INTERNATIONAL CONFERENCE OF AGRICULTURAL ECONOMISTS
ICAE
29th | Milan Italy 2015
UNIVERSITÀ DEGLI STUDI DI MILANO AUGUST 8 - 14
AGRICULTURE IN AN INTERCONNECTED WORLD

Mandatory Integrated Pest Management in the European Union: Experimental insights on consumers' reactions

M. Lefebvre[1,2], C. Biguzzi[3], E. Ginon[3], S. Gomez-y-Paloma[1], S. R. H. Langrell[4], S. Marette[5], G. Mateu[3], A. Sutan[3]

1 European Commission, Directorate General Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), Agriculture in the Economy Unit, Edificio Expo. c/ Inca Garcilaso, 3, ES-41092 Seville, Spain

2 Montpellier SupAgro, UMR 1135 LAMETA, F-34000 Montpellier, France

3 Laboratory for Experimentation in Social Sciences and Behavioral Analysis (LESSAC), Burgundy School of Business, F-21000 Dijon, France

4 European Commission, Directorate General for Health and Consumer Protection, Food and Veterinary Office, Plant health, food of plant origin and food quality Unit, Grange, Co. Meath, Ireland

5 INRA, UMR Economie Publique, F-78850 Thiverval-Grignon, France

Corresponding author: lefebvremarianne@gmail.com

Abstract: An experiment with 189 French consumers was conducted to analyse consumers' reaction to the transition towards Integrated Pest Management (IPM) as the standard in European farming. Results indicate high substitutability between IPM and organic tomatoes. IPM sales will benefit from the withdrawal of conventional produces from the market only if there is a significant reduction in the price of IPM compared to organic and/or an important increase in the shelf space dedicated to IPM. While information on IPM guidelines increases IPM products purchases, providing extra information on residue levels in IPM tomatoes has no further impact on consumers' choices.

JEL code: C91, D12, Q13, Q18

Keywords: Integrated Pest Management, Organic, Tomatoes, Sustainable Use of pesticides Directive, Multinomial probit, Real Choice Experiment, Laboratory Experiment

I. Introduction

Many scientific and regulatory claims have been made over recent years about the potential harmful effects of pesticide intensive farming systems for both environment and human health (Aubertot et al. 2005). The search for sustainability of agriculture has led to explore potential alternatives to crop protection and to the adoption by the European Union in 2009 of the Sustainable Use of pesticides Directive (SUD). This directive provides a framework for action to achieve a sustainable use of pesticides and to promote the adoption of low pesticide input pest management. Integrated Pest Management (IPM) has been retained as one of the possible approaches to achieve low pesticide-input pest management in the EU, together with organic farming (EU 2009). As described in the SUD, IPM is a system based on three main principles: i) the use and integration of measures that discourage the development of populations of harmful organisms; ii) the careful consideration of all available plant protection methods, including: biological, mechanical and chemical control; and iii) the use of chemical control to levels that are economically and ecologically justified. This possible application of chemical pesticides helps to bypass the problem of low yields linked to organic farming, leading to more affordable products. As a result, IPM has been described as "a middle course between the extreme constraints of organic farming standards and the increasingly unacceptable pursuit of intensive agriculture" (Wibberley 1995), and as "a third way, both economically realistic and environmentally beneficial' (Morris and Winter 1999).

Whilst consumers' willingness to pay (WTP), and preferences for organic food products, is now well recognised (Aertsens et al. 2009; Wier and Calverley 2002; Yiridoe et al. 2002), the knowledge of the IPM market is much more limited. Do consumers recognize the benefits of this "third way"? Are consumers willing to pay a price premium, and, if so, what is the quantum of this premium compared to organic? Widespread adoption of IPM by farmers will depend, among other drivers, on the profitability of this crop protection strategy (Lefebvre, Langrell, and Gomez-y-Paloma 2014). Predicting the proportion of consumers in the market who will try IPM products, when other products are available, is a key question, and within this context, this article aims to analyse consumers' preferences for Integrated Pest Management, when conventional and organic produces are also available.

Marketing Integrated Pest Management products for the end-consumer is neither a simplistic nor straight forward task for several reasons. First, pest control based on economic thresholds and decision models appears difficult to communicate since there is no clear commitment regarding the reduction in overall pesticides use. Moreover, given the varieties of principles covered by the term "IPM" (as illustrated by the list of general principles of IPM in the Annex III of the Sustainable Use Directive), there is a risk of multiplication of labels, with quite different interpretations and approaches. Not least, such a situation may add to the possible market saturation of certification schemes and labels and information overload for end-consumers. Producers are encouraged to apply to different certifications for the same product in order to have access to different market segments, resulting in increased production costs whilst, simultaneously, further contributing to consumer confusion (Canali 2011). The large number of different logos indicating environmental sustainability already available in the market raises the question of whether their associated messages are successfully conveyed to consumers. Previous research has shown that most existing logos fails to convey their message, which suggest the need to provide consumers with adequate information on environmental sustainability (Ginon, Ares, et al. 2014).

These different arguments may explain why retailers have been reluctant to create a specific market segment for IPM. Currently, in Europe, products grown using IPM are rarely identified as such in the market place for end-consumers. However, retailers use IPM as a prerequisite for producers to deliver products to market segments with stricter environmental specification or to be in the group of suppliers supermarkets will preferentially call upon (ENDURE 2010). Complying with these general principles of Integrated Pest Management can lead producers to sell at higher prices (but not always) (Canali 2011).[1] As a consequence of this market organization, market data on consumption of IPM products at household level are inexistent. As

[1] This is explicitly stated in the Global GAP business-to-business certification, which includes requirements concerning integrated crop management: "Most people confuse GlobalGAP with higher prices, that is, they think that once you have been certified you can charge higher prices than the one who hasn't been. That is not very true. Yes, global gap opens up many markets for you, but it is not an assurance for higher prices. In most European countries, certain products are not allowed unless they are certified. So the benefits of Global GAP are more markets than more money. But then again if you push more products, you will enjoy economies of scale and make more profits" (http://www.globalgap.org/uk_en/index.html, accessed July 2013).

a result of the scarcity of market data for new or non-labelled products, the burgeoning literature on food choices relies increasingly on experimental data, using non-hypothetical and incentive compatible choice methods to elicit consumers' preferences and WTP (Becker, DeGroot, and Marschak 1964). Several of these studies have focused on "green" or "eco" products, obtained from more sustainable farming systems, with the aim of distinguishing market segments and estimating their market potential at premium prices.

It has been previously shown that consumers are willing to pay more for reduced exposure to pesticide risk in general (Florax, Travisi, and Nijkamp 2005) and for organic products in particular (Aertsens et al. 2009; Yiridoe et al. 2002; Wier and Calverley 2002). However, it remains unclear how products complying with other environmental certifications are valued by consumers. While several studies have focused on estimating WTP for food products with environmental attributes others than organic, research on IPM is much more limited. Marette et al. (2012) studied the effect of a new label signalling apples that only use a few pesticides (corresponding to a 50% reduction in the pesticide use compared to conventional apples). The authors decided to name this alternative ‘‘Few Pesticides’’ rather than ‘‘Integrated Pest Management’’ in order to make the low-quantity of pesticides explicit to participants. Doing so, they have hidden part of IPM complexity, which is nonetheless an important feature to understand this market. Bazoche et al. (2013) elicited consumers’ WTP for apples to which are attached different kinds of certification concerning pesticide use, including IPM. Here, the focus was placed on the impact of information provided to consumers concerning pesticide use, with control for sensory characteristics. Together, both studies suggest that IPM can satisfy a niche market for consumers with different preferences on the trade-off between price and pesticide reduction.

Our experimental study further contributes to the understanding of consumers' preferences for IPM, when conventional and organic products are also available, using the example of fresh tomatoes. Very few studies have focused on vegetables whereas vegetables have high market share within organic consumption and concentrate a lot of effort in IPM research (van der Velden et al. 2012). Although all the available evidence on preferences for tomatoes production systems to date focuses on organic (Weaver, Evans, and Luloff 1992; Yue, Alfnes, and Jensen 2009; Ali Bashir 2012; Mesías Díaz et al. 2012), this study compliments the available literature by capturing in the laboratory the evolution of the legislative environment, according to which all growers in the European Union should follow IPM guidelines (or be certified organic) from 1st January 2014. While previous studies have provided estimations of WTP for IPM, we focus on the analysis of the market impacts, i.e. how the market shares will be redistributed across IPM and organic production when conventional products are withdrawn from the market. To do so, we investigated how IPM tomatoes consumption would be influenced by a reduced availability of conventional products and an increase in shelf space dedicated to IPM. The experimental design accounts for the potential impact of relative prices on consumers' preferences. We also analyse the impact of providing to consumers extra information on the characteristics of the final products (focusing on pesticide residue levels), in addition to the description of the production system. Overall, the results allows for the provision of recommendations for effective marketing and pricing decisions of IPM products and for improving the consumer responses to the new legislative environment on IPM. The paper is structured as follows; Section II presents the method employed and data generated. Results are presented in section III, and discussed in section IV. Section V provides conclusive remarks.

II. Data and Method

1. Participants

The experiment was conducted at the Laboratory for Experimentation in Social Sciences and Behavioral Analysis (LESSAC) in Dijon, France, with 189 food shoppers (129 female and 60 male), aged between 22 and 75.

We rely on a convenience sample recruited using two different procedures: half of the participants were randomly selected from a panel of volunteer consumers having participated in other studies at LESSAC and half were recruited thanks to posters in the market of Dijon city and by word of mouth. Among the persons willing to participate, priority selection was made of those buying tomatoes in autumn/winter in order to ensure they will be interested in buying tomatoes during the experiment.[2]

[2] In the recruitment email, respondents were asked which vegetables they were used to buy at this period of the year (autumn) in a list of ten vegetables.

Participants were asked to fill out a detailed questionnaire on their socio-demographic and consumption characteristics at the end of the experiment. The sample is relatively balanced in terms of age and consumption habits (Table 1). The high percentage of female respondents was expected and desirable, since we were targeting actual shoppers. As with all surveys, sample representativeness is a concern. The sample chosen may not adequately correspond to the population that will purchase tomatoes. The effect of population choice on our results concerning preferences for IPM is likely indeterminate. There may also be some degree of sample selection bias, in which the people who elected to participate in the experiment are more concerned by their food purchase habits. Given these potential sources of bias, we caution that our findings may not represent those of other populations.

A total of ten sessions, of less than 90 minutes each, were organised during November 2013. Participants were randomly assigned to each session, ensuring the socio-demographic characteristics of the participants were not significantly different in the different sessions.

Table 1: Socio demographic characteristics and consumption habits of the participants

	Mean	St Dev	Min	Max
Female (%)	0.68	0.47	0	1
Age	39.48	14.85	22	75
Weekly consumption of tomatoes in winter (kg)	0.77	1.08	0	13
Weekly consumption of tomatoes in summer (kg)	2.20	1.71	0	10
Price usually paid for a kg of tomatoes (€/kg)	1.98	0.74	0	6
Share of organic tomatoes in total consumption (%)	0.26	0.29	0	1
Consumers never consuming organic tomatoes (%)	0.43	0.50	0	1
Consumers only consuming organic tomatoes (%)	0.04	0.19	0	1

2. *Experimental design*

Choice mechanism

While experimental actions (Vickrey 1961; Becker, DeGroot, and Marschak 1964) have been widely used to analyze consumers' preferences and willingness to pay for new products, real choice experiments are developing fastly (Lusk and Schroeder 2004; Alfnes et al. 2006; Michaud, Llerena, and Joly 2012; Ginon, Chabanet, et al. 2014). Experimental auctions are criticized for their lack of realism since food shoppers are usually not price makers. Real choice experiments are favored for their ability to combine discrete choice questions with posted prices and real economic incentives. Such surveys typically require consumers to make choices between several alternatives defined by their attributes. Food shoppers are usually more familiar with such decision task where there are price takers. The discrete choice methodology also provides great flexibility in the sense that many different scenarios can be presented in a single study.

The preference revelation mechanism chosen here is a posted prices choice experiment. The prices are fixed for each round, and participants choose one of the tomato options and the desired quantity.

Contrarily to most choice experiments, participants do not have to select a choice card, but a type of product and a quantity. We needed the information on quantities to be able to compute market shares and evaluate the impact of a change in the attributes on market shares. For this reason, we forced participants to buy a positive quantity (minimum 0,1Kg). In other words, the experiment did not include an opt-out alternative. Each respondent was, however, selected to take part in the experiment only if he or she actually consumes tomatoes in winter.[3]

Products and attributes

The choice set was simplified to tomatoes from three production systems: IPM, conventional and organic tomatoes. We decided to include conventional and organic produces in the choice set because IPM is often seen as a third way between these two types of production.

The experimental design focused on three main attributes. First, we investigate how the purchase of IPM tomatoes is influenced by the availability of conventional and organic products, and by the shelf space dedicated to IPM. Second, the impact of providing extra information on the characteristics of the final products to consumers (focussing on pesticide residue levels), in

---

[3] Opt-out alternatives have become fairly standard in discrete choice experiments and are generally recommended(Hensher 2010), specifically since opt-outs better reflect reality (Carson et al. 1994). Kallas et al. (2012) provide a comprehensive overview of the theory and implications of including (and types) an opt-out alternative and Boxall, Adamowicz & Moon (2009) review potential bias from including an opt-out alternative. Yet recent studies without opt-out alternatives exist (Carlsson, Frykblom, and Lagerkvist 2007; Hasund, Kataria, and Lagerkvist 2011; Kallas, Escobar, and Gil 2012; Rigby, Alcon, and Burton 2010; Miettinen, Hietala-Koivu, and Lehtonen 2004; Alphonce and Alfnes 2015). As we were primarily interested in estimating the impact of the different attributes, and not the total WTP for each product, this ought to be an appropriate design (Carlsson, Frykblom, and Lagerkvist 2007; Alphonce and Alfnes 2015).

addition to the usual description of the production system, was analysed. Lastly, the potential impact of relative prices on consumers' preferences was also assessed.

Prices

To analyse the impact of prices on choices, the prices of the different tomatoes across sessions and in the different rounds was varied. In the two first rounds, the tomatoes were priced according to reference prices. The reference prices were those observed in retail contexts (supermarkets) the week before the experiment (autumn prices) for the consumers participating to sessions 1, 2, 3, 6, 7 and 8. For the other participants, the reference prices corresponded to the price of tomatoes in summer (cheaper than in autumn). Then, two other price lists were tested in the other rounds. The difference between the prices of organic and IPM tomatoes was increased compare to real prices in price list 2 and was reduced in price list 3. The full list of prices is available in annex C and the price list associated to each round is specified in Table 2.

Moreover, the impact of an innovative pricing mechanism that accounts for the potential impacts of demand on producers' willingness to adopt more sustainable farming practices was tested. By increasing their demand of organic or IPM products, consumers can encourage their production, and in the medium run, prices of IPM and organic products may decrease when supply increases. We refer to this mechanism as the "price elasticity mechanism". In half of the sessions (sessions 6 to 10), the participants received the following information at the beginning: "If many of you choose to buy organic or IPM tomatoes, the prices of these tomatoes will decrease for the participants of the other sessions".[4] More precisely, the experiment was configured as follows: if the market share of IPM (organic) is higher or equal to 70% in round t and session X, the price of IPM (organic) is reduced by 20% in round t of the next sessions, compare to the prices in annex C. For the other sessions without the price elasticity mechanism, prices were those indicated in annex C.

[4] The design can be interpreted as a modified voluntary contribution mechanism. In the traditional voluntary contribution mechanism, each member of a group of potential beneficiaries of the public good decides simultaneously on a portion of its initial endowment to contribute to a group account. Here, the contributions to the public good do not benefit directly to the group but are transferred over time to a future group (inter-temporal transfers). Moreover, we combine the voluntary contribution mechanism with supply and demand conditions in the market for a private good. Here, the "public good", provided thanks to individual contributions, is a reduction in the price of sustainable products for next generations.

Information on the production system and extra information on residues

Given the difficulty to present Integrated Pest Management guidelines to the end-consumer, we wished to test whether providing extra information on the characteristics of the final products, focusing on pesticide residue levels, in addition to information on the production system and crop protection strategies, were useful to promote IPM. In the experiment, participants were able first access to information on the technical specifications of the production system of each type of tomatoes. Then, from round 5, they could access extra information on the properties of the final product in terms of residue levels. From round 7, the complete information was disclosed to all participants to ensure measurement of the net impact of the other attributes (reduction in the shelf-space dedicated to IPM and relative prices), assuming all consumers are informed. The content of this information is presented in annex A.

Successively revealing information to participants with regard to various characteristics of the product under study is a common design feature of food choices experiments (Marette, Messéan, and Millet 2012). Most of the time, information is displayed to all participants and data are analysed assuming that all the information provided is processed to make informed decisions. Here, in contrast, participants had to click to view the information. Voluntary access to information better captures a real shop situation where consumers have to actively look for information (either on the label or on the internet) (Hu et al. 2006). Here, extra information was introduced sufficiently early in the experiment to account for the potential diminished attention to new information at the end of the experiment. The experiment focuses on the impact of providing extra information. We therefore did not rely on a between-subject design where some participants would have access to information on the production system while others have the information on residue levels, nor tested order effects.

Shelf space dedicated to IPM

In order to capture the evolution of the legislation on crops pest management, the shelf space[5] dedicated to conventional tomatoes during the experiment was reduced. At the beginning, participants were able to purchase fresh tomatoes from the conventional production system of three varieties, one type of IPM tomato and one type of organic. This captures the current

[5] The shelf space corresponds to the amount of space for one product in a store.

situation where conventional farming remains the norm and conventional tomatoes occupy a large shelf space (3/5). Then, we reduced the number of different conventional tomatoes available for sale from 3 to 1. The shelf space of IPM and organic tomatoes therefore mechanically increased (from 1/5 to 1/3). In the last rounds, conventional tomatoes were not available anymore and organic and IPM tomatoes equally shared the shelf space.

To summarize, the number of products in the choice set varies across rounds: 5, 3 or 2. There are three types of production systems, but with three types of conventional tomatoes in the first rounds, therefore a total of five types of tomatoes.

We provided to participants explanations on the justification for the changes in the products available before the changes (messages in annex B). Moreover, in each session, the order of presentation of the different types of tomatoes was modified on the computer screen to help avoid position bias. Five different orders were tested over the ten sessions.

Table 2: Experimental design – description of the 10 rounds

Rounds	1	2	3	4	5	6	7	8	9	10
Produces available										
Conventional (Round)	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO
Conventional (Large Tomatoes-On-Vine A)	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO
Conventional (Large Tomatoes-On-Vine B)	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO
Organic (Large Tomatoes-On-Vine)	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
IPM (Large Tomatoes-On-Vine)	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Available information (see Annex A)										
Production system	NO	u.r	u.r	u.r	u.r	u.r	YES	YES	YES	YES
Characteristics of the final product	NO	NO	NO	NO	u.r	u.r	YES	YES	YES	YES
Prices (see Annex C)										
Price list	Ref	Ref	2	3	2	3	2	3	2	3

Note: u.r. = upon-request

3. *Experimental procedure*

Each participant took part in one session composed of 10 rounds. Product availability, information available to participants and prices varied across rounds, as described in Table 2. At the beginning of each session, the participants received 20 Euros as a participation fee. In each round, each participant could choose the type and the quantity of tomatoes in Kilograms he wanted to purchase, with a minimum of 0.1kg. It was possible to buy only one type of tomato in each round.

To induce real economic incentives, individuals were informed from the beginning that one of their decisions would be randomly drawn at the end of the experiment. As the random draw resulted in the purchase of the type and quantity of tomatoes they had chosen at the price specified, they had to consider each choice made during the experiment as a real purchase decision. The dominant strategy for participants is to choose the alternative that they prefer in each of the choice sets, thereby revealing their true preferences, and incentive compatibility follows.

The participants played the experiment individually and electronically following the experimental procedures. The experiment was programmed and conducted with the software z-Tree (Fischbacher 2007). Participants could see the types of tomatoes available and their respective prices on the computer screen and had to enter the quantity and type of tomatoes they wished to buy. Efforts were undertaken to make the experiment similar to a real buying situation. Instead of pictures or images, real tomatoes were used as product stimuli. The tomatoes were arranged on a table and participants were encouraged to view them during the experiment. We made sure the appearance of the tomatoes is similar across IPM, traditional and organic production methods. Only vine and round conventional tomatoes look different.

4. *Method for data analysis*

In order to measure the impact of the different attributes on consumption choices, two approaches were relied upon. First, we focus on market level, and measure the impact of the different variables of the experimental design on market shares. Second, we focus on individual preferences for the different types of tomatoes.

Market shares

From retailers' point of view, the quantities bought by the consumers is an important piece of information to understand the evolution of the market in the presence of new products. To account for quantities, we compare the market shares of each type of tomato across rounds and sessions. The market share of product *j* in round *t* is defined as the total quantities of product *j* purchased in round *t* by all participants divided by the total quantities of tomatoes bought in round *t* (all types of tomatoes). To deal with the limited number of observations, we rely on non-parametric tests. More specifically, we use the Mann–Whitney two-sample test to compare the choices of participants in different sessions, or with different characteristics (informed vs non-informed). We also use the Wilcoxon test for comparing choices across rounds (paired sample): Q_{ij}^{t} and $Q_{ij}^{t'}$, with Q_{ij}^{t} the quantity of tomatoes of type *j* chosen by participant *i* in round *t*. Lastly, we verify whether the distributions of the quantities purchased over the different rounds are different, we rely on the Skillings–Mack statistic (SM). This nonparametric statistical test is useful for the data obtained from block designs with missing observations occurring randomly – here there are missing data when the product is not available in some rounds- (Chatfield and Mander 2009).

Discrete choice model

The theoretical framework for analysing the choice of tomatoes can be cast in a random utility model. Formally, consider a consumer i from a sample of N consumers who has to choose a type of tomatoes from a feasible set defined by $\mathrm{j} = 1,2,3$ alternatives, namely, IPM (1), conventional (2), and organic (3). Each consumer i attaches a utility value U_{ij} to each type of tomatoes and chooses the type of tomatoes j that maximizes her utility in each choice situation t.

Following the approach of Alvarez et al. (2000) and Jumbe & Angelsen (2011), we use a multinomial probit model (MNP). The MNP does not impose the IIA property inherent in other multinomial choice models such as the multinomial logit because the error process of the MNP allows for correlations between the disturbances for the different choices (Train 2009). The choice of the MNP has been motivated by the desire to relax IAA and to allow for more flexible substitution patterns between alternatives. This is particularly relevant here given that we want to analyse substitutability across different types of tomatoes, when the choice set is modified by a change in the legislative environment.[6] The MNP is also flexible in that not all cases need to have faced all J alternatives. This is a useful feature given that the choice set varies from 5, 3 to 2 in the experiment. Moreover, errors can be clustered at the individual level in order to take into account that the same individual is making 10 choices (one per round). The model does not account for the quantities purchased by each individual. As we observed that the quantity bought by each individual is stable across rounds (see section III.1), this ought to be an appropriate model.

The utility that a consumer obtains from alternative j is decomposed into observed and unobserved parts:

$$U_{ij} = X_{ij}\beta + z_i\alpha_j + \varepsilon_{ij} \; \forall j = 1,2,3 \qquad (1)$$

With $V_{ij} = X_{ij}\beta + z_i\alpha_j + \varepsilon_{ij}$ the deterministic part of the model, where X_{ij} is a vector of alternative-specific variables (price, shelf space dedicated to the alternative, information of the respondents on this alternative[7]), β is a vector of parameters, z_i is a vector of individual-specific variables including socio-economic characteristics of the respondent (sex, age, weekly consumption of tomatoes in autumn, usual price paid for tomatoes, share of organic in tomatoes consumption) and descriptors of the decision context in choice situation t (autumn prices, price elasticity mechanism, order of presentation of the products), α_j is a vector of parameters of the jth alternative and ε_{ij} the error terms.

The choice probability of alternative j rather than any other alternative j' for individual i is given by:

[6] An alternative could have been to use the mixed logit model, which also does not impose IIA. It also has the advantage not to require an identical and independent distribution of error terms across individuals and alternatives. The mixed logit allows estimating standard deviations of mean parameters and therefore heterogeneity in the preferences for a particular attribute. Given that the primary focus of the model is on exploring substitution patterns between alternatives, rather than random taste variation across individuals, the multivariate probit ought to be the appropriate model (Glasgow 2001).

[7] While price and shelf space are attributes of the alternatives defined in the experimental design, the value of the information attributes are not fixed prior to the experiment since they depend on whether the individuals have requested information about a specific alternative (for rounds 1 to 5) or not. Nevertheless, they remain alternative-specific attributes.

$$
\begin{aligned}
P_{ij} &= \text{Prob}\,(V_{ij} + \varepsilon_{ij} > V_{ij'} + \varepsilon_{ij'}) \quad \forall j \text{ and } j' \neq j \\
&= \text{Prob}\,(\varepsilon_{ij'} - \varepsilon_{ij} < V_{ij} - V_{ij'}) \\
&= \int_{\varepsilon} I\left(\varepsilon_{ij'} - \varepsilon_{ij} < V_{ij} - V_{ij'}\right) f(\varepsilon_i)\, d\,\varepsilon_i \quad (2)
\end{aligned}
$$

Where $I(.)$ is the indicator function, equalling 1 when the expression in parenthesis is true and 0 otherwise. This is a multidimensional integral over the density of the unobserved portion of utility $f(\varepsilon_i)$. In the MNP, $f()$ is multivariate normal with zero means and the variance-covariance matrix Ω.

$$
\Omega = \begin{pmatrix} \sigma_{i,1}^2 & \sigma_{i,12} & \sigma_{i,13} \\ \sigma_{i,12} & \sigma_{i,2}^2 & \sigma_{i,23} \\ \sigma_{i,13} & \sigma_{i,12} & \sigma_{i,3}^2 \end{pmatrix} \qquad (3)
$$

The MNP model imposes a significant computation burden because of the need to evaluate probabilities from the multivariate normal distribution. These probabilities are evaluated using simulation techniques because the integral in equation (2) cannot be solved analytically. The model is estimated using maximum simulated likelihood, implemented by the Geweke-Hajivassiliou-Keane (GHK) algorithm (asmprobit in Stata 10).

As described by Train (2009, section 2.5), the model requires normalization because both the level and scale of utility are irrelevant. To normalize location, the variance of IPM tomatoes ($j = 1$) is normalized to 1 as the base alternative. We selected IPM as the base alternative since IPM is bound to become the main production system in the new legislative environment and our interest is on the substitution between IPM and conventional and IPM and organic products. To normalize for scale, one of the diagonal elements of the variance-covariance matrix must be fixed to a constant. We normalize the variance of conventional tomatoes ($j = 2$) to 2 as the scale alternative. Hence, we have the following variance-covariate matrix:

$$
\tilde{\Omega} = \begin{pmatrix} 2 & \Theta_{23} \\ \Theta_{23} & \Theta_{33} \end{pmatrix}
$$

There are now two elements in $\tilde{\Omega}$. These two elements are the only identified parameters in the model. Estimation of the multinomial probit involves estimating $\tilde{\Omega}$, β and α_j.

III. Results

1. Descriptive analysis of market shares

Participants bought on average 0.70 kg of tomatoes in each round. This quantity corresponds to the average weekly consumption of tomatoes in autumn/winter declared by the participants in the post experiment questionnaire. Moreover, only between 10 and 13 participants per round choose the minimum quantity (0.1Kg). These two elements confirm participants' overall interest in buying tomatoes during the period of our study and the fact that the experiment is perceived as a real purchase opportunity.

Participants have purchased different types of tomatoes in the different rounds, suggesting that they have different preferences for the different attributes of the products. The Skillings Mack statistics (SM) shows that the differences in the quantity purchased of each type of tomatoes were statistically significant across rounds (IPM: SM=114.293, p-value=0.000; Organic: SM=137.048, p-value=0.000; Conventional: SM=218.033, p-value=0.000). Only 13 participants (6.88%) made the same choice of tomato type during the ten rounds. Among them, ten always chose organic tomatoes. These ten consumers declared to consume on average 72.5% of organic in their real life tomato consumption. They exhibited strong preferences towards organic and they seemed to be less influenced by the attributes of the products in the experiment.

However, the quantity of tomatoes purchased (all types) was not significantly different across rounds (SM=7.222, p-value=0.6140), suggesting that participants do not modify the quantities purchased when they switch to another type of tomatoes (even if the price is higher or lower).

Impact of the between-subject design variables

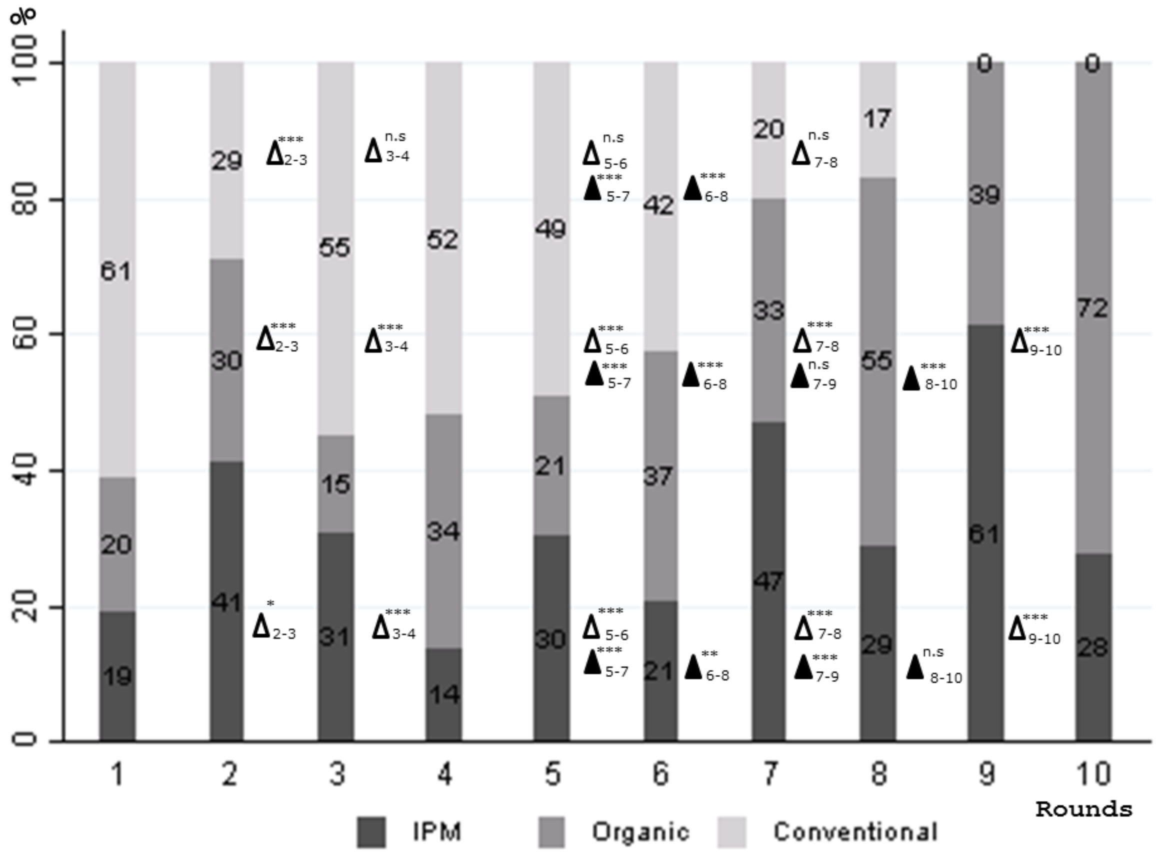
We observed a mostly non-significant impact of the between-subject variables. First, the quantities of conventional, IPM and organic tomatoes bought in the round 1 are not significantly different across sessions with different order of presentation of the products.

Moreover, the market share of IPM tomatoes averaged over all rounds was equal with summer and autumn prices (33%). However, given that the price premium for organic tomatoes is lower in summer, the market share of organic tomatoes is higher in sessions with summer prices (39% vs 33% in autumn), at the expense of conventional tomatoes (28% vs 35% in autumn).

Last, the price elasticity mechanism has an impact only in the first round. In round 1, in the sessions with the mechanism, participants purchased significantly less conventional tomatoes and significantly more IPM tomatoes (at the 1% level), while the quantities of organic tomatoes purchased are the same with and without the mechanism. But in other rounds, no significant differences were observed between the quantities of conventional, IPM and organic tomatoes bought by the participants of the sessions with and without the mechanism. Moreover, the 70% threshold for the market share of organic or IPM tomatoes necessary to trigger the price elasticity mechanism was never reached in any of the rounds or sessions. This suggests that informing participants that their choices will impact future prices had a low impact, at least not sufficient to reduce future prices.

Given these results of mostly non-significant impact of the between-subject variables, data of all sessions were pooled (with the different order of presentation of the products, with autumn and summer prices, and with and without price-elasticity mechanism). We systematically verified that similar conclusions were reached when analysing the data separately in the different sessions. Market shares in the different rounds for all ten sessions are presented in Figure 1. The differences across rounds are measured by comparing the quantities purchased of each type of tomatoes by each participant in the different rounds.

Figure 1: Market share of IPM and organic and conventional tomatoes by round (n=189, all 10 sessions)



Note: $\Delta_{t-t'}^{ns}$ denotes non-significant difference, $\Delta_{t-t'}^{*}$ denotes significant difference at 10%, $\Delta_{t-t'}^{**}$ denotes significant difference at 5% and $\Delta_{t-t'}^{***}$ denotes significant difference at 1% as tested by the Wilcoxon test for comparing paired sample choices Q_{ij}^{t} and $Q_{ij}^{t'}$, with Q_{ij}^{t} the quantity of tomatoes of type *j* chosen by participant *i* in round *t*. The white triangles correspond to the measure of the impact of prices, while black triangles correspond to the impact of the shelf space dedicated to IPM.

Impact of relative prices on market shares

The market share for conventional tomatoes significantly increases between rounds 2 and 3 (from 29 to 55%), when IPM and organic tomatoes become relatively more expansive compared to conventional tomatoes (Figure 1). This substitution impacts more the organic market (30% in round 2 to 15% in round 3) than the IPM market (41% to 31%). This is explained by the fact that there is a larger price difference between IPM and organic tomatoes in round 3 than round 2. Between rounds 3 and 4, organic tomatoes win market share at the expense of IPM tomatoes (with the market share of conventional tomatoes remaining stable). IPM market share drops from

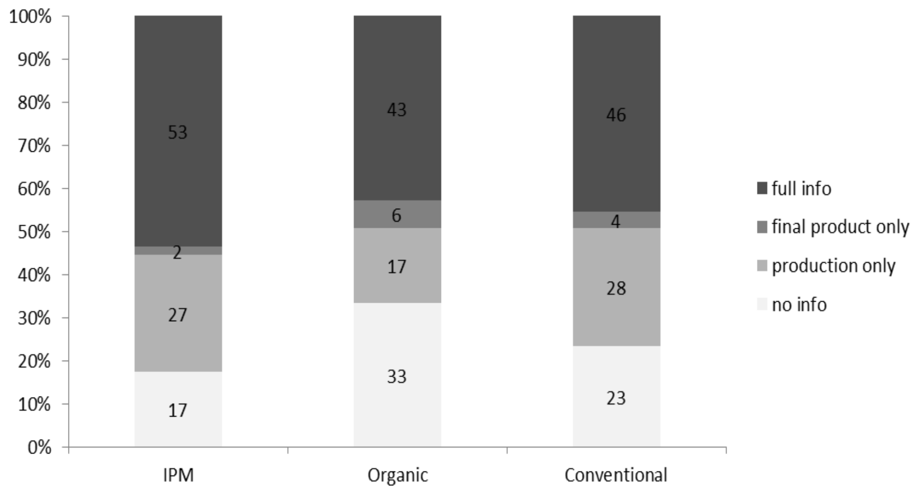
31% to 14% and the quantities of IPM tomatoes purchased are significantly lower, due to the smaller price difference between organic and IPM tomatoes in round 4 than in round 3. The same result is observed in rounds 5 and 6, 7 and 8 and 9 and 10.

Impact of information on market shares

Most of the participants exhibited interest in getting more information about the products. In the last round before full disclosure of the information to all participants (round 6), only 23% of the participants did not read any information on conventional production system, 17% on IPM and 33% on organic farming (

Figure 2). Participants were clearly less interested in information on organic farming, which was expected given the overall good knowledge of organic agriculture in the general public. This also suggests that participants are curious and willing to learn about unknown production systems such as IPM. Among the participants looking for information, most of them have showed interest in both level of information (on the production system and the characteristics of the final product in terms of residues). Only a small percentage of participants only looked at the information on the residues without reading the information on production.

Figure 2: Level of information of participants before full disclosure of the information to all participants (round 6)



In order to measure the impact of information on consumption choices, we separated the sample into two groups: participants who chose to access information on the IPM production system were classified as "Info" and those who did not look at the information on IPM as "NoInfo".[8] Participants who received information on IPM in round 4 but did not read any extra information on the residue levels in IPM tomatoes are classified as "NoInfo" in rounds 5 and 6. The two participants who were not interested in the information on the production systems, but did read the information on the residue levels, were classified as "NoInfo" in rounds 2 to 4, but as "Info" in rounds 5 and 6. Figure 3 represents the market shares of IPM, organic and conventional tomatoes by round, separately for those participants informed and not informed about IPM.

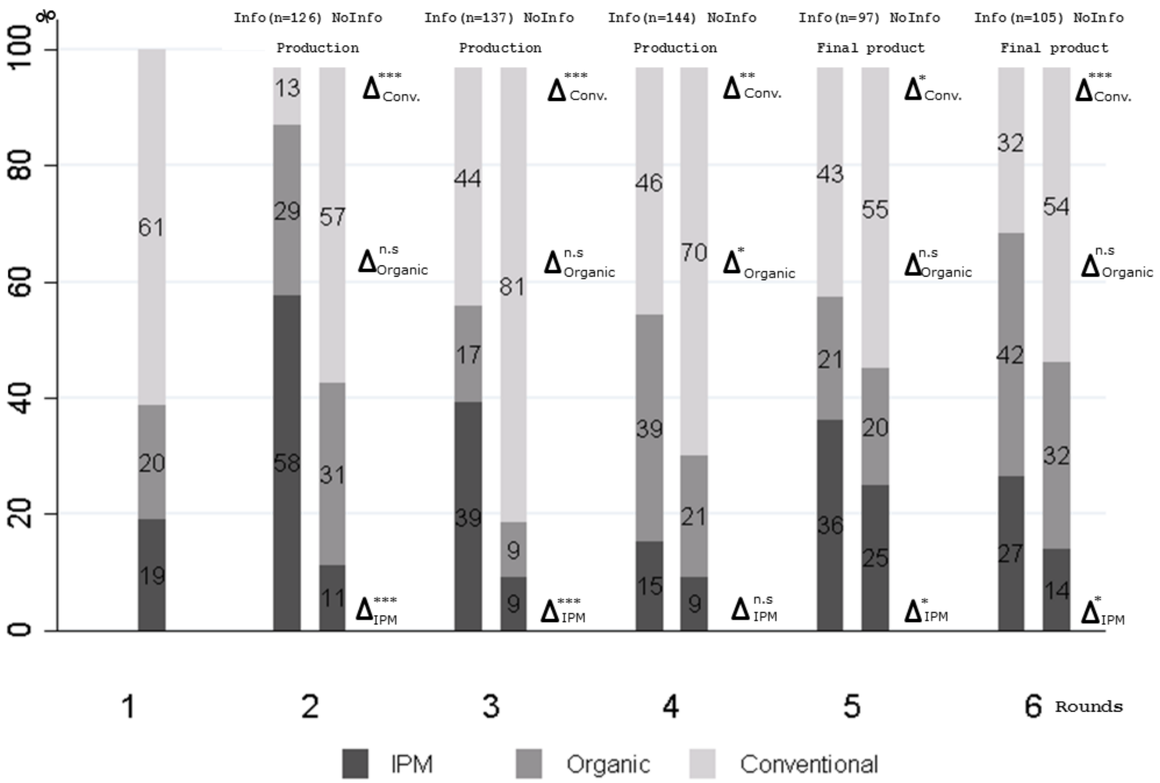
In round 1, in the absence of any information on the different tomatoes, the market share of conventional tomatoes was highest (61%), corresponding to shelf-space dedicated to them (3/5). Moreover, even if organic tomatoes were the most expensive, the market share of organic tomatoes was slightly higher than that of IPM tomato. A strong and positive impact of the information on the production system disclosed in round 2 was observed. Indeed, in round 2, the market share of IPM was significantly higher for participants informed on the IPM production system. Informed participants bought significantly more IPM tomatoes and significantly less conventional tomatoes. The same result held with another price list in round 3. But when the difference between the prices of organic and IPM tomatoes was low (round 4), the impact of being informed on IPM on the quantities of IPM tomatoes purchased was not significant. Rather, some of the informed participants switched to organic tomatoes, probably due to the low price difference.

When extra information on the characteristics of IPM product in terms of residues was available, the informed participants bought significantly more IPM tomatoes than those non-informed (rounds 5 and 6). However, comparing choices across rounds with the Wilcoxon test (paired sample), we observe that, for the informed participants, the quantities of IPM tomatoes bought did not significantly increase in round 5 compared to round 3 (p-value=0.51) and round 6 compared to round 4 (p-value=0.10). It suggested that the extra information on the residues

[8] We have verified results are similar if we use two alternative criteria to define the informed consumers: i) informed participants are those having read the information for the three types of tomatoes, while the non-informed are those who did not read all the information; ii) informed participants are those having read information on at least one of the production systems and non-informed are those who did not look at any information). Given that the paper focuses on how to communicate on IPM, we decided to present results relative to being informed or not about IPM.

levels had only a limited impact in convincing new consumers to switch to IPM, given that some of the consumers had already switched as a result of the information on the production system.

Figure 3: Market share of IPM, organic and conventional tomatoes by round and level of information



Note: Δ^{ns} denotes non-significant difference, Δ^{*} denotes significant difference at 10%, Δ^{**} denotes significant difference at 5% and Δ^{***} denotes significant difference at 1% as tested by the Mann–Whitney two-sample test comparing the distribution of the quantities of tomatoes of each type chosen by the sample of informed participants and the sample of non-informed participants. The size of the sample of informed participants is indicated in parenthesis (n=).

Impact of the shelf space dedicated to IPM on market shared

The reduction in the shelf space dedicated to conventional tomatoes after round 6 had a significant impact on the quantities of IPM and organic tomatoes bought (Figure 1, black triangles). More precisely, in terms of market shares, it benefited equally organic and IPM tomatoes. The market share of organic rose from 21% in round 5 to 33% in round 7 and from 37% in round 6 to 55% in round 8, and for IPM it rose from 30% in round 5 to 47% in round 7 and from 21% in round 6 to 29% in round 8. When conventional tomatoes totally disappeared from the market after round 8, it benefited more IPM than organic when the price difference between organic and IPM was large (round 9). The market share rose from 47% in round 7 to 61% in round 9 for IPM and from 33% in round 7 to 39% in round 9 for organic. However, when the price premium for organic is low (round 10), even if organic tomatoes are more expensive than IPM tomatoes, the suppression of conventional tomatoes benefited mostly the organic market (from 55% in round 8 to 72% in round 10).

In order to better understand how these different factors interact to impact consumers' decisions, we analysed individual choices between the different tomatoes with an econometric model.

2. *Econometric analysis*

We present the estimates from the multinomial probit model of the determinants of consumer choice of tomatoes in Table 4 and the marginal effects in Table 5. The interpretations are made on the marginal effects results. The model fits is satisfactory, with a log simulated-pseudolikelihood of -1621.6441.

We have tested that IIA is violated. Under the IIA assumption, we would expect no systematic change in the coefficients if we excluded one of the alternatives from the model. We reestimate the parameters, excluding the conventional alternative, and perform a Hausman test against the fully efficient full model. We find that we can reject the null hypothesis of no systematic differences in coefficients (chi2=11789.56; Prob>chi2 = 0.0000).

First, we confirm results from non-parametric tests on the non-significant impact of between-subject design variables. The variables PEM and autumn are not significant, suggesting that preferences are not impacted by the price elasticity mechanism and the autumn prices. But we observe that the probability to choose conventional tomatoes rather than IPM can be impacted by the order of presentation of products in the first rounds, suggesting that it is important to control for this order in the estimation.

Female consumers are 9% more likely to consume IPM tomatoes, but gender differences are not significant for conventional and organic consumption. Age has a significant negative influence on IPM and positive influence on organic consumption, but the effect is small. The usual price paid for tomatoes has no significant influence on any of the choices. Frequent consumption of organic products has, however, an impact on choices in the experiment: it significantly increases the probability to choose organic and reduces the probability to choose conventional tomatoes. This confirms that laboratory tests are not so disconnected from a real purchase situation. The non-significant impact on IPM choice seems to suggest that both organic consumers and non-organic consumers are interested in IPM in the experiment.

The price, shelf space and information coefficients are almost all significant, which confirms that the tested attributes influenced consumers' choices. As expected, the price has a negative influence and the shelf space dedicated to a product has a positive influence on the probability to select an alternative.

Concerning the impact of prices, increasing the price of conventional tomatoes by 10 Euro cents per kilogram decreases conventional tomato consumption choice by 2% percentage points, and correspondingly increases by 1.1 and 0.9 percentage points respectively the consumption of IPM and organic tomatoes. Interestingly, reducing the price of IPM by 10 Euro cents significantly increased consumption of IPM (5.3 percentage points), mostly at the expense of organic consumption which decreased by 4.2 percentage points, while conventional tomatoes consumption decreased only by 1 percentage point. Symmetrically, increasing the price of organic tomatoes by 10 Euro cents benefits mostly to IPM.

A similar pattern is observed for the impact of shelf space dedicated to each type of tomatoes. Our results indicated that increasing shelf space dedicated to IPM by 10 percent would lead to a 21.4 percentage points increase in IPM consumption, and significantly reduce conventional tomatoes consumption by 4.5, and organic by 16.9 percentage points, respectively. Similarly, a 10 percent reduction in the shelf space for conventional tomatoes reduced conventional consumption by 7.8 percentage points, whilst significantly increasing IPM and organic consumption by 4.4 percentage points and 3.4 percentage points, respectively.

We also observed a significant positive impact of information on consumption. Consumers informed on a production system are significantly more likely to buy the tomatoes corresponding to this production system and less likely to consume other tomatoes. Overall, information had a larger impact for IPM and organic than conventional tomatoes. One could have expected a negative impact of being informed on conventional production on the probability to choose conventional tomatoes, but we did not observe such an effect. The impact of the information on the final characteristics of the product, in terms of residue levels, was lower and significant only at the 10% level for IPM. Everything else equal, being informed on IPM production system increased the probability to choose IPM tomatoes by 18.2 percentage points, but mostly at the expense of organic tomatoes since conventional consumption reduces less than organic consumption (respectively 3.6 and 14.6 percentage points). Symmetrically, being informed on organic increased the probability to choose organic tomatoes, but mostly at the expense of IPM tomatoes.

Table 3: coding of the variables

Variable	Definition
p	Price of the tomatoes
sh	Shelf space dedicated to the product
info1	=1 if the participant is informed on the production system of the product
info2	=1 if the participant is also informed on the characteristics of the final products in terms of residues
Gender	= 1 if the participant is a female
age	In years
kgweek_nov	Weekly consumption of tomatoes in November
usualprice	Price usually paid by the participant for tomatoes
halforganic	=1 if more than half of the usual tomatoes consumption of the participant is organic
autumn	=1 for sessions with autumn prices (see annex C)
PEM	=1 for sessions with the price elasticity mechanism
order_CICOC	=1 if the order of presentation of the products in the first rounds is Conventional-IPM-conventional-Organic-Conventional
order_CCIOC	=1 if the order of presentation of the products in the first rounds is Conventional- Conventional-IPM-Organic- Conventional
order_ICCOC	=1 if the order of presentation of the products in the first rounds is IPM-Conventional- Conventional-Organic-Conventional
order_COCIC	=1 if the order of presentation of the products in the first rounds is Conventional-Organic-Conventional-IPM-Conventional
order_CCCOI	=1 if the order of presentation of the products in the first rounds is Conventional- Conventional- Conventional-Organic-IPM

Table 4: Alternative-specific multinomial probit – estimates

VARIABLES		Conventional/IPM	Organic/IPM
female		-0.264	-0.109
		(0.189)	(0.0759)
age		0.00211	0.00451**
		(0.00634)	(0.00227)
kgweek_nov		-0.0577	-0.0362
		(0.0643)	(0.0246)
usualprice		-0.176	0.0468
		(0.140)	(0.0466)
halforganic		-0.894***	0.384**
		(0.249)	(0.149)
autumn		-0.417	0.0117
		(0.324)	(0.0928)
PEM		-0.106	0.00999
		(0.182)	(0.0589)
order_CICOC		0.697**	-0.124
		(0.283)	(0.103)
order_CCIOC		0.788***	-0.0873
		(0.278)	(0.109)
order_ICCOC		-0.0995	-0.0223
		(0.320)	(0.0886)
p	-0.773***		
	(0.222)		
sh	0.0313***		
	(0.00318)		
i1	0.284**		
	(0.139)		
i2	0.162		
	(0.105)		
Constant		-1.140**	0.0818
		(0.454)	(0.151)
Θ_{23}	0.0049		
Θ_{33}	0.2161		
Observations	5,292		
Log simulated-pseudolikelihood	-1621.6441		
Wald chi2(24)	152.30		
Prob > chi2	0.0000		

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Std. Err. adjusted for 189 clusters in id

order_COCIC and order_CCCOI dropped because of collinearity

Table 5: Alternative-specific multinomial probit –marginal effects at means

	Pr (choice = IPM) = 0.339			**Pr (choice = conventional) = 0.327**			**Pr (choice = organic) = 0.333**		
	dp/dx	Std. Err.	P>z	dp/dx	Std. Err.	P>z	dp/dx	Std. Err.	P>z
Alternative-specific attributes									
Price									
IPM	**-.527555**	.061658	0.000	**.109985**	.034965	0.002	**.417548**	.065191	0.000
Conventional	.109984	.034965	0.002	-.194654	.055738	0.000	.08468	.023408	0.000
Organic	.417571	.065198	0.000	.084669	.023404	0.000	-.502228	.05986	0.000
Shelf-space									
IPM	**.021388**	.00632	0.001	**-.004459**	.000579	0.000	**-.016928**	.006325	0.007
Conventional	-.004459	.000579	0.000	.007891	.000708	0.000	-.003433	.000431	0.000
Organic	-.016929	.006325	0.007	-.003433	.000431	0.000	.020361	.006431	0.002
Info1									
IPM	**.182329**	.054055	0.001	**-.035892**	.018718	0.055	**-.146433**	.060989	0.016
Conventional	-.03988	.019504	0.041	.070359	.031676	0.026	-.030483	.012805	0.017
Organic	-.148765	.059591	0.013	-.028369	.012877	0.028	.177129	.054944	0.001
Info2									
IPM	.109754	.066221	0.097	-.022925	.014727	0.120	-.086825	.059681	0.146
Conventional	-.023104	.014939	0.122	.040952	.026062	0.116	-.01785	.011395	0.117
Organic	-.086891	.059751	0.146	-.017723	.011214	0.114	.104611	.065399	0.110
Case-specific variables									
female*	.094317	.043828	0.031	-.05466	.049703	0.271	-.039652	.053753	0.461
age	-.002739	.001336	0.040	.000037	.001644	0.982	.002702	.001587	0.089
kgweek_nov	.027751	.01397	0.047	-.010557	.016475	0.522	-.017193	.015528	0.268
usualprice	-.000233	.026701	0.993	-.049427	.036859	0.180	.049662	.035303	0.160
halforganic*	-.115096	.091202	0.207	-.242676	.04975	0.000	.35778	.11485	0.002
autumn*	.05376	.062592	0.390	-.107564	.084508	0.203	.053809	.072115	0.456
PEM*	.009733	.039131	0.804	-.027877	.046961	0.553	.018145	.045294	0.689
order_CICOC*	-.047241	.061979	0.446	.197386	.078104	0.011	-.150151	.065626	0.022
order_CCIOC*	-.078339	.056984	0.169	.218167	.076656	0.004	-.139836	.065001	0.031
order_ICCOC*	.026384	.065881	0.689	-.022458	.080012	0.779	-.003924	.068435	0.954

(*) dp/dx is for discrete change of indicator variable from 0 to 1

IV. Discussion

Results from the multinomial probit allow comparing three leviers to foster IPM consumption. First, increasing by 10% the shelf space dedicated to IPM can increase IPM consumption by 21.4 percentage points. Second, increasing the share of consumers informed on IPM production guidelines can increase consumption by 18.2 percentage points. Last but not least, reducing the price of IPM can foster consumption (+5.2% percentage points for a 10 Euro cents reduction). In the absence of any information on the cost of implementing such actions, it is not possible to compare what is the most cost-efficient levier. Nevertheless, our results suggest that they are all likely to modify consumption patterns.

We observed that consumers' preferences for IPM tomatoes are strongly impacted by the price difference with organic counterparts. The market share of IPM drops when the price difference between IPM and organic is reduced. Moreover, when conventional tomatoes are withdrawn from shelves, we observe that IPM wins market shares only if the price difference with organic tomatoes is sufficiently high (at least 60 cents per kg). Results of the multinomial probit also suggest that if prices of conventional tomatoes increase (for example due to a tax on chemical input use), conventional tomatoes consumption will decrease, but it will benefit slightly more to organic than IPM consumption. Only a significant reduction in the price of IPM tomatoes compared to organic ones can foster IPM consumption. Moreover, we observed that increasing the shelf space dedicated to IPM leads to an increase in IPM consumption, mostly at the expense of organic tomatoes. The substitutability of IPM and organic tomatoes was also visible through the impact of information since being informed on IPM increased the probability to choose IPM tomatoes, mostly at the expense of organic tomatoes, and vice-versa.

Taken together, the above results indicate that strong substitution opportunities exist between IPM and organic tomatoes, while substitution with conventional tomatoes is more limited. This somehow contrasts results of previous research which showed that IPM was perceived by consumers as a third way, but closer to conventional than organic. Marette et al. (2012) found that the average WTP for apples with a "few pesticides" label was closer to the WTP for conventional apples than the WTP for organic apples. Bazoche et al. (2013) found that, compared with the regular product, the average premium for IPM certification is 24.5 per cent, while it is equal to 50.5 per cent for organic certification.

Given the low knowledge and recognition of IPM in the general public, understanding how to communicate about IPM to the end-consumers appears to be a crucial element to make sure IPM will be seen as profitable by producers. We observed in our experiment that consumers are more interested in information on IPM than on conventional and organic farming. They show interest in both the information on the production system and the characteristics of the final product. We have found that consumers increase their consumption of IPM products when they get access to information on this production system. This suggests that retailers could start communicating to the end-consumer on IPM, rather than limiting IPM as a market-access tool.

However, while residues control is a rapidly growing component of private standards and supermarket communication to consumers, we observed that providing extra information on the residue levels to consumers, in addition to the information on the production system, does not further influence consumers' choices. This suggests that for those consumers not reacting to the information on the production systems, extra information on residue levels does not modify neither their purchase habits. It confirms that only some individuals are responsive to information campaigns and changing the content of the information does not allow reaching other population segments. A further interpretation could be that consumers are not yet ready for messages highlighting the complex and uncertain links between actions (pesticide use) and results (pesticide residues in food). We know from the scientific literature that some of the applied pesticides find their way as residue in food, but their residual quantity differs according to the type of pesticides, the type of products and the production system (Bakery et al. 2002). In the coming years, it will be interesting to confront these results with the analysis of retailers marketing and communication strategies on IPM, in particular with reaction to the new EU legislation.

Another important result concerns the non-significant impact of informing consumers that their consumption choices today impact future prices of IPM and organic tomatoes. It suggests that the option to educate consumers on the impact of their consumption choices on future prices is not efficient. One explanation could be that participants' incentives to contribute to price reduction are reduced in an inter-temporal setting like the one of this experiment (where only the participants of future sessions benefit from the price reduction). We know that inter-temporal settings create anonymity of contributions, and previous research has shown that anonymity reduces voluntary contributions to a public good (Andreoni and Petrie 2004; Rege and Telle 2004; Alpizar, Carlsson, and Johansson-Stenman 2008). Moreover, while other researchers have found that the inter-temporal setting can favour the idealistic/non-purely economic motives, and therefore the contribution to the public good (Grolleau, Sutan, and Vranceanu 2013)such drivers may be difficult to activate here given that the benefits are a reduction in prices, i.e. something very associated to economic motives.

Last, but not least, with the multivariate probit model, we found a strong correlation between consumers' choices of tomatoes and tomato attributes such as price, dedicated shelf space, and availability of information. However, the characteristics of the consumers appear far less relevant to explain choices in the experiment. One may argue that individual characteristics are not significant because there is high heterogeneity in the sample.

V. Conclusion

This paper has analysed consumers' choices between Integrated Pest Management, conventional and organic tomatoes. We have conducted a real choice experiment with 189 French consumers, selected from a sample of ordinary food shoppers. In each of the ten rounds of the experiment, participants could choose to buy fresh tomatoes, indicating the type of tomatoes (conventional, IPM or organic) and quantity they wanted. The experiment was designed to analyse how IPM consumption would be influenced by a reduced availability of conventional products and an increase in the shelf space dedicated to IPM products following the change in the European legislation on crop protection. Furthermore, we also studied the impact of providing extra-information to the consumers on the pesticide residues in tomatoes, in addition to the information on the different production systems and crop protection strategies.

Results indicate the existence of strong substitution opportunities between IPM and organic tomatoes, whilst substitution with conventional tomatoes appears more limited. Experimental results also indicate that the withdrawal of conventional tomatoes from shelves due to the implementation of the Sustainable Use of pesticides Directive could benefit organic rather than IPM sales if the price difference between organic and IPM is low, even if organic produces are more expensive. Only a significant reduction in the price of IPM tomatoes, compared to organic and/or an important increase in the shelf space dedicated to IPM, would appear to increase IPM sales. However, raising awareness on the impact of consumption choices on future prices of the product has only a limited impact in this context. Results also provided an insight into the nature and extent of information for communication to consumers to increase their understanding of IPM. While information on IPM guidelines increases IPM products purchases, providing extra information on residue levels in IPM tomatoes has no further impact on consumers' choices.

Given the importance of the relative prices to trigger a change in consumption pattern in favour of IPM products, our results call for further research on the impact of IPM adoption on production costs. Overall, there is a lack of quantitative evidence on the potential of Integrated Pest Management to increase economic sustainability relative to non-IPM strategies under region- and crop-specific growing conditions. Indeed, data on the economic costs of IPM solutions are scarce, and even more so with consideration of the European context (Lefebvre, Langrell, and Gomez-y-Paloma 2014). None of the existing studies (Vasileiadis et al. 2011; Pelzer et al. 2012; Mouron et al. 2012) focuses on tomatoes production. More information on IPM production costs in the long run will further help to guide producers' and retailers' pricing decisions in the new context.

Acknowledgments and disclaimer:

The survey on which this paper is based was funded by the IPTS, JRC-European Commission in the context of the project "Consumers' willingness to pay for Integrated Production: experimental design and data collection", PO 153580. However, the views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission. Marianne Lefebvre acknowledges funding from Agropolis Fondation and the French National Research Agency (program ''Investissements d'avenir'' ANR-10-LABX-0001-01, Project ''CAP-eye''). The authors would like to thank the partners of the FP7-PURE project for supporting the initial idea. We would especially like to thank Christine Poncet (INRA) for contributing to the elaboration of the information on the different types of tomatoes disclosed to participants.

References

Aertsens, J., W. Verbeke, K. Mondelaers, and G. Van Huylenbroeck. 2009. "Personal Determinants of Organic Food Consumption: A Review." Edited by G. van Huylenbroek. *British Food Journal* 111 (10): 1140–67.

Alfnes, F., A. G. Guttormsen, G. Steine, and K. Kolstad. 2006. "Consumers' Willingness to Pay for the Color of Salmon: A Choice Experiment with Real Economic Incentives." *Americal Journal of Agricultural Economics* 88 (4): 1050–61.

Ali Bashir, K. 2012. "Determinants of Willingness-to-Pay a Premium for Organically Produced Tomatoes in Riyadh City, Kingdom of Saudi Arabia (KSA)." *African Journal of Agricultural Research* 7 (43): 5726–33.

Alphonce, Roselyne, and Frode Alfnes. 2015. "Eliciting Consumer WTP for Food Characteristics in a Developing Context: Comparison of Four Methods in a Field Experiment." *Working Paper Series*, March. School of Economics and Business, Norwegian University of Life Sciences.

Alpizar, F, F Carlsson, and O Johansson-Stenman. 2008. "Anonymity, Reciprocity, and Conformity: Evidence from Voluntary Contributions to a National Park in Costa Rica." *Journal of Public Economics* 92 (5-6): 1047–60.

Alvarez, R. Michael, Jonathan Nagler, and Shaun Bowler. 2000. "Issues, Economics, and the Dynamics of Multiparty Elections: The British 1987 General Election." *The American Political Science Review* 94 (1). Cambridge University Press: 131.

Andreoni, J, and R Petrie. 2004. "Public Goods Experiments without Confidentiality: A Glimpse into Fundraising." *Journal of Public Economics* 88 (7-8): 1605–23.

Aubertot, J N, J M Barbier, A Carpentier, J J Gril, L Guichard, P Lucas, S Savary, I Savini, and M Voltz. 2005. *Pesticides, Agriculture et Environnement: Réduire L'utilisation Des Pesticides et En Limiter Les Impacts Environnementaux*. Edited by Rapport d'Expertise scientifique collective INRA et Cemagref. France.

Bazoche, P, F Bunte, P Combris, E Giraud-Héraud, A Seabra-Pinto, and E Tsakiridou. 2013. “Willingness to Pay for Pesticides’reduction in EU: Nothing but Organic?” *European Review of Agricultural Economics* 41 (1): 87–109.

Becker, G M, M H DeGroot, and J Marschak. 1964. “Measuring Utility by a Single-Response Sequential Method.” *Behavioral Science* 9 (3): 226–32.

Boxall, Peter, W. L. (Vic) Adamowicz, and Amanda Moon. 2009. “Complexity in Choice Experiments: Choice of the Status Quo Alternative and Implications for Welfare Measurement.” *Australian Journal of Agricultural and Resource Economics* 53 (4): 503–19.

Canali, G. 2011. “The Role of the ‘Integrated Production’ Scheme in the Fruit and Vegetable CMO.” In *The Common Agricultural Policy after the Fischler Reform*, edited by A Sorrentino, R Henke, and S Severini, 417–30. Farnham, England: Ashgate.

Carlsson, F., P. Frykblom, and C. J. Lagerkvist. 2007. “Consumer Willingness to Pay for Farm Animal Welfare: Mobile Abattoirs versus Transportation to Slaughter.” *European Review of Agricultural Economics* 34 (3): 321–44.

Carson, Richard T., Jordan J. Louviere, Donald A. Anderson, Phipps Arabie, David S. Bunch, David A. Hensher, Richard M. Johnson, et al. 1994. “Experimental Analysis of Choice.” *Marketing Letters* 5 (4): 351–67.

Chatfield, M, and A Mander. 2009. “The Skillings–Mack Test (Friedman Test When There Are Missing Data).” *The Stata Journal* 9 (2): 299–305.

ENDURE. 2010. *The Potential Role of Supermarket Procurement Strategies as Drivers of IPM*. Edited by ENDURE Policy Brief. Vol. 2.

EU. 2009. “Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 Establishing a Framework for Community Action to Achieve the Sustainable Use of Pesticides.” http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:309:0071:0086:en:PDF.

Fischbacher, U. 2007. “ Z-Tree: Zurich Toolbox for Ready-Made Economic Experiments.” *Experimental Economics* 10 (2): 171–78.

Florax, R, C M Travisi, and P Nijkamp. 2005. "A Meta-Analysis of the Willingness to Pay for Reductions in Pesticide Risk Exposure." *European Review of Agricultural Economics* 32 (4): 441–67.

Ginon, Emilie, Gastón Ares, L H Esteves dos Santos Laboissière, Joëlle Brouard, Sylvie Issanchou, and Rosires Deliza. 2014. "Logos Indicating Environmental Sustainability in Wine Production: An Exploratory Study on How Do Burgundy Wine Consumers Perceive Them." *Food Research International* 62: 837–45.

Ginon, Emilie, C. Chabanet, P. Combris, and S. Issanchou. 2014. "Are Decisions in a Real Choice Experiment Consistent with Reservation Prices Elicited with BDM 'auction'? The Case of French Baguettes." *Food Quality and Preference* 31: 173–80.

Glasgow, G. 2001. "Mixed Logit Models for Multiparty Elections." *Political Analysis* 9 (2): 116–36.

Grolleau, G, A Sutan, and R Vranceanu. 2013. "Taking the Well-Being of Future Generations Seriously: Do People Contribute More to Intra-Temporal or Inter-Temporal Public Goods?" *ESSEC Working Paper 1313*.

Hasund, Knut Per, Mitesh Kataria, and Carl Johan Lagerkvist. 2011. "Valuing Public Goods of the Agricultural Landscape: A Choice Experiment Using Reference Points to Capture Observable Heterogeneity." *Journal of Environmental Planning and Management* 54 (1). Routledge: 31–53.

Hensher, David A. 2010. "Hypothetical Bias, Choice Experiments and Willingness to Pay." *Transportation Research Part B: Methodological* 44 (6). Elsevier: 735–52.

Hu, W, M Veeman, W Adamowicz, and G Gao. 2006. "Consumers' Food Choices with Voluntary Access to Genetic Modification Information." *Canadian Journal of Agricultural Economics* 54 (4): 585–604.

Jumbe, Charles B.L., and Arild Angelsen. 2011. "Modeling Choice of Fuelwood Source among Rural Households in Malawi: A Multinomial Probit Analysis." *Energy Economics* 33 (5): 732–38.

Kallas, Zein, Cristina Escobar, and José Maria Gil. 2012. “Assessing the Impact of a Christmas Advertisement Campaign on Catalan Wine Preference Using Choice Experiments.” *Appetite* 58 (1): 285–98.

Lefebvre, Marianne, Stephen R. H. Langrell, and Sergio Gomez-y-Paloma. 2014. “Incentives and Policies for Integrated Pest Management in Europe: A Review.” *Agronomy for Sustainable Development*.

Lusk, J. L., and T. C. Schroeder. 2004. “Are Choice Experiments Incentive Compatible? A Test with Quality Differentiated Beef Steaks.” *American Journal of Agricultural Economics* 86 (2): 467–82.

Marette, S, A Messéan, and G Millet. 2012. “Consumers’ Willingness to Pay for Eco-Friendly Apples under Different Labels: Evidences from a Lab Experiment.” *Food Policy* 37: 151–61.

Mesías Díaz, F J, F Martínez-Carrasco Pleite, J-M. Martínez Paz, and P Gaspar García. 2012. “Consumer Knowledge, Consumption, and Willingness to Pay for Organic Tomatoes.” *British Food Journal* 114 (3): 318–34.

Michaud, C., D. Llerena, and I. Joly. 2012. “Willingness to Pay for Environmental Attributes of Non-Food Agricultural Products: A Real Choice Experiment.” *European Review of Agricultural Economics* 40 (2): 313–29.

Miettinen, A, R Hietala-Koivu, and H Lehtonen. 2004. “On Diversity Effects of Alternative Agricultural Policy Reforms in Finland: An Agricultural Sector Modelling Approach.” *Agricultural and Food Science* 13: 229–46.

Morris, C, and M Winter. 1999. “Integrated Farming Systems: The Third Way for European Agriculture?” *Land Use Policy* 16 (4): 193–205.

Mouron, Patrik, Bart Heijne, Andreas Naef, Jörn Strassemeyer, Frank Hayer, Jesus Avilla, Aude Alaphilippe, et al. 2012. “Sustainability Assessment of Crop Protection Systems: SustainOS Methodology and Its Application for Apple Orchards.” *Agricultural Systems* 113 (0): 1–15.

Pelzer, Elise, Gabriele Fortino, Christian Bockstaller, Frédérique Angevin, Claire Lamine, Camilla Moonen, Vasileios Vasileiadis, et al. 2012. “Assessing Innovative Cropping

Systems with DEXiPM, a Qualitative Multi-Criteria Assessment Tool Derived from DEXi." *Ecological Indicators* 18 (0): 171–82.

Rege, M, and K Telle. 2004. "The Impact of Social Approval and Framing on Cooperation in Public Good Situations." *Journal of Public Economics* 88 (7-8): 1625–44.

Rigby, D., F. Alcon, and M. Burton. 2010. "Supply Uncertainty and the Economic Value of Irrigation Water." *European Review of Agricultural Economics* 37 (1): 97–117.

Train, K E. 2009. *Discrete Choice Methods with Simulation*. 2nd ed. Cambridge University Press.

Van der Velden, N, R Suay, A Urbaneja, M Giorgini, M Ruoco, C Poncet, and A Lefèvre. 2012. *Recent Developments and Market Opportunities for IPM in Greenhouse Tomatoes in Southern Europe: Consequences for Advanced IPM Toolboxes and Greenhouse Engineering . Internal Deliverable FP7 PURE*.

Vasileiadis, V P, M Sattin, S Otto, A Veres, Z Pálinkás, R Ban, X Pons, et al. 2011. "Crop Protection in European Maize-Based Cropping Systems: Current Practices and Recommendations for Innovative Integrated Pest Management." *Agricultural Systems* 104 (7): 533–40. doi:10.1016/j.agsy.2011.04.002.

Vickrey, William. 1961. "COUNTERSPECULATION, AUCTIONS, AND COMPETITIVE SEALED TENDERS." *The Journal of Finance* 16 (1): 8–37.

Weaver, R D, D J Evans, and A E Luloff. 1992. "Pesticide Use in Tomato Production: Consumer Concerns and Willingness-to-Pay." *Agribusiness* 8 (2): 131–42.

Wibberley, J. 1995. "Cropping Intensity and Farming Systems: Integrity and Intensity in International Perspective." *Journal of the Royal Agricultural Society of England* 156: 43–55.

Wier, M., and C. Calverley. 2002. "Market Potential for Organic Foods in Europe,." *British Food Journal* 104 (1): 45–62.

Yiridoe, E.K., S. Bonti-Ankomah, Martin, and R.C. 2002. "Comparison of Consumer Perceptions and Preference toward Organic versus Conventionally Produced Foods: A

Review and Update of the Literature." *Renewable Agriculture and Food Systems* 20 (4): 193–205.

Yue, C, F Alfnes, and H H Jensen. 2009. "Discounting Spotted Apples: Investigating Consumers' Willingness to Accept Cosmetic Damage in an Organic Product." *Journal of Agricultural and Applied Economics* 41 (1): 29–46.

Annex A: Information available to participants upon request (translated from French by the authors)

More information on the production system (available only from round 2)	Generic information on production system (displayed for Conventional, IPM and Organic)	Crop protection has a key role in agriculture since it protects crops from weeds, diseases and pest which are major causes of yield losses. Many crop protection methods exist (chemical pesticides, choice of crop varieties, soil management, use of beneficial insects…) and are used according to the crop protection strategy chosen by the farmer.
	Conventional	In conventional farming, chemical pesticides are used systematically and routinely for crop protection. It is the kind of crop protection which dominated the 20th century and which accounts for most farming today. Tomatoes from conventional farming receive on average 30-35 spraying during the growing season (average for soil-less tomatoes, which represent most of tomatoes production in conventional agriculture)
	IPM	Integrated Pest Management can be considered as a third-way between conventional and organic crop protection strategies: the use of chemical pesticides is not prohibited but limited, thanks to a more efficient and targeted spraying and to the use of other methods (physical protection, organic protection, cultural practices …). Many tomatoes are produced nowadays with integrated pest management but the information is rarely disclosed in supermarkets. Spraying of tomatoes is reduced to less than 5 per growing season with integrated pest management. This is less than in conventional farming but more than in organic (average for soil-less tomatoes, which represent a large majority of the tomatoes produced with integrated pest management).
	Organic	The specifications for organic farming totally prohibit the use of chemical pesticides. All organic tomatoes are soil- grown and with no chemical pesticides, contrarily to crop protection strategies used in conventional farming and integrated pest management.
More information on the characteristics of	Generic information on pesticide residues	Pesticides tend to stay in fruits and vegetables, even after washing or peeling them. In order to protect consumers' health and promote good practices in

the final product (available from round 5)	(displayed for Conventional, IPM and Organic)	farming, maximum residue levels have been set legally. It aims at avoiding that consumers eat more than the acceptable daily intake of the active substance. Fruits and vegetables with residue levels beyond this limit cannot be sold.
	Conventional	All conventional tomatoes contain less pesticide residues than the maximal limit imposed by regulation.
	IPM	Tomatoes produced according to Integrated Pest Management contain less pesticide residues than the maximal limit imposed by regulation, and, in average, 10 times less pesticides residues than what is observed in tomatoes from conventional production system.
	Organic	Chemical pesticides not being authorized in organic farming, organic tomatoes can be considered as residue-free compare to conventional and IPM tomatoes. However, some studies have revealed that residues can be found in organic tomatoes, since pesticides can have been used in neighbour fields or in the past in the same field.

Annex B: Messages justifying the changes in the shelf space dedicated to IPM (translated from French by the authors)

Disclosed to all participants between rounds 6 and 7	The European Union has decided that from 2014, all farmers will have to use Integrated Pest Management to protect their crops against pests and diseases. Crop protection strategy as currently used in conventional production system will therefore be prohibited from 2014. Since farmers are anticipating this change, we can already observe that the share of conventional tomatoes in total production is diminishing. There is now only one type of conventional tomatoes available, plus on type of IPM and one type of organic tomatoes.
Disclosed to all participants between rounds 8 and 9	Crop protection strategies used in conventional production system will be forbidden starting from 2014. From now, only IPM and organic tomatoes are available.

Annex C: Tomatoes prices

€/Kg		Conventional (round)	Conventional (Large Tomatoes-On-Vine A)	Conventional (Large Tomatoes-On-Vine B)	IPM	Organic	Price difference (Organic-IPM)
Summer (sessions 4,5,9,10)	Reference (rounds 1 and 2)	1.5	1.9	2	2.2	2.6	0.4
	Price list 2 (rounds 3, 5, 7 and 9)	1.1	1.7	1.8	2.4	3	0.6
	Price list 3 (rounds 4, 6, 8 and 10)	1.5	1.6	1.7	2.5	2.6	0.1
Autumn (sessions 1,2,3,6,7,8)	Reference (rounds 1 and 2)	1.5	2	2.2	2.5	3	0.5
	Price list 2 (rounds 3, 5, 7 and 9)	1.1	1.8	2	2.7	3.4	0.7
	Price list 3 (rounds 4, 6, 8 and 10)	1.5	1.6	1.7	2.5	2.6	0.1