Abstract:

In most competitive fresh fruit and vegetables chains, growers are faced with the need to comply with the requirements of increasingly safety demanding customers. Integrated Pest Management (IPM) practices have become a reliable solution for small-scale growers that cannot afford the cost of a Good Agricultural Practices (GAP) certificate. While the literature on farmer adoption of IPM practices focuses on farmer and farm characteristics, only a few authors underline the importance of technology and marketing. Moreover, only a few papers have studied IPM adoption in developing or emerging countries. Our paper aims to fill this gap by focusing on Turkey, an emerging country with dominant small-scale growers, where diffusion of IPM is still in its infancy. It also takes into account factors that go beyond the farmers and farm characteristics that are usually addressed by literature. 186 tomato growers have been surveyed in the province of Antalya, a region of Turkey supplying 85% of the national production of tomato grown under greenhouse. A counter of the eleven most salient IPM practices is used to model IPM adoption. The analysis confirms most of the predictions and highlights the key role of marketing and technology as determinants of IPM adoption.

Keywords: Integrated Pest Management, Quasi-Poisson model, Turkey, farmers, fruits and vegetables, tomato, adoption

1. Introduction

Recent crises, whose most infamous one is the mad cow, reinforced sanitary and phytosanitary requirements. Since the beginning of 2000s, from producers to sellers, all the actors of the sector are involved to answer these requirements. While public authorities mainly define and enforce maximum residue limits and molecules authorized, private actors define specifications from which they establish requirements, mainly at the production level. Standards defined have to ensure that all means have been put in place to ensure the quality of the products.

Turkey is in a process to integrate the European market. Moreover, since 2001, the EU pre-adhesion process translates into a harmonization in terms of legislation, including the agricultural sector. The Turkish agricultural sector is mainly dominated by the production of fruits and vegetables. As a matter of fact, this sector contributes for more than 55 % to the agricultural value in 2009. More precisely, the tomato production is the main production of this sector. Because of the need of legislation harmonization, exporters requirements and domestic distribution constraints, farmers have to adopt and to comply with these evolutions. Traceability, the rational use of chemical inputs and the implementation of integrated pest management practices are some examples of challenges that farmers have to face to meet the new requirements.

In order to understand to what extent producers are more or less willing to change their production practices, we use a body of literature based on the simultaneous analysis of skills and resources. From cases in developing countries as well in developed ones, these papers highlight the importance of the individual characteristics of farmers and the structural characteristics of their farms, in order to explain the implementation of more safe and environmentally-friendly agricultural practices. While these factors are unanimously taken into account, only a small part of the literature extends this reflexion by considering both the technology and the marketing strategy.

To appreciate the degree of IPM practices implemented by tomato producers, a survey of 186 growers was performed in spring 2011 in Antalya, the main production region for tomatoes in Turkey. From the use of footbaths at each entry of the greenhouse to the use of pheromones, eleven practices have been considered to measure the intensity of implementation of more sustainable practices. In this framework, a Quasi-Poisson model was performed in order to take into account the specificity of the count data distribution and to understand to what extent individual characteristics, structural characteristics, technology knowledge and the marketing strategy condition the implementation of IPM practices.

Our article is organized as follows. In the first part, we underline the specificity of the Turkish supply chain that faces a strengthening of sanitary and phytosanitary requirements. In the second part, we consider the theoretical framework that lets appreciate factors encouraging the implementation of IPM practices. In the third part, we develop the material and method used including the database and the econometric modelling. In the fourth part, we expose empirical results and conclude, identifying further perspectives to our research.

2. The Turkish context

2.1. The importance of tomato's production in Turkey

The fresh fruits and vegetables (FFV) sector is a key sector in Turkey. FFV production represents around 55% of the agricultural value in 2009, whereas Turkey ranks among major world exporters just after the United States and the European Union. Turkey is specialized in particular in tomato production and is the fourth country producer in the world. In 2010, Turkish fresh tomato exports were more than 540 kT (Turkish Ministry of Agriculture, 2010). Turkish farms growing FFV are characterized by a small size. According to Turkstat, in 2006, more than 90.7% of these farms had an agricultural income inferior to 13.000 TRY[1], equivalent to 6500€[2], from which 65.9% that have less than 4.000 TRY - 2000€. We have to notice that at the same period, the minimum wage was set up to 540 TRY - 270€.

Turkish tomato production is concentrated in Antalya province. This province includes 77% of all Turkish farms producing tomatoes as well as 40% of the national tomato area. 50% of the tomato production of this province is exported (Turkish Ministry of Agriculture, 2010). Tomato production in Antalya province is made by small-scale farms that have on average 0.7 ha of vegetable greenhouse. Despite such a small size, Turkey is a key actor on the tomato international market. This position is all the more surprising that almost 80% of the tomato production is oriented towards the domestic market. Initially oriented to Middle East and North African (MENA) countries, Turkey progressively changed its export strategy by diversifying and upgrading its country portfolio. The next section highlights the impact of such a shift in the export strategy on sanitary and phytosanitary management issues.

2.2. Diversification of tomato export destinations and implications in terms of requirements imposed by importers' countries

Initially, Turkish FFV exports were mainly oriented to the Russian market, and to a lesser extent to the MENA markets. Most destination countries were low safety demanding. The rejection of a pepper's shipment at the boarder of Germany has initiated a trend towards a significant upgrade of average requirements. Major upgrading in safety requirements have taken place in Russia and the Eastern European countries with their mid-2000s accession to the European Union.

The customers portfolio diversification has been in favor of the most demanding countries, in particular Russia and the Eastern part of the European Union and seems to coincide with the pre-accession of Turkey to the European Community. In the agricultural sector, there is an ongoing process with a *de facto* harmonization with EU regulation, in particular regarding sanitary and phyto-sanitary standards. It is worth mentioning that one of the four pillars of the National Rural Development Strategy in the European Union is food safety.

[1] Turkish currency is *Türk lira*.
[2] The exchange rate in june 2006 : 1 TRY = 0.5€.

Until 1996, Turkey benefited from preferential treatments with the European market, in particular from subsidies to fertilizers. The 2007-2013 IPARD (Rural Development Program working as an instrument of pre-accession), in accordance with the 9th development Turkish plan, defined as a priority the upgrading of food safety. Such a priority was included in the Axis 1 "Improvement of market efficiency and implementation of Community standards" (73% of the global budget) and within this axis, in the theme "restructuration and adoption to standards" (76% of the Axis 1 budget) and in the theme "support for the establishment of producers groups" (7% of the Axis 1 budget).

Since 2001, and the process of agricultural reform, Turkey has been anticipating the need to harmonize his legislation with the European one. A key point of this harmonization in the agricultural domain was the implementation of traceability at the production level. In 2004, the Turkish Good Agricultural Practices (GAP) was created. Like GlobalGap, this GAP standard allows to certify that good agricultural practices have been implemented along the whole production process and fit with some safety legal rules. In 2012, the Ministry of Agriculture imposed to all fresh produce growers, the creation for each crop and destination (domestic or export) of a file containing the following information: grower identity, type of product, production area, volumes on sale (regulation 5957-2012). Another safety regulation aims to control the chemical input buying process at the grower level (Yasarakinci, 2009). Since 2009, growers should receive a formal prescription by a public or certified private agent in order to buy pesticides.

Private actors have been part of this safety upgrading process as well. In particular, considering that the public system of laboratories was not sufficient, they have made significant investments in the creation of private laboratories. In 2000, 50 laboratories specializing in pesticide residues were identified (OCDE/OMS, 2011). The threat of consumer/citizen NGOs' claims over sanitary issues has led some Turkish retailers to be more careful with their suppliers. Part of their efforts was channeled through the implementation of private GAP standards at the grower level (Global GAP, TNC) and to a lesser extent at the packer level (BRC).

The change in the Turkish foreign customers portfolio translates into more market safety requirements and therefore more constraints for growers to comply with such requirements. To understand to what extent and how Turkish farmers implement IPM practices, a survey was performed among 186 growers.

3. Analytical framework

Several production practices co-exist in order to reduce the use of chemical inputs (Pretty, 1995). To keep pest production below an economic injury level, farmers can implement IPM (Fernandez-Cornejo, 1996 ; Kogan, 1998). According to the USDA (United States Department of Agriculture), "*IPM is a management approach that encourages natural control of pest population by anticipating pest problems and preventing pest from reaching economically damaging level. All appropriate techniques are used such as enhancing natural enemies, planting pest-resistant crops, adopting cultural management and using pesticides judiciously"* (Fernandez-Cornejo, 1996).

A huge literature has tried to identify factors leading to the implementation of such alternative practices. The richness of this literature comes from the diversity of approaches. Almost all authors consider the implementation of IPM practices in a dichotomous way, focusing on the adoption, or not, of a certificate. For instance, the adoption of a certificate, such as Global Gap, is widely considered in the literature (McNamara et al., 1991; Burton et al., 2003; Dörr and Grote, 2009). Some authors also consider a gradual indicator of the implementation of IPM (Zhou et al., 2001). Others consider a counter corresponding to the number of practices implemented (Rauniyar and Goode, 1992; McDonald and Glynn, 1994; Saltiel et al., 1994; Lohr and Park, 2000; Chaves and Riley, 2001; Shennan et al., 2001 ; Robertson et al., 2005; Isgny et al., 2008; Puente et al., 2011).

Whatever the IPM indicator considered, almost all authors underline the importance of individual and structural characteristics (McNamara et al., 1991; Fernandez-Cornejo, 1996; Dörr and Grote, 2009). Combined to these characteristics, only few authors highlight the need to take into account other key factors such as the production techniques implemented (Dörr et Grote, 2009) and the marketing strategy (Souza Monteiro et Caswell, 2009).

The first distinctive feature of our study is to take into account simultaneously all these factors. All hypotheses are summarized in Table 1 and all variables considered are detailed in Table 2.

Table 1. Determinants of the adoption of sustainable farming practices – Hypotheses, testable propositions and expected sign

Table 2 – Description of variables

3.1. Hypothesis 1 - Farmer characteristics

The vast majority of the literature focuses on objective farmers' characteristics such as the level of education, experience and off-farm activity; while fewer also take into account subjective ones such as the attitude towards risk.

The main farmer's characteristic explaining the implementation of IPM is the level of education. The age of the farmer is rarely considered independently because of its closed link with the level of education. Authors support the idea that the higher the level of education, the more likely the farmer is to implement such practices. As a matter of fact, the level of education refers both to the capability to evaluate and recognize potential damages due to pest and disease; and the ability to face risks related to any change of production practice (Taylor and Miller, 1978; Schultz, 1981; Ervin and Ervin, 1982; Bultena and Hoiberg, 1983; Korsching et al., 1983; Feder et al., 1985; Gould et al., 1989; McNamara et al., 1991; Napier and Brown, 1993; Van der Berg and Jiggins, 2007; Dörr and Grote, 2009; Sharma et al., 2011; Xhoxhi et al., 2014). The effect of this characteristic is validated in almost all studies mentioned.

H11: The more the farmer is educated and the more likely he is to implement IPM practices

Authors agree to emphasize the role of off-farm activity even if they consider differently the impact of such activity on the implementation of IPM practices. For almost all studies off-farm activity is highlighted to be relevant even if not significant (McNamara et al., 1991 ; Fernandez-Cornejo et al., 1994 ; Fernandez-Cornejo, 1996). Some authors consider that having another activity can bring an income supplement that could help to finance the implementation of IPM practices (Clay et al., 1998 ; Galt, 2008). We assume that farmers who have another activity, in addition to their farm activity, are less likely to implement IPM practices since these farmers have less agricultural time and hence they are less invested on their farm (Mumford and Norton, 1984; Feder et al., 1985; Gould et al., 1989; Knowler and Bradshaw, 2007).

H12: The more the farmer has an off-farm activity and the less likely he is to implement IPM practices

Lastly, the type of ownership has to be taken into account. Depending on the degree of agricultural area under property, the producer will be more or less willing to implement IPM practices. More precisely, the more the area is under property and the more the farmer will implement such practices. When a farmer owns his farm, he is more likely to have a long-term vision (Feder et al., 1985 ; Clay et al., 1998), to have access to credit (Schultjer and Van der Veen, 1977 ; Feder et al., 1985) and hence to benefit from his investments.

H13: Ownership of the farm leads to higher implementation of IPM practices

In addition to these objective individual characteristics, some studies underline the importance of some more subjective factors. One key hypothesis is that a farmer who deliberately takes risks is more likely to implement IPM practices (Ervin and Ervin, 1982; Lynne et al., 1995; Baumgart-Getz et al., 2012). All farmers do not have the same attitudes towards risk and do not have the same behavior even though they face the same context and have the same objective characteristics. We have to notice that risk perception can refer to economic risk (Rogers, 1962; Byerlee and Hesse de Polanco, 1986; Napier and Brown, 1993; McDonald and Glynn, 1994; Traoré et al., 1998; Somda et al., 2002) or health risk (Traoré et al., 1998; Li, 2002; Deng et al., 2003; Zhou et al., 2011). One way to appreciate this risk perception is to measure, thanks to a Lickert scale, the perceived risk by producers for the main pest and diseases.

H14: The lower the farmer risk aversion, the more likely the farmer is to implement IPM practices

The risk perception can be considered in terms of environmental risk (Ervin and Ervin, 1982; Gould et al., 1989; Huffman and Mercier, 1991; Westra and Olson, 1997; Traoré et al., 1998). Farmers can reveal, by their productive practices, some kind of soil concern, and the more a farmer is concerned the more he is likely to implement IPM practices.

H15: The more the farmer is concerned by soil quality, the more likely the farmer is to implement IPM practices

Beyond these individual characteristics, almost all authors incorporate farm structural characteristics into their modeling. Hence, the implementation of IPM practices may depend not only on farmers' characteristics, but also independently on their farms' characteristics.

3.2. Hypothesis 2 - Farm characteristics

Farm size, for example measured through total utilized agricultural area (UAA), is a criterion widely discussed in the literature. While Dörr and Grote (2009) demonstrate that farmers who are less likely to implement IPM practices hold biggest farms, Burton et al. (2003) demonstrate the opposite effect. Pamucku (2003) relativizes this last result finding a quadratic form more than a linear one, while Mc Namara et al. (1991) demonstrate the non-significance of UAA. This apparent contradiction is due to the meaning of this indicator. On the one hand, the positive effect of the area translates into the physical potential of farms, the ability to benefit from economies of scale and the greater potential to have access to credit (Weil, 1970; Feder et al., 1985; Norris and Batie, 1987; Belknap and Saupe, 1988; Caswell et al., 2001; Henson and Loader, 2001; Daberkow and McBride, 2003; Vorley qnd Fox, 2004; Jaffee et al., 2005; Okello, 2005; Chemnitz, 2007; Galt, 2008; Asfaw et al., 2010; Sharma et al., 2011; Zhou et al., 2011). On the other hand, the negative effect translates a greater share of family workforce (Clay et al., 1998; Xhoxhi et al., 2014). The hypothesis made is that family workforce is less educated in terms of agricultural training and is hence less aware about the necessity to implement environmentally-friendly practices. We can note that all these authors highlight the importance of such factors to understand farmers' practices. We assume here that implementing IPM practices on large farms is facilitated because of economies of scale. As a matter of fact, we assume that the greenhouse area, which lets us appreciate the physical size of the farm, reveals an economic potential that incite farmers to adopt environmentally-friendly practices.

H21: The larger is the farm of the grower,
the more likely he is to implement IPM practices

Another factor considered is the total workforce in the farm. Authors suppose that labor is a substitute to pesticide use (McNamara et al., 1991; Asfaw et al., 2010; Kersting and Wollni, 2011). Therefore, a farmer is less likely to use pesticides in an intensive way when his activity is structurally based on more labor.

H22: A farmer is more likely to implement IPM practices
if his activity is based on more labor

Some authors take into account the degree of specialization (Dörr et Grote, 2009).
On the one hand, the degree of specialization can be considered both from an agronomic and from an economic perspective since specialization translates into a greater dependence of the income to a single production. In such a case, a greater degree of specialization leads to a more intensive use of pesticides (Mc Laughlin and Mineau, 1995; Traoré et al., 1998; Altieri, 2000; Roschewitz et al., 2005; Dörr and Grote, 2009).

On the other hand, the specialization translates into a higher sensibility of soil to pest and diseases. This agronomic point confirms the economic one since a more specialized farm will be more likely to use pesticides (Traoré et al., 1998). Hence, the specialization appears to have an overall negative impact on the use of pesticides.

H23: The more specialized a farm is and the less likely the farmer is to implement IPM practices

3.3. Hypothesis 3 – Agricultural technology

Considering agricultural technology, we observe that technology or farming systems can be more or less sophisticated. Authors are unanimous to underline that the more the system used is sophisticated and the more the farmer is likely to implement IPM practices (McNamara et al., 1991; Dörr and Grote, 2009; Asfaw et al., 2010; Kersting and Wollni, 2011). The previous implementation of a sophisticated technology is a springboard for the implementation of new practices or new technologies. More precisely, studies underline that the adoption of a sophisticated technology facilitates the adoption of other ones. The adoption of a first sophisticated technology translates into a capability to evaluate brakes and leverages and to assume the potential risks associated. The dynamics described is impulsed by the adoption of a previous technology, which can be qualified as a springboard (McNamara et al., 1991 ; Dörr et Grote, 2009 ; Asfaw et al., 2010 ; Kersting et Wollni, 2011).

H3: The implementation of a previous sophisticated technology increases the probability to implement IPM practices

For the tomato production under greenhouse, three main sophisticated technologies can be considered. All technologies considered let regulate weather conditions under the greenhouse in terms of temperature or humidity. The first one is the material used to build the greenhouse: plastic *versus* glass. The second one is the use of a heating system. The last technology is the implementation of a roof sprinkler. This technic lets regulate the hygrometry in the greenhouse. Hygrometry is a measure of the humidity in the air [34]. All these technics - irrigation, heating system and roof sprinkler - let ensure better management of the greenhouse and hence control the development of diseases and pests.

3.4. Hypothesis 4 - Marketing

Marketing strategy is a largely neglected factor influencing the way a producer chooses to implement IPM practices. Marketing refers essentially to the destination of the production. Before establishing more precisely the literature related to the marketing strategy, the Turkish commercial context has to be exposed. In Turkey, since 1995 producers must sell their production to a commission agent or to a cooperative, except if their production is dedicated to export or food industry market. For producers, the main goal of this public market reform was to better value their production by concentrating the farmer supply and strengthening the power of negociation through market rules (commission agent) and collective action

[3] http://devel.tomaviso.com/culture-tomate/page.php?cat=1&rub=6&ssrub=69&pg=144

[4] http://www.la-croix.com/Actualite/Economie-Entreprises/Economie/La-production-de-tomates-une-industrie-de-haute-technologie-_NP_-2012-06-10-816660

(cooperatives) (Lemeilleur, 2008, 2011). This mutation of the FFV sector is summarized as follows: it *"has thus been drastically restructured on the lines of the kind of marketing organizations for FFV growers: cooperatives and commission agents"* (Lemeilleur, 2011, p. 274).

Supermarkets have grown rapidly these last years (Me, 2003 ; Codron et al., 2004 ; Reardon et al., 2009 ; Lemeilleur, 2011). They mainly source their FFV from local growers. The FFV sector is crucial for supermarkets since it is the base of the Turkisk alimentation: it represents 20 % of consumers' expenses in 2003 (Saunier-Nebioglu, 2000). In opposition to traditional retailers, the aim of supermarkets is to offer a standardized production which meets phytosanitary' requirements (Codron et al., 2004). Until the beginning of 2010, consumers were little concerned with safety requirements. Nowadays, the public regulation has been strengthened and its enforcement is effective, one of the salient examples being the case of the store manager of Carrefour in Turkey. In 2009, because residues of pesticides were found on peaches sold in this supermarket and because there was no traceability that could let identifying the producer, the director of Carrefour was pursued and threatened to go to jail (Lemeilleur, 2008).

The export market is another way to better value farmer's production. Since the middle of 1980's, and because FFV are highly valued on the export market, producers were given incentives such as exemption from customs duties or export credit (Codron et al., 2012). In the same way that producers have to comply with phytosanitary requirements to sell on the domestic market, they have to comply with importers' safety requirements. Whatever the destination of the production, farmers thus evolve in a dynamic commercial environment where phytosanitary safety requirements are increasing.

The literature, whatever the context considered, takes into account these requirements in terms of implementation of environmentally-friendly practices. More precisely, studies converge to state that the higher the final buyer's phytosanitary requirements, the more likely the farmer is to develop IPM practices (Galt, 2008 ; Ozler et al., 2009 ; Souza Monteiro et Caswell, 2009 ; Zhou et al., 2011). If farmers do not answer these requirements, they may not be able to access the market. As a matter of fact, phytosanitary requirements can be assimilated to non-tariff barriers (Disdier et al., 2006).

By sorting their production, growers add value to their products and are able to get access to the more demanding buyers who are nowadays, looking not only for high quality products but also for products complying with safety requirements. Farmers who differentiate their production by sorting are therefore more likely to implement environmentally-friendly practices.

H41: Farmers who sort their production
are more likely to implement IPM practices

A second indicator related to the marketing strategy lies in means of payment and more precisely in the possibility for farmers to be paid by cash before the production is sold. To be paid in advance is associated in the literature to the implementation of more environmentally-friendly practices (McNamara et al., 1991; Fernandez-Cornejo et al., 1994; Souza Monteiro and Caswell, 2009; Kersting and Wollni, 2011). As a matter of fact, farmers need increased cash flows to implement IPM practices. This cash lets them to finance investments related to these practices or additional workforce needed to observe and treat pests and diseases directly instead of using pesticides.

H42: Farmers who are paid by cash are more likely to implement IPM practices

3.5. Weather conditions

Weather conditions are one of the most important factors considered to explain the use of pesticides in the literature (Houmy, 1994; Aubert and Enjolras, 2014). Climatic constraints are assessed or measured through rainfall, temperatures or even the location when these variables are not available (Fernandez-Cornejo, 1996; Galt, 2008; Sharma et al., 2011). In our case, no difference in terms of pest and disease pressure has been detected between the three counties under scrutiny in the Antalya province. Therefore, weather conditions are dismissed from our analysis.

4. Materials and methods

4.1. The database

The production of tomatoes in Turkey is concentrated in the province of Antalya, which produces 85% of total Turkish tomatoes grown under greenhouse. Antalya province is located in the Mediterranean region and composed by 13 districts including Kumlunca, Serik and Aksu (Figure 1). These three districts represent about 50% of the number of tomato producers, of the province tomato area and of the province tomato production. Given their dominant weight, surveys were limited to this area.

Figure 1. Turkish districts

Given the geographical proximity of the three districts, climatic conditions and pest and disease pressure are quite similar. Similarly, private organizations and public institutions do not significantly differ. Hence, we did not realize a stratification based on producers' location. Nevertheless, to take into account that the number of producers varies depending on the district, the number of producers under survey in a district has been chosen proportional to the total number of producers located in it.

Within each district, producers were randomly selected on a list provided by the Sub-Directorial Ministry of Agricultural of each district. Because of difficulties to survey producers, we did not realize a stratified sampling based on the agricultural area but on the location. Interviews were realized face-to-face with 186 growers in spring 2011. Producers were asked about the implementation of IPM practices. In order to understand their behavior they were also surveyed on farm structures, farmer characteristics, the technology used as well as the farming system and marketing.

4.2. Scoring of IPM practices

The implementation of IPM practices can be considered in terms of intensity (Rauniyar and Goode, 1992; McDonald and Glynn, 1994; Saltiel et al., 1994; Lohr and Park, 2000;

Chaves and Riley, 2001; Shennan et al., 2001; Robertson et al., 2005; Isgny et al., 2008; Puente et al., 2011). In Turkey, regarding tomato production, the following eleven items are concerned by IPM practices: harvest and cropping equipment cleaning, greenhouse walls washing and spraying entrance of the greenhouse, existence of footbaths at each entrance of the greenhouse, weeding in and outside the greenhouse, yellow sticky traps, elimination of first contaminated plants, use of biological auxiliaries, curtain for doors, blue traps, use of resistant varieties and use of pheromone (Figure 2).

Figure 2. IPM practices

Using a 1-5 Likert scale, producers revealed the degree of implementation for each practice. From "very weak" (1) to "very strong" (5), farmers declare to what extent they implement each of environmental-friendly practices identified[5]. A practice is considered as implemented since the grower declares it "mostly" or "all the time". The IPM score calculated corresponds to the number of practices implemented, which can vary theoretically from 0 to 11. Because of the possible dependence of practices considered, the methodology is quite debated. As a matter of fact, such a counter can be considered only if the implementation of one practice does not require, or prevent, the implementation of another one. To validate this point, we have not only considered the correlation between each scale related to each practices (Table 3) but also their independence thanks to a scree plot of eigenvalues (Figure 3). Hence, we can conclude that the use of such counter is relevant since each practice appears to be independent from the others.

Table 3. Correlation of IPM practices implemented

Figure 3. Scree plot of eigenvalues

In the Turkish case, the score calculated varies empirically from 1 to 11. On average, farmers implement near than 6 practices. This translates the fact that all farmers are implementing more safe and environmentally-friendly practices, to some extent.

4.3. Econometric models

The count data reveals the number of IMP practices implemented by producers. The nature of this variable imposes not to implement a linear model. Hence, several models can be estimated depending on the distribution of the counter (Haavelmo, 1944; Maddala, 1983; Wooldridge, 2002; Greene, 2006; Cameron and Trivedi, 2010).

The first model considered is a Poisson that supposes equi-dispersion: the mean-variance equality, conditioned by explanatories variables (Cameron and Trivedi, 1990; Saez-Castillo and Conde-Sanchez, 2013). In such a case, we validate the following hypothesis:

$$H_0: Var(Y/X) = E(Y/X) = \mu \qquad [1]$$

The main limit of such model is the validation of the equation [1]. To insure the validity of the model, we implement an over-dispersion test that tests the alternative hypothesis, developed by [2]:

[5] More precisely, farmers can declare 1 « Very Weak », 2 « Weak », 3 « Medium » 4 « Strong » and 5 « Very strong ».

$$H_{alt}: Var(Y/X) = \theta\mu \quad [2]$$

Where θ is the coefficient of dispersion.

Because the test underlines an over-dispersion, two models that can remedy this distribution constraint are implemented: the Quasi-Poisson and the Negative Binomial (Ver Hoef and Boveng, 2007). The difference is based on the specification of the variance. While the Quasi-Poisson model assumes that there is a linear over-dispersion of the variance [3], the Negative Binomial model assumes a quadratic form [4].

$$Quasi - Poisson\ variance: Var(Y/X) = \theta\mu \quad [3]$$

$$Negative\ Binomial\ variance: Var(Y/X) = \mu + \gamma\mu^2 \quad [4]$$

Whatever the model implemented, the model can be formulated by equation [5]:

$$Y_i = \alpha + \beta IC_i + \lambda FC_i + \delta MS_i + \rho T_i + \varepsilon_i \quad [5]$$

Where:
Y: the number of IPM practices implemented
IC: variables related to individual characteristics
FC: variables related to farm characteristics
MS: variables related to the marketing strategy
T: variables related to the technology implemented
ε is the error term
$\alpha, \beta, \lambda, \delta, \wedge \rho$ are the coefficients associated to each item

To identify the most appropriate model, even if they often give similar results, we compare for each one the observed count and the predicted count (Ver Hoef and Boveng, 2007). Thanks to the Quasi-Poisson model, the correlation equals 0.2016, while it is 0,1556 for the Negative Binomial one. Hence, the model chosen for explaining the number of IPM practices is a Quasi-Poisson model (Table 6).

Table 6 – Quasi-Poisson Model

5. Results

The implementation of IPM practices appears to be influenced by the individual characteristics of farmers, the structural characteristics of their farm, technology and their marketing strategy. Since the econometric analysis confirms the statistical analysis (Table 4 and Table 5), a combined reading is done.

Table 4 – Statistic descriptive of quantitative variables

Table 5 – Statistic descriptive of qualitative variables

The first result is that almost all individual farmer characteristics appear to have no impact on the number of IPM practices implemented by producers. This result highlights, in the

Turkish context, that almost all farmers are involved in implementing more sustainable practices. This point coincides with the fact that, on average, six IPM practices are implemented. Hence, we observe that farmers who have another activity are not more likely to implement more practices than the others. In the same way, to own a farm is not a salient criterion in the Turkish case.

We have to notice that two characteristics have an impact on the farmers' behaviour. The first one is the level of education. Farmers who are more educated, are more likely to implement more IPM practices. As a matter of fact, while farmers who have a higher level of education implement seven IPM practices on average, the others implement less than six.

The second characteristic having an impact of the number of IPM practices implemented is a subjective one. Farmers who are more environmentally concerned are more likely to implement a high number of IPM practices. This degree of consciousness, measured through the number of tomatoes produced during the season, reveals a concern of soil quality in the long term. As a matter of fact, farmers who implement only one tomato production during the season let the soil be rested a part of the season. Hence, the more farmers are concerned by soil quality, the more they implement IPM practices.

Beyond these individual characteristics, we observe that the structural characteristics of the farm also condition the number of IPM practices implemented. Hence, results show that biggest farms are more likely to implement more IPM practices than smaller ones. Moreover, farms are more likely to implement more IPM practices since they are specializing in tomato production. These results highlight that farms that are less likely to implement more IPM practices are the smallest and diversified ones. Hence, despite Turkey mainly comprises "small farms", the results confirm the main hypotheses stated from the literature. The largest farms, which are more specialized and held by a more educated farmer, are more likely to implement environmentally-friendly practices.

We have to notice that the relative importance of labor has no impact on the implementation of more sustainable practices. As a matter of fact, each IPM practice is specific and does not translate into a higher need of workforce. The use of footbaths at each entry of the greenhouse is one example.

In addition to individual and farm structural characteristics, the degree of technology upgrading should be taken into account. The technology implemented is considered in relation to the use of glass, heating system and roof sprinklers. Results demonstrate that the more the greenhouse is built with glass and the more the farmer is more likely to implement IPM practices. Similarly, farmers who use a roof sprinkler are more likely to implement a higher number of IPM practices. Farmers who are able to manage the temperature of their greenhouse using such sophisticated system are more likely to implement IPM practices. Statistics descriptive reveals that these farms use, on average, seven IPM practices, while it is less than six for others farms. These results confirm the importance of previously implemented sophisticated technologies.

The last dimension taken into account is marketing. Results show that farmers who differentiate and value their production implement more environmentally-friendly practices. As a matter of fact, farmers who sort their production before selling it implement six IPM practices, against less than 5.5 for farmers who do not sort their production. This result confirms the fact that farmers who differentiate their production are clearly in a dynamics of adding value . Such a process goes hand in hand with the implementation of environmentally-friendly practices.

6. Concluding remarks

The aim of our study is to better understand farmers' behaviour as regards to the implementation of IPM practices in the Turkish context. Turkey is a relevant case study since this country is increasingly gaining access to safety-demanding European markets. Hence, Turkey has to harmonize its legislation especially in the agricultural sector where sanitary and phytosanitary requirements at the national level are less restrictive than at the European or international levels.

To understand to what extent Turkish farmers are willing to implement IPM practices, we have considered the individual characteristics of the farmers, the structural characteristics of their farms, the more or less sophisticated greenhouse technology and the marketing strategy. Thanks to a survey of 186 farmers, we have measured these characteristics and hence been able to identify salient factors that spur the implementation of safer and environmentally-friendly practices.

One salient result of this study is that both individual and structural characteristics condition practices implemented on the farm. Farmers who are more educated are more inclined to implement more IPM practices on their farm rather than farmers who are less educated. The level of education lets appreciate the capability to evaluate risks and the capability to change productive practices. Results also underline the fact biggest farms, specialized in tomato production, are more likely to implement practices. To be specializing in a single production raises awareness farmers to soil concern in the long term leading them to implement more IPM practices that preserve soil quality.

A key result is that the use of upgraded greenhouse technology is a further driver for the implementation of more sustainable farm practices. This result highlights a virtuous circle in terms of practices: the more farmers implement sophisticated technology such as a roof sprinkler, the more they are likely to implement IPM practices on their farms.

The second original point is the importance of marketing strategy. Since producers try to add value to their production on wholesale markets, they are more likely to adopt a production pattern based on a more environmental-friendly behavior. Hence, a key factor leading to the implementation of such practices is the opportunity to provide a better valuation of the production.

The Turkish case is an example of the complexity in fully understanding the mechanism of IPM implementation. Several internal factors such as farmer and farm characteristics are well-identified drivers for more safe and environmentally-friendly practices. In addition, the fact that farmers have already implemented sophisticated technology acts as a springboard to implement IPM practices. Moreover, the implementation of environmentally-friendly practices is also conditioned by farmers' actions in favour of a differentiation of their production. Farmers who sort their production are more likely to increase their production valuation whatever the pathway and hence to supply buyers with phytosanitary requirements.

In terms of public policies, one recommendation is to support farmers' education in order to improve their professional skills, since the level of education is one of the main factors positively influencing the implementation of IPM practices.
Another recommendation is to make market information publicly available and stimulate its dissemination through the sector, and to let small farmers be more aware about distributors' requirements.
Lastly, one recommendation is to support them to comply through consultancy services and capacity building.

Future research should deepen these results by studying in more detail the dynamics of Turkish farms. The long-term strategy in terms of production practices should let understand the internal dynamic of farms. Also, combining such practices with the marketing strategy may allow to understand to what extent the implementation of more sustainable practices can modify farmers' option in terms of marketing strategy, or conversely to what extent the evolution of sellers' requirements can modify farmers' production strategy.

Figure 1. Turkish districts

Source: https://fr.wikipedia.org/wiki/Antalya

Figure 2. IPM practices

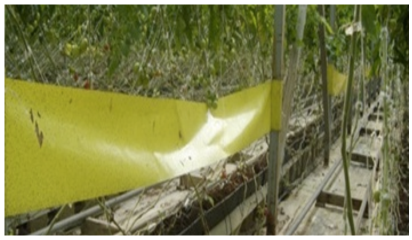
Curtain for doors

Auxiliaries

Pheromones

Elimination of first contaminated plants

Footbath at the entry of greengouse



Yellow traps

Figure 3. Scree plot of eigenvalues

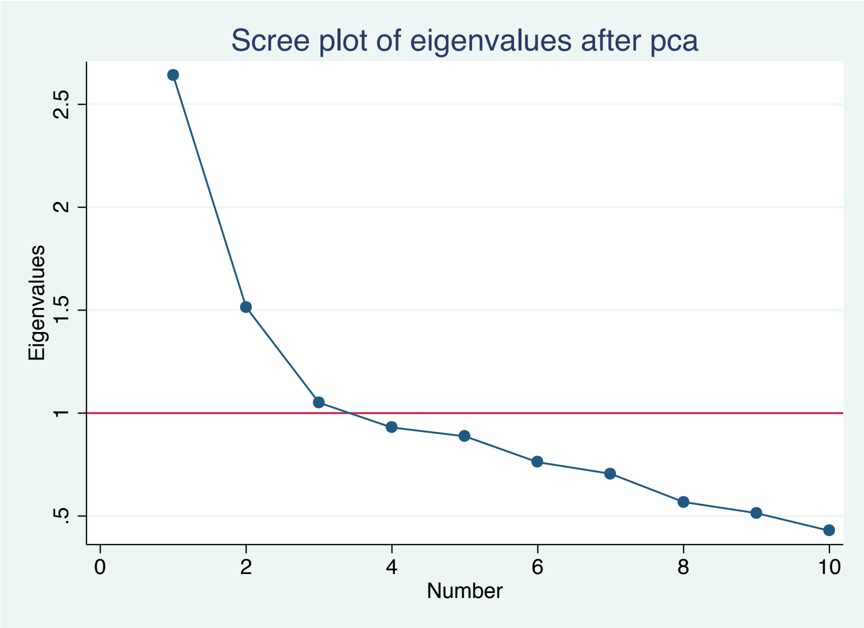


Table 1. Determinants of the adoption of sustainable farming practices - Hypotheses, testable propositions and expected sign

Individual characteristics (H1)	**Structural characteristics (H2)**	**Technology characteristics (H3)**	**Commercial characteristics (H4)**
H11: Level of education (+)	H21: UAA (+/-)	H31: Share of glass greenhouse (+)	H41: Sort production (+)
H12: Off farm activity (+/-)	H22: AWU / UAA (+)	H32: Heating system (+)	H42: Cash payment (+)
H13: Owner (+)	H23: Degree of specialization (+/-)	H33: Roof sprinkler (+)	
H14: Risk perception (+)			
H14: Environmental sensibility (+)			

Table 2: Description of variables

Variable		Unit	Definition
IPM practices			
counter		counter	Number of IPM practices implemented
footbath		Yes / No	Existence of footbaths at each entrance of the greenhouse
contaminated		Yes / No	Elimination of first contaminated plants
weeding		Yes / No	Weeding in and outside the greenhouse
harvest		Yes / No	Harvest and cropping equipment cleaning
resistant		Yes / No	Resistant varieties
spray		Yes / No	Greenhouse walls washing and spraying entrance of the greenhouse
trap		Yes / No	Yellow sticky traps
auxiliaries		Yes / No	Use of biological auxiliaries
curtain		Yes / No	Curtain for doors
blue		Yes / No	Blue trap
pheromone		Yes / No	Pheromone recipient
Individual characteristics			
Off farm activity		Yes / No	The farmers has an off-farm activity
Education	1	Yes / No	Primary level
	2	Yes / No	Secondary level
	3	Yes / No	Superior level
Owner		Yes / No	The farmer owns his farm
Pest and disease perception		Lickert scale	A Lickert measure the risk perception for 7 pest and 10 disease
Environmental sensibility		Yes / No	There is one production during the season
Structural characteristics			
AWU/ UAA		-	Total of agricultural workforce on agricultural utilized area
UAA		acre	Utilized Agricultural Area
UAA^2			Quadratic form of the Utilized Agricultural Area
Degree of specialization		%	Share on tomato area on total area
Technical characteristics			
Share of glass greenhouse		%	Share of glass greenhouse on total greenhouse area
Heating system		Yes / No	The farmers uses a heating system
Roof sprinkler		Yes / No	The farmer uses a roof sprinkler
Commercial characteristics			
Sort		Yes / No	The farmer sorts his production before selling it
Cash		Yes / No	The farmer is paid by cash

Table 3: Correlation of IPM practices implemented

	Harvest	Footbath	Weeding	Contaminated	Resistant	Spray	Water	Trap	Auxiliaries	Curtain
Harvest	1.0000									
Footbath	0.2516	1.0000								
Weeding	0.3551	0.0147	1.0000							
Contaminated	0.3632	-0.0318	0.3817	1.0000						
Resistant	-0.0052	-0.0662	0.0149	0.1833	1.0000					
Spray	0.3083	0.1498	0.1491	0.1673	-0.0132	1.0000				
Water	0.3031	-0.0392	0.2205	0.4804	0.0839	0.1271	1.0000			
Trap	0.1256	-0.0348	0.0850	0.2792	0.0961	0.1009	0.2054	1.0000		
Auxiliaries	0.0873	0.2113	0.0786	0.1041	-0.0373	0.0481	0.0307	0.1093	1.0000	
Curtain	0.1791	-0.1706	0.2397	0.4915	0.2482	0.0505	0.3425	0.2660	0.0398	1.0000

Table 4. Descriptive statistics of quantitative variables

	Pest perception	Disease perception	AWU / AUA	Greenhouse area	Share of glass greenhouse	Degree of specialization	Counter of IPM practices
Pest perception	1.0000						
Disease perception	0.5884	1.0000					
AWU / AUA	-0.0166	0.0827	1.0000				
Greenhouse area	-0.1997	-0.1440	-0.1920	1.0000			
Share of glass greenhouse	-0.0506	0.0822	0.6775	-0.0650	1.0000		
Degree of specialization	-0.0586	-0.1075	-0.0521	0.0217	0.0655	1.0000	
Counter of IPM practices	-0.0212	-0.0436	-0.0206	0.2541	-0.0087	-0.0691	1.0000

Table 5. Statistic descriptive of qualitative variables

		Repartition	Mean	Equality of mean	Std Deviation	Equality of variance
			Counter of IPM practices			
Individual characteristics						
Off farm activity	No	140	6.06429	ns	1.767861	ns
	Yes	46	5.67391		2.022697	
Owner	No	32	6.15625	ns	1.439296	**
	Yes	154	5.92857		1.910094	
Education	Primary	116	5.69828	reference	1.674462	reference
	Secondary	24	5.66667	ns	2.119612	**
	Superior	46	6.80435	***	1.857352	*
Environmental sensibility	No	50	5.42	***	2.011092	**
	Yes	136	6.16912		1.732287	
Technical characteristics						
Heating system	No	14	5.78571	ns	1.847184	ns
	Yes	172	5.98256		1.840016	
Roof sprinkler	No	161	5.78882	***	1.818	*
	Yes	25	7.12		1.536229	
Commercial characteristics						
Sort	No	36	5.33333	**	2.042408	*
	Yes	150	6.12		1.756751	
Cash	No	135	5.95556	ns	1.633907	***
	Yes	51	6		2.306513	

Keys: Differences are significantly different at the 10% (*), 5% (**) and 1% (***) thresholds.

Table 6. Econometric model

	Coef.	Robust Std. Err.	z	P>|z|
Individual characteristics				
Off farm activity	.0659857	.052054	1.27	0.205
Education	*Reference: Primary level*			
Secondary	-.0136327	.0722483	-0.19	0.850
Higher	.1296101***	.0463646	2.80	0.005
Owner	.0180118	.0542165	0.33	0.740
Pest perception	.025893	.0244484	1.06	0.290
Disease perception	-.0140412	.0249748	-0.56	0.574
Environmental sensibility	.122233*	.067243	1.82	0.069
Structural characteristics				
AWU / UAA	-.011982	.0379951	-0.32	0.752
UAA	.0041639**	.0020632	2.02	0.044
UAA2	-.0000116	8.84e-06	-1.31	0.191
Degree of specialization	.0018176**	.0007605	2.39	0.017
Technical characteristics				
Share of plastic greenhouse	.0008618*	.0005157	1.67	0.095
Heating system	.0072429	.0920434	0.08	0.937
Roof sprinkler	.1366466**	.056126	2.43	0.015
Commercial characteristics				
Sort	.1035798*	.0616043	1.68	0.093
Cash	.0071859	.0544173	0.13	0.895
Constant	1.278915***	.1792539	7.13	0.000
Number of observations	186			
Pseudo R2	3.14%			
Predicted count	20.16%			

Keys: Estimates significant at the 10% (*), 5% (**) and 1% (***) thresholds.

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