Aubert (Magali), Debrune (Orane), Huat (Joël), Parrot (Laurent), « The institutional environment. Key support for formal market gardeners in Mayotte », *Systèmes alimentaires / Food Systems*, n° 4, 2019, p. 185-206

DOI : 10.15122/isbn.978-2-406-09829-4.p.0185

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RÉSUMÉ – Mayotte est une région "ultra-périphérique" de l'Europe depuis 2014 et les producteurs doivent se mettre en conformité avec les exigences règlementaires. Notre attention se porte sur la tomate, très sensible aux ravageurs. Sur la base de données de terrain, nos résultats soulignent d'une part le rôle clé du technicien dans le changement de pratiques des producteurs et d'autre part que les aides européennes, telles qu'elles sont versées, sont un frein à ce changement dans le contexte mahorais.

MOTS-CLÉS – Mayotte, tomate, pratique respectueuses de l'environnement, modèle logit, bootstrap

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ABSTRACT – This article focuses in Mayotte that is an 'ultra-peripheral' region of Europe since 2014, and is consequently supposed to comply with European requirements. We study the tomato production, the most sensitive production to pests. Based on an exhaustive filed data results show that the technical support is a key to let farmers implement more environmentally friendly practices. Results also underline that the way financial European supports are distributed is a brake because of Mayotte's context.

KEYWORDS – Mayotte, tomato, environmental-friendly practice, logit model, bootstrap resampling

THE INSTITUTIONAL ENVIRONMENT

Key support for formal market gardeners in Mayotte

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INTRODUCTION

While the use of pesticide increases yields and farmers' income, the counterpart is the negative impact on both human health and the environment (Aktar et al., 2009; Inserm, 2013). Because of these negative effects, public authorities define and impose phytosanitary requirements to guarantee the products are safe.

In 1992, the Common Agricultural Policy reform included the environmental dimension to avoid damage caused by agricultural activity mainly by providing financial incentives. Progressively, the European policy takes an agricultural model dedicated to the implementation of environmental-friendly practices into account[1]. Biodiversity, landscapes, climate change, the quality of air and water became an integral part of European policy guidelines. Progressively, price and production supports became direct aid policies and rural development measures, reducing the pressure to produce more, which intensified the use of pesticides. Agri-environmental measures or green payments are supposed to promote agricultural economic development through the environment, since the rules imputed for access to these public subsidies are respected. In addition to financial incentives, Europe is committed to reducing the risks of exposure to pesticides. In 2005, Regulation (EC) N° 396/2005 defines Maximum Residue Limits (MRLs) for authorized active substances in food in order to reduce the exposure of consumers to excessively high product doses. In 2009, Europe adopted the "pesticide package": each Member State has to define a national action plan mainly aimed at reducing the use of pesticides.

France uses more pesticides than any other country in the EU (Aubertot et al., 2007). To reduce the use of pesticides, France implemented a national action plan called Ecophyto 2018 and Ecophyto 2025, launched and co-piloted by the Ministry of Agriculture. The first 2018 plan, whose aim was to quantitatively reduce the use of pesticides did not achieve its objectives (Potier, 2014). Hence, the second plan adopted both quantitative and qualitative objectives. This plan aims at reducing the use of pesticides by 50% by 2025, thus inciting producers to adopt environmentally friendly practices and involving all actors of the sector.

The development of agro-ecology supported by the Agricultural Ministry in 2012 led to the appearance of a new model as a guideline for French agricultural development. Defined as *«the application of ecological science to the study, design and management of sustainable agrosystems»* by the French government, agro-ecology is a *«set of agricultural practices favoring biological interactions aiming for use Optimization of the possibilities offered by agrosystems»*. This approach aims to combine the productivity of the agricultural sector and the rational use of natural resources. Wherever

1 https://ec.europa.eu/agriculture/envir/cap_en

possible, pesticides must be replaced by natural processes. Improving soil quality, maximizing ecosystem services, optimizing farm resilience and, indirectly, reducing health risks, are the main objectives targeted by agro-ecology.

Changes in European and French requirements in terms of reducing the use of pesticides involve a change in producers' practices. Although the French territory is concerned by these requirements, Mayotte Island is a particularly interesting field of study since it has only been a French department since 2011 and an overseas region since 2014. Hence, the harmonization of these practices with European and French regulations is recent (Sourisseau et al., 2008). The compliance of the agricultural practices in Mayotte with the health and environmental requirements is far from reaching the expected levels and there is still a major gap between theory and practice (Daaf, 2016). Mayotte, and most islands in general, exacerbate food policy challenges (Sankat et al., 2007).

Mayotte is also interesting because its history has led to cohabitation between formal and informal populations. Only formal ones can benefit from technical and financial support. Because of this potential support and the implication of such support, our study focuses on formal farmers who account for 20% of total agricultural production.

Pesticides are, in Mayotte, only used for horticulture (Daaf, 2016). The main horticultural production being the tomato, we focus our study on this production. This production is otherwise the most sensitive to pests.

The aim of this study is to analyze to what extent farmers in Mayotte is inclined to adopt alternative practices. In the following section, we explain the specificity of Mayotte's context. In the second part, a review of the literature enabled us to identify the factors that influence the farmers' behavior, particularly their willingness to adopt environmentally friendly practices. The third part defines data, methods and the econometric model. The last part identifies some policy implications as regards the results obtained.

1. CONTEXT

Mayotte is a 375 km² group of islands located in the Indian Ocean, 300 km away from Madagascar and 500 km from East Africa. The archipelago, composed of 2 main islands (Grande-Terre and Petite-Terre), is situated between the equator and the Tropic of Capricorn tropics, 8 000 km from metropolitan France. Mayotte is an interesting case study as it shares many constraints of every small island economy including vulnerability to natural and exogenous economic shocks, high cost of transport, dependence on the products or services provided by other countries. It complicates industrialization, diversification and competitiveness (Rivière, 2010). Because Mayotte acquired the status of a French Overseas Department in 2011 and the status of an 'Ultra-peripheral Region' of Europe on January 1, 2014, the political, financial and economic framework is evolving.

As a result, a process of departmentalization has been engaged including legal, economic, legislative and social adaptations to meet European and French requirements (Sourisseau et al., 2008). Its isolation, small area, small economy, hilly landscape and hard climate (two distinct seasons under a wet tropical climate) are recognized by the new European status (De Lavergne et al., 2012). It gives Mayotte access to financial measures, particularly concerning trade and fiscal policy for agriculture and fishing. Mayotte must meet European requirements for the agricultural sector, in particular, the European framework directive 2009/128/CE, aimed at the sustainable use of plant protection products in every Member State. The French Ecophyto plan, which has only been in operation in Mayotte since 2013, led to a drastic change in production practices. The transition towards agro-ecological practices and innovative methods as an alternative to the use of plant protection products is promoted by European and French financial and technical support. Structuring the food value chain, upgrading farms, innovation and transfer projects are part of European and French programs such as PDR[2], POSEI[3], PEI[4] or

2 Rural Development Program.
3 Programmes of options specifically relating to remoteness and insularity.
4 European Program of Innovation.

RITA[5]. They aim to improve the Mayotte agricultural sector and to reduce the use of pesticides on the island.

In Mayotte, pesticides are only used for horticulture (Daaf, 2016), which are at the heart of local preoccupations and territorial stakes. The vegetable sector is one of the most dynamic on the island, accounting for 1.9% of the total cultivated area and 8% of farms. Cash crops provide fast financial flow due to their short production cycle and as such are attracting an increasing number of producers: 40 hectares[6] was estimated to be used for horticulture in 2003 versus 130 in 2010. Horticultural crops are produced for local consumption and production is increasing in response to the 2011 riots "against the high cost of living" as well as to reduce imports and fulfill the island's potential food autonomy. Seasonality (southern summer and southern winter) drives farmers' production strategy (DAAF, 2019). Heavy rainfall during the southern summer limits field production, and is responsible for the variation in prices over the course of the year. This is particularly true for the production of tomatoes: 44% of horticultural farms grow tomatoes of which 93% are fielding tomatoes (58 ha of the total agricultural area). Tomato production is limited to the dry season (June to September), when the agro-climatic conditions are the best. But this is also when tomato production is highly impacted by white fly (*Neoceratitis cyanescens).* A member of the Tephritidae family, this pest is responsible for major variations in yield from 0.7 t/ha to 89 t/ha (Huat et al., 2013). The fly prick fruits of the Solanaceae family to lay its eggs. Favored by the injury, other pathogens than the white fly larvae also enter the fruit and cause rot, which is then no longer consumable.

Chemical products are mainly used to control the fly, which can destroy almost all the harvest. In such a case, pesticides are used to maintain yields. However, some farmers can decide to apply chemical inputs to increase rather than maintain their yields. As a matter of fact, as underlined in the literature, an intensive use of pesticides decreases the mean of yields but increases their standard deviation (Feder & Umali, 1993; Just & Pope, 1978). The products mainly used on the island (lambda-cyhalothrine et deltaméthrine) are neither specific, nor selective, and only partially control the pest. The rules defined by the European directive for phytosanitary

5 Innovation and agricultural transfer network.
6 1 hectare (denoted ha) = 2,47105 acres.

products, mainly maximum dose, number of applications, pre-harvest delay or physical protection, are not respected by all the producers on the island (Didelot et al., 2017). A treatment frequency indexes 4 to 8 times higher than that used in metropolitan France has been observed in certain cases (Daaf, 2018). Essays using plastic crocks, at treatment frequency 3 or 4 times higher than what it is advocated, raise the importance of means set up to structure and frame horticultural production and phytosanitary use. Products that are not permitted in France, and that are supposed to be distributed through the official center with a Certyhphyto, can still be found on many farms. Only 20% of farmers are formal and can buy chemical products in official distribution networks. This reveals the importance of the informal supply system: products are illegally imported from bordering islands and farms thus have easy have access to them.

Unlike the efficient control system in metropolitan France, few checks are carried out in Mayotte before the products are sold. The tomato value chain is not structured, and 90% of sales take through informal trade networks, and do not respect either the maximum residue limit, nor the traceability of the origin or quality of the product. Instead, based on an opportunist logic, both producers and consumers create a low competitiveness in the tomatoes sector. The limited market represented by the island, the atomization and seasonality of the offer destabilize the local economy. A formal sector, which requires quantity and quality standards, is thus difficult to develop.

Despite the high use of pesticides in Mayotte, few techniques are available or known to farmers to effectively control the fly. Tomatoes are an integral part of the diet of the population of Mayotte and reducing their import dependency is also a goal from the government. Integrated innovative practices should thus be introduced in production systems. The benefits of implemented such practices have already been highlighted in Kenya and Benin, in terms of agronomic productivity (reduction in the number of pests, increase in yield) and economic viability. However, ensuring the adoption of agro-ecological practices to meet European regulation could be difficult. To comply with the food habits of the local population, develop new markets, respond to the needs of the increasing population and the demand from the supermarket for fresh fruit and vegetables, it is important to understand the personal, structural, and institutional determinants of farmers' production strategies.

2. THEORETICAL FRAMEWORK

In this section, we define what more environmentally friendly practices are before considering the determinants of the implementation of such practices. "Environmental-friendly practices" is a term that covers different behaviors ranging from the adoption of a certificate to the implementation of a specific practice such as the use of nets to protect crops from insects (Okoye, 1998; Traoré et al., 1998; Fernandez-Cornejo & Ferraioli, 1999).

To understand to what extent farmers are likely to implement environmentally friendly practices, we conducted a review of the literature to identify the obstacles and levers of this choice. The determinants related to the implementation of more environmentally friendly practices are widely reported in the literature. All studies conducted in both developing and developed countries, highlight the importance of farmers' characteristics (H 1), their farm characteristics (Hypothesis 2), their financial resources (H 3), and their geographical location (H 4). More than these characteristics, widely covered by the literature, we expand our study by considering other determinants less widely discussed: the perception of hazards by farmers (H 5) and the institutional environment in which farmers evolve (H 6). These hypotheses are summarized in Figure 1.

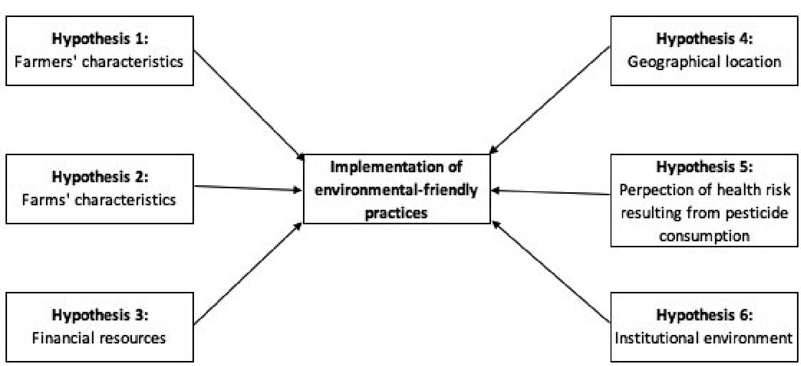

Fig. 1 – Determinants of the implementation of environmental-friendly practices.

– **H 1: Farmers' characteristics**

The main characteristic of the farmers considered is their age (Fernandez-Cornejo & Ferraioli, 1999). Almost all studies underline the fact that younger farmers are more aware of the impact of pesticides on the environment. They are assumed to be more educated about these impacts and to be more likely able to estimate the positive impact of the implementation of environmental-friendly practice. Hence, H 1 states that:

Younger farmers are more likely to implement environmental-friendly practices.

Another individual characteristic taken into account is whether or not farmers have an off-farm activity. The impact of such an activity is ambivalent since, on the one hand, it can result in a higher income meaning the farmer is more likely to implement more environmentally friendly practices (Knowler et Bradshaw, 2007)or, on the other hand, meaning the farmer is less involved in his farm thereby reducing the probability of implementing such practices. Since the main obstacle mentioned by farmers in Mayotte to the adoption of alternative strategies is the sale price, we assume here that:

Farmers who have off-farm activity are more likely to implement environmental-friendly practices.

– **H 2: Farm characteristics**

In addition to the individual characteristics of the farmers, reports in the literature assume that farm characteristics also influence farmers' behaviour. The area cultivated is the only unanimous factor considered. Although all authors appear to agree that it is essential to take the size of the farm into account, its impact on the implementation of more environmental-friendly practices is subject to debate. Some authors consider that bigger farms benefit from economies of scale and are hence more likely to implement such practices. Others consider that smaller farms are more inclined to implement such practices (Aubert et Enjolras, 2014). In the context of Mayotte, we consider the physical dimensions of the farm through the workforce employed. Hence, we assume that:

Farms that use a bigger workforce are more likely to implement environmental-friendly practices.

The second characteristic considered is the degree of crop diversification. For some authors, the more diversified the farmers, the less they are economically dependent on this activity. In such a case, they are more likely to implement environmental-friendly practices. This point is reinforced by the fact that being diversified also implies less pressure from parasites.

Diversified farms are more likely to implement environmental-friendly practices.

– **H 3: Financial resources**

The individual characteristics of farmers and the characteristics of their farm are the two main items considered in the literature to understand to what extent they are likely to implement environmental-friendly practices. However, in addition to these characteristics, the financial dimension needs to be highlighted (Knowler et Bradshaw, 2007). Farmers who benefit from financial support from the Common Agricultural Policy or who benefit from access to credit are supposed to be more likely to invest to answer phytosanitary requirements. We have to underline that European supports, in the same way as the access to credit, can be used differently from a producer to another but we assume that these financial supports are a prerequisite to the implementation of more environmental-friendly practices.

Farmers who benefit from any financial support are more likely to implement environmental-friendly practices.

– **H 4: Location**

Some variables are considered as controlled rather an active, since farmers cannot change them. Location is such a variable. Location includes several characteristics that may be opportunities or constraints to the implementation of environmental-friendly practices. But all opportunities become constraints if they are lacking. One constraint to the adoption of an alternative strategy is access to water. One opportunity for the adoption of an alternative production strategy is infrastructure, more precisely, access to suitable roads. The last constraint identified concerns access to plots. Some farmers have more than 50% of their plots with a slope superior to 15%. Exploiting these plots is complicated and does not facilitate the implementation of environmental-friendly practices. We assume that farmers have to adapt to their geographical environmental.

Farmers' behavior in terms of use of pesticides is influenced by their geographical location.

– **H 5: Perception of health risk resulting from pesticide consumption**

Few authors in the literature take the farmers' perception of health hazards into account. Any innovation or newness involves some degree of uncertainty (Lefebvre et al., 2014). This perception is quite difficult to measure and a national survey will not necessarily collect this subjective information. One way to quantify the risk perceived by producers is to consider the risk related to the use of pesticides on health. Hence, we asked farmers the following question : *"Have you, or your relatives, ever suffered from any health problem due to tomato consumption*?" It is acknowledged that farmers who suffered or whose relatives have suffered from the consumption of contaminated products are more aware of the impact of pesticides than others. We assume that:

Farmers who suffered or whose relatives have suffered from the consumption of contaminated products are more likely to implement environmental-friendly practices.

– **H 6: Institutional environment**

More than the characteristics of farmers and of their farm, the institutional environment in which they evolve can favor the implementation of environmental-friendly practices. Concerning tomato production, one way to measure the support provided by the institutional environment is through questions concerning access to technical support. Farmers who benefit from technical support provided through an institutional way have mainly access to information, advice and potentially a follow-up of their plot. This kind of support is much more appropriated to support producers to reduce their use of chemical input by implementing alternative practices rather than an informal support. We distinguish producers depending they declare have access, or not, to support from an official structure such as cooperatives or DAAF.

Farmers who have access to information in a formal way are more likely to implement environmental-friendly practices.

All the variables considered are listed in Table 1.

Tab. 1 – Description of variables.

Variable	Unit	Definition
Interest variable		
pps	yes/no	Use of phytosanitary product
Farmers' characteristics (H1)		
age	-	Age of the farmer
off_farm_activity	yes/no	The farmer has an off-farm activity
Farm characteristics (H2)		
workforce	-	Number of workforce employed
horticulture_diversification	-	Number of horticulture products produced
specialization in tomato	%	Share of area dedicated to the tomato production
expansion	yes/no	The farmer intends to expand his agricultural activity
Financial dimension (H3)		
access to credit	yes/no	The farmer already asked his/her bank for a loan
financial_support	yes/no	The farmers has/had financial support from France or Europe
Location (H4)		
location	(1) west (2) east (3) south	Location of the farm
Perception of health risk resulting from pesticide use (H5)		
background	yes/no	Damage to health after eating tomatoes
Institutional environment (H6)		
reference	formal/informal	Technical reference

3. MATERIALS AND METHODS

This section describes the data and the empirical methodology. We are particularly interested in the farmers' choice to use, or not, phytosanitary products. First, we describe the database obtained from face-to-face interviews conducted with all formal tomato producers. Second we explain the econometric model implemented. Finally, we define the resampling methodology used to take into account, on the one hand, the exhaustivity of farmers surveyed and, on the other hand, the low number of formal tomato producers in Mayotte.

3.1. DATABASE

An agricultural census conducted in Mayotte in 2010 identified all farms cultivating more than 1 hectare or more than 0.2 hectare of specialized production. Although we hypothesize that the landscape of Mayotte changed between 2010 and 2017, since we have no more recent data, we positioned our sample with respect to the 2010 census, with all bias implied by these changes.

Since there is no individual list of formal farmers, a preliminary qualitative survey enabled us to identify this population. More precisely, seven structures were surveyed: the cooperative COOPAC, the Agri-Evolution Mahorais group, the DEPHY network, the agricultural school, the trade union "Young farmers", the association "Saveur et Senteur de Mayotte" and the CIRAD. These structures let us identify the main formal farmers. To ensure all formal farmers were surveyed, we implemented a snowball sampling methodology that allowed us to identify all other formal tomato producers. To complete our sample, we visited the agricultural markets and asked each seller to give us the name of their suppliers.

To ensure the validity of our sample and also that the producers surveyed represented almost all the formal population (farmers who have a SIRET[7] identification), we compared the area of our sample with

7 SIRET is the French Identification System for Enterprise (Système d'identification du répertoire des établissements).

the tomato area identified in the agricultural census. The agreement between the areas led us to consider that almost all formal farmers were surveyed.

The database is composed of 46 farmers from which half of them implement alternative productive practices. The 23 other farmers use pesticides.

3.2. ECONOMETRIC MODEL

We observe, in Mayotte, that the quantity of pesticides used are much higher than the legal dose. Recent press articles underline the need to comply with phytosanitary requirements defined at the national and European level (Perzo, 2019). Beyond the nonconformity of pesticides quantity used with MRL (Maximum Residual Level), farmers use non authorized products that are considered unsafe for both farmers ans consumers.

To appreciate the quantity of pesticides used in Mayotte, we need first information on each active molecule used, even non-authorized, and their condition of applications. The obtention of such information implies a traceability of each treatment done by the farmer on each plot during the whole season. Since we do not dispose of such precise information, we consider a dichotomy proxy that is the implementation, or not, of alternative practices to pesticides use.

A logit model was used to appreciate to what extent tomato producers are inclined to implement more environmentally friendly practices by distinguishing farmers who use pesticides from farmers using anti-insect nets. Indeed, their choices are influenced by their institutional environment and are depending on individual and structural characteristics of farms. Formally, this model can be written as follows:

$$Y_i = 1 \text{ if } Y_i^* > 0;\ 0 \text{ otherwise}$$

And:

$$\begin{aligned} Y_i^* = \alpha + \beta \mathit{Individual\ Characteristics}_i + \gamma \mathit{Structural\ Characteristics}_i \\ + \zeta \mathit{Financial\ Characteristics}_i + \theta \mathit{Location} + \lambda \mathit{Perception}_i \\ + \delta \mathit{Institutional\ Environment}_i + \varepsilon_i \end{aligned}$$

Where:

Y_i^* is the choice made by the farmer to use anti-insect nets or pesticides
β is the coefficients associated with individual characteristics
γ is the coefficients associated with structural characteristics
ζ is the coefficients associated with financial characteristics
θ is the coefficients associated with location
λ is the coefficients associated with perception of health implication from pesticide use
δ is the coefficient associated with the institutional environment in which the farmer evolves
ε_i is the error term.

3.3. BOOTSTRAP RESAMPLING METHOD

Even though the survey of producers was exhaustive, their number was not sufficient to implement an econometric model with robust results. To compensate for the lack of observations, we used the bootstrap resampling method. The aim of this method is usually summarized as follows: "to pull oneself up by one's on bootstraps". This process enables the creation of information based on the information contained in the original database, thanks a random draw. The new database can then make statistical inferences. This methodology is used in the case of empirical samples (Davidson et Mac Kinnon, 1993).

Considering a vector x that can be denoted as follows: $x = (x_1 \ldots x_n)$, B bootstrap sampling can be performed where one new vector is denoted $x^* = (x_1^* \ldots x_k^*)$. An empirical rule estimates the optimal number of B to guarantee the quality of results: from 25 estimations we obtain a first estimation and from 50 we obtain relevant estimations.

In our study, we first considered 50 samples comprising 100 replications and then 50 samples comprising 150 replications of the initial database. Using simulations, we compared the results we obtained to confirm the robustness of the results.

3.4. ESTIMATION RESULTS AND DISCUSSION

Since econometric results confirmed the statistics (Table 2 and Table 3), our reading focused on econometric analysis.

TAB. 2 – Quantitative characterization of formal farmers depending on whether they use pesticides or not.

	Pps	Mean	Equality of mean	Standard Deviation	Equality of variance
Farmers' characteristics (H1)					
age	No	46.30	*	12.95	ns
	Yes	53.00		13.45	
Farm characteristics (H2)					
workforce	No	1.91	***	1.05	ns
	Yes	2.89		1.08	
horticulture_ diversification	No	5.75	ns	2.62	ns
	yes	6.04		2.82	
specialization in tomato	No	13.22	ns	3.41	ns
	yes	13.67		4.59	

Source: Own data.
Keys: Whatever the test considered, H0: there is no difference in terms of means (or standard deviation) for the variable considered versus H1: there is a significant difference at the 1% (***), 5% (**) and 10%(*) thresholds.

TAB. 3 – Qualitative characterisation of formal farmers depending on whether they use pesticides or not.

		Distribution		Equality of distribution
		Use of pesticide		
		no	yes	
Farmers' characteristics (H1)				
Off_farm_activity	no	79%	78%	ns
	yes	21%	22%	
Farm characteristics (H2)				
Expansion	no	57%	65%	ns
	yes	43%	35%	
Financial dimension (H3)				
Loan	yes	62%	65%	ns
	no	38%	35%	
Financial support	no	50%	56%	ns
	yes	50%	44%	
Location (H4)				
Location	West	46%	35%	reference
	East	38%	35%	ns
	South	16%	29%	***

Perception of health risk resulting from pesticide use (H5)				
Perception	no	38%	53%	ns
	yes	62%	47%	
Institutional environment (H6)				
Reference	informal	75%	65%	ns
	institutional	25%	35%	

Source: Own data.
Keys: The null h considers equality of proportion between producers who use pesticides and other producers. Proportion are significantly different at the 1%(***), 5%(**) and 10%(*) thresholds.

The model made us aware that almost all the factors influencing the farmers' behavior are considered since the model's concordance rate was 82.16% (Table 4).

Tab. 4 – Econometric model.

	Coef.	Std. Err.	z	P>|z|	Marginal effects
H 1: Individual characteristics					
Age	0.0059019	0.0349473	0.17	0.866	0.09
Off-farm activity	-0.7086424	0.9634848	-0.74	0.462	-6.73
H 2: Structural characteristics					
Workforce	1.3909***	0.488455	2.85	0.004	22.84
Specialization in tomato	0.0359451	0.0260401	1.38	0.167	0.59
Horticultural diversification	0.1249624	0.1721143	0.73	0.468	1.78
Expansion	1.116221	1.019156	1.10	0.273	17.69
H 3: Financial characteristics					
Loan	-0.5927116	1.047991	-0.57	0.572	-6.01
Financial support	1.177423	1.132234	1.04	0.298	17.19
H 4: Location					
Location	*(Reference : West)*				
East	0.0148257	1.044913	0.01	0.989	0.17

South	2.145506*	1.275832	1.68	0.093	31.76
H 5: Perception of health risk resulting from pesticide use					
Background	0.150235	.903114	0.17	0.868	1.81
H 6: Institutional environment					
Reference	1.702858*	1.032916	1.65	0.099	24.36
Constant	-6.843223	2.69473	-2.54	0.011	
Concordance rate	82.61%				

Keys: Estimates significant at the 1% (***), 5% (**) and 10% (*) thresholds.
Marginal effects on the Means are indicated en the percentage (%).

Econometric results identify not only levers at the level of the farmers but also obstacles that prevent producers from promoting their productive efforts in terms of environmental-friendly practices (Table 4).

Results of the econometric model highlighted that, in the context of Mayotte, individual characteristics do not affect the practices implemented (H 1 invalidated). Neither the age of the farmer nor potential off-farm activity had an impact on the use of pesticides. This information is all the more important as it reflects the importance of environmental factors.

Considering the physical dimension of the farm, as expressed via the total workforce, our model underlines the fact that farms that employ more labor are more likely to implement environmentally friendly practices (H 2 validated). More precisely, farmers who employ workforce increase their probability to implement more environmentally friendly practices without any pesticides use from 22.84% compared to farmers who do not employ the workforce. This result shows that bigger farms benefit from economies of scale and have a higher economic potential that enables them to reduce their use of chemical inputs.

The financial dimension of the farm is considered through access to European financial support. The results highlight the specificity of the context of Mayotte. The absence of significance reveals that even if farmers benefit from European financial support, they are no more likely to implement environmental-friendly practice (H 3 invalidated). To understand, let us highlight the experience of one farmer interviewed during our survey who benefited from financial support to buy a cistern, but the farmer could not use it because it was stolen even before being installed. This result identifies theft as a major problem in Mayotte.

Our results also confirm the importance of the location (H 4 validated). Results underline that being located in the South, rather than in the West or in the East, translate into an increase of the probability to implement alternative practices, and hence not to use pesticides, from 31.75%. Even if Mayotte is a small island, there are geographical specificities between the three main regions in terms of access to water, access to roads and hence access to training. Mayotte is subject to a water gradient. Southern farmers have access to less water than farmers in the north. Water is a precondition for tomato productivity. Location also includes the existence of roads and hence access to training. Training centers like the agricultural school in Coconi where all farming training courses are held are located in the center of the island. Depending on the location of the farmer, access to these centers may be an obstacle. Farmers located in the south are again disadvantaged since departmental roads are sparse in this part of Mayotte.

Farmers' hazard perception did not appear to be relevant to understand the farmers' behavior with respect to environmental-friendly practices (H 5 invalidated). Even if farmers are aware of the environmental impact of the pesticides, the fact of being ill after eating contaminated fruits appears to be sufficient to modify their behavior as a consumer but not their agricultural practices.

The last hypothesis tested in our model was the importance of access to information (H 6 validated). We observed that farmers who benefitted from formal information are more likely to implement environmental-friendly practices than those who get their information through informal networks. More precisely, farmers who access to formal information have a higher probability to implement alternative practices from 24.36% compared to other farmers. During our survey, almost all farmers emphasized the need for more support in obtaining knowledge and acquiring skills from a technician and in transferring the knowledge acquired. Although they have access to some information through their official or non-official networks, they want concrete support in the form of a technician on their land. Almost all the farmers would like to adopt environmentally friendly practices but they do not know what to do. The long-term follow-up is necessary for all the farmers who need advice, since between custom and belief, some farmers do not hesitate to treat their tomatoes with *ourouva*, which is a toxic plant, or to use fire to destroy pests. Supervision and monitoring would help farmers improve their practices.

Beyond the results obtained by the econometric model, discussion with farmers revealed two main obstacles to implement environmental-friendly practices and let us confirm and enrich quantitative results.

At the financial level, farmers require support right from the beginning since some of them can neither read nor write, nor speak French. During our survey of producers, some admitted not benefiting from European financial support to which they are entitled because of this language divide.

The second obstacle which is the most important factor for the adoption of environmental-friendly practices is the lack of laboratories to perform phytosanitary tests. Since there is no laboratory in Mayotte, even if producers implement environmental-friendly practices, they cannot promote the quality of their products; farmers nor cooperatives can promote alternative practices. No collective action can be undertaken at this stage.

CONCLUSION

Mayotte has been a French department since 2011 and an overseas department since 2014. The recent integration of Mayotte as part of France and hence of the European Union Mayotte is an original case study. Mayotte is required to fulfill European phytosanitary requirements and farmers' practices must respect European legislation. The tomato crop production in Mayotte is a relevant case study since first the tomato production is a perishable crop and second Mayotte is an insular location. Although our analysis focused on the island of Mayotte, the situation is similar to other small island developing states. Hence, farmers have to adopt and modify their productive practices to answer the increasing international, European and national phytosanitary's requirements. For these reasons, the scope of the results go beyond our study context.

The aim of our study is to understand to what extent farmers are more likely to implement environmental-friendly practices. To appreciate the extent to which individual characteristics of the farmers, and the structural and financial characteristics of their farm affect their use of pesticides, we create an original database including all formal farmers. More than these factors, the study also considered the specificity of the location and the impact of the institutional environment through the farmers' access to formal or informal networks. Based on an exhaustive survey of formal tomato producers, we implemented logit model that let us differentiate producers who do not use phytosanitary producers from the others. Even is all formal farmers were surveyed, we correct the low number of observations thanks bootstrap sampling.

Our main results confirm the farmers' need for institutional support. While some supports need to be defined at the level of the producers, others need to be identified at a more aggregated level.

At the producer level, financial support does not appear to be the primary lever. Because of thefts, farmers cannot always profit from such support, as the equipment may be stolen before it is even installed. Another problem preventing farmers from benefiting from financial support is the language divide. Not all members of the population of Mayotte speak and read French.

At an aggregated level, the first obstacle we identified was infrastructure. Some regions benefit from access to water and roads, others do not. The problem is not only the need for infrastructure since the lack of roads prevents farmers from benefiting from training courses, since they have no way of accessing them. The infrastructure dimension appears applies to a laboratory. There is no laboratory in Mayotte to provide certification that the practices implemented by farmers are environmentally friendly and fulfill phytosanitary requirements. In this context, farmers are not encouraged to implement the practices since there is no way of checking their production's quality.

Mayotte is a relevant case study that accurately reflects the need to answer phytosanitary's requirement in an insular context. Thanks to the fact Mayotte recently became a French department, efforts are underway and in time farmers will improve their practices. One possible way of extending this study and improving the comprehension of farmers' change in behavior is to follow them over time to appreciate to what extent farmers in Mayotte are inclined to adopt alternative practices.

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