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# Knowledge and adoption of organic agriculture: Diffusion over time among Andalusian olive farmers

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# KNOWLEDGE AND ADOPTION OF ORGANIC AGRICULTURE: DIFFUSION OVER TIME AMONG ANDALUSIAN OLIVE FARMERS


## ABSTRACT

The objective is to analyse the diffusion over time process of the knowledge and adoption of a sustainable technological innovation -organic agriculture- in the South of Spain -Andalusia region- and for a crop of paramount importance there -olive- within the framework of the Diffusion of Innovations Theory. Results show that diffusion is essentially due to an autonomous "contagion" among olive growers with a little external intervention. In many regions, particularly in low yield conditions, adoption of organic farming has come to an standstill, demonstrating the need to strengthen or modify the mechanisms of diffusion commonly used up to this time.



*Keywords:* Diffusion of innovations, diffusion over time, organic farming, *Olea Europaea L.*

*JEL Classification Codes*: O31 - Innovation and Invention: Processes and Incentives; Q01 - Sustainable Development; Q16 - R&D, Agricultural Technology, Agricultural Extension Services.


## 1 Introduction

The growing need to *rationalize the use of inputs* in agriculture and to obtain *quality agricultural products* by increasing the level of *productive efficiency*, together with the demand for *greater environmental sustainability* of farming systems by harmonizing *agricultural production* and *environmental protection*, have led to the development and diffusion of alternative forms of farming for several decades. These new agricultural practices aim to reduce the negative impact of certain *external factors* and overcome a series of problems that have given rise to higher costs in economic, technical, sociocultural and environmental terms (Parra López, 2003).

Although its implementation has been gradual, *organic farming* is currently one of the main alternatives to conventional forms of agricultural production. According to the MAPA (Spanish Ministry of Agriculture, Fisheries and Food) (2000), organic farming is one of the fasting growing agricultural sectors in the European Union, with an annual growth rate of 25%. Recent data (FiBL, 2002) indicate that in the year 2001, the total crop surface dedicated to organic farming in the EU was 4,442,876 ha., accounting for 3.24% of the total Utilized Agricultural Area (UAA). In this same year, 2.04% of all farms in the EU were organic.

In Spain, organic farming practices have spread at a much faster pace than in the rest of the EU, especially from 1991 to 2001 when 115 times more surface area was converted to organic farming. By the year 2001, approximately 1.66% of the UAA was dedicated to organic farming in Spain (FiBL, 2002).

Within this context of increasing growth, the development of *organic olive groves* has been particularly remarkable. In Spain, the surface area dedicated to organic olive farming and the number of organic olive growers has grown exponentially to become the first organic crop in terms of surface area, with the exception of "pastureland, meadowland and forage" (MAPA, 2002). Indeed, in the final year of our study, olive groves comprised approximately 17% of the total organic surface in the country.

In spite of the enormous growth in organic olive production in Spain, olives continue to be grown almost exclusively by conventional means. According to recent data from 2001 (MAPA, 2002), only 3.6% of the total olive surface of Spain is organic. Even more significant is the case of the Autonomous Community of Andalusia, the main olive producing region in the world. In this region only 2.2% of surface area was organic in the year 2001 (MAPA, 2002; Junta de Andalucía, 2002). Given the importance of olive production in Andalusia and the relatively small presence of organic farming in this region, the sector clearly has a large potential to develop organic farming in the coming years.

Moreover, little research has been done to analyse the process of diffusion of these practices. Since the publication of the pioneering study by Ryan and Gross (1943) on hybrid seed corn, regarded as the first and foremost study of the diffusion of innovations from a classic approach, numerous empirical analyses have been done in this line. A comprehensive review of international studies on this topic see Feder et al. (1982), Feder and Umali (1993) and Rogers (1995), among others. However, few empirical studies are available in the scientific literature dealing specifically with the process of the *diffusion of organic farming*. One of these is the work by Lampkin and Padel (1994) who analyse the characteristics, causes and barriers to the adoption of organic farming from an international perspective. Another is the paper by Diebel et al. (1993) who, by means of a non-linear mathematical program, analyse the potential economic barriers facing farmers when adopting low-input agriculture. Finally, in Spain, we should mention the study by Chinchilla Fernández (1999). This study, which was carried out from a sociological approach, deals with the diffusion of organic farming in olive groves of Andalusia; a phenomenon that is of special interest to us here. In his work, Chinchilla Fernández analysed the network of social agents that in some manner intervene in the process of diffusion of technological innovations in Andalusia, specifically organic olive farming.

The main objective of the present article is to analyse the process of diffusion of the knowledge and the adoption of organic olive farming in Andalusia, as a technological innovation, from its origins to the present time. After examining the key mechanisms for the diffusion of organic practices, our aim is to develop strategies to promote the adoption of this way of “doing” agriculture.

## 2 Methodology

This study was conducted within the framework of the classic paradigm for the Diffusion of Innovations, while incorporating some of the most recent theoretical contributions to this field of study (mainly Rogers, 1995). Our analysis fundamentally consists of applying and contrasting different models of diffusion over time to a technological innovation in Andalusian olive groves, specifically organic farming. The choice of this approach is justified because it allows a systematic study of the diffusion of innovations from a micro-level with the adopters as the essential unit of analysis. In the two sections that follow, the basic theoretical principles behind the diffusion of innovations over time are described and the empirical analysis is discussed.

### *2.1 Theoretical principles of the diffusion of innovations over time*

If the relationship between time (horizontal axis) and number of individuals who have adopted a given innovation up to that time (vertical axis) is represented in graph form, we obtain what is known as the *cumulative adoption curve*. By deriving this curve, we are able to represent the number of individuals who have adopted the innovation within a given time differential. This is known as the *frequency distribution of adopters over time.* Different curves were used depending on the type of innovation in order to achieve the best possible fit for the different processes of diffusion analyzed in each case (Pemberton, 1936; Ryan and Gross, 1943; Griliches, 1957; Fourt and Woodlock, 1960; Rogers, 1995; among others). For a review of the models proposed in the literature see Gómez Muñoz (1986). The logistic curve model and exponential curve model are among those proposed. As shown below, each curve corresponds to a completely different mechanism of diffusion.

The *logistic curve* is a symmetrical S-shaped curve that is very similar to, although less flat than, the normal curve first proposed by Griliches (1957). This curve fits well to the description of processes in which the diffusion of the innovation is solely the result of *interaction between members* *of a system in which the innovation is spread*, and where the presence of other agents outside the system is negligible. In other words, this is a process by which information is passed from one member of a system to another "by contagion" or imitation.

The mathematical expression for the density function of the logistic curve adapted to the adoption of innovations process (*frequency distribution of adopters over time)* is:

$$\frac{dY}{dt} = \frac{b}{K} * Y * (K - Y) \tag{1}$$

Where:

Y: Cumulative number (or percentage) of adopters up to a given time *t*.
K: Maximum expected number (or percentage) of adopters (ceiling).
b: Imitation coefficient.

The quotient b/K can be interpreted as the percentage of still non-adopter individuals who adopt the innovation in a time differential dt for the each individual that has already adopted.

By integrating the previous expression, the cumulative distribution function for the logistic curve is obtained:

$$Y = \frac{K}{1 + e^{-(a + b*t)}} \tag{2}$$

Where the new parameter is:

a: Integration constant.

At the opposite end we find models which propose that the flow of information solely reaches the individual through *sources outside the system* to which they belong and where there is no interaction among members of the system. Among these, the so-called *exponential* model (proposed by Fourt and Woodlock, 1960) follows a concave shape for the cumulative adoption curve in which the influence of other adopters is negligible.

The density function for the exponential curve is expressed mathematically as:

$$\frac{dY}{dt} = p * (K - Y) \tag{3}$$

Where:

Y: Cumulative number (or percentage) of adopters up to a given time *t*.
K: Maximum expected number (or percentage) of adopters (ceiling).
p: External influence coefficient.

The coefficient *p* can be interpreted as the percentage of still non-adopter individuals who adopt the innovation within a time differential dt solely by means of external influences. As can be seen, this percentage is constant and is independent of the number of individuals that have already adopted. Hence, the number of adopters over time solely depends on those remaining to adopt who are "persuaded" or influenced by outside sources at a constant rate.

By integrating, the cumulative distribution function is obtained for the exponential curve:

$$Y = K - e^{-(c + p^* t)} \qquad (4)$$

Where the new parameter is:

c: Integration constant.

For practical purposes, the cumulative adoption curve is usually fit to the logistic model if it is believed that the "contagion influence" is greater than the outside influence and the level of goodness of fit is verified. If the fit is insufficient, the exponential curve can be used. If a satisfactory fit is still not achieved, other more sophisticated models can be tested.

Finally, it should be noted that while these models of diffusion initially refer to the *adoption* of innovations, they can also be used to describe the process of diffusion of *knowledge* of the innovation (Gómez Muñoz, 1986).

## *2.2 Empirical analysis*

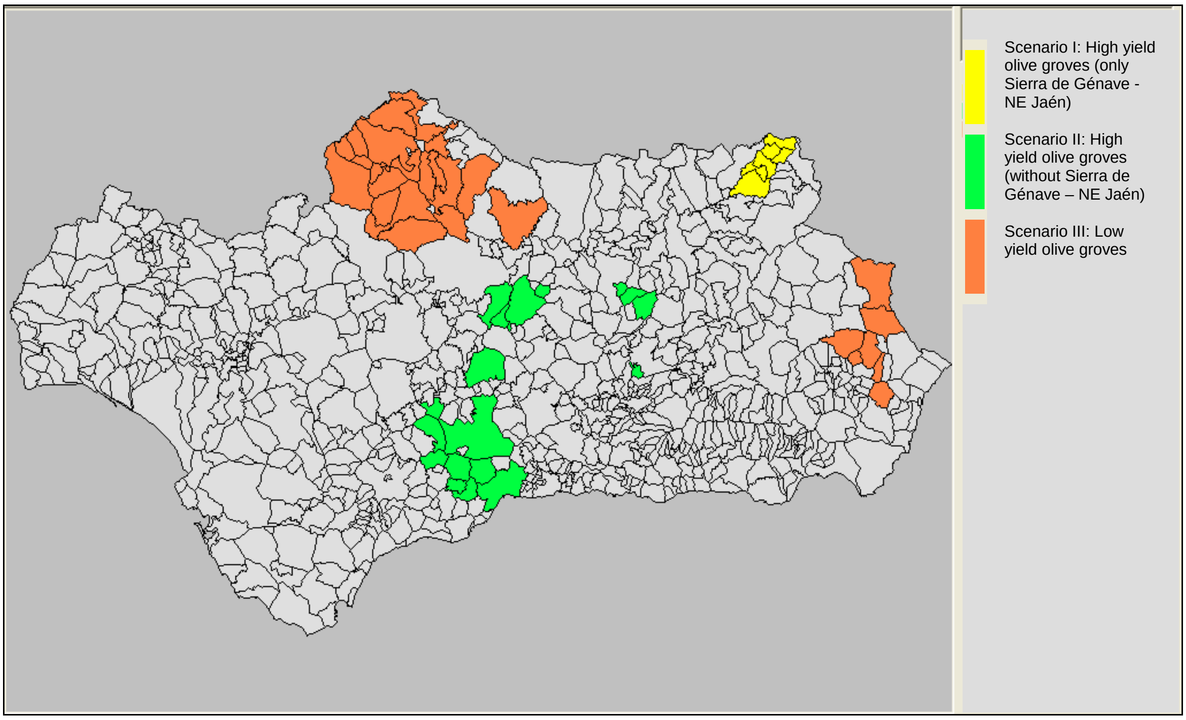
First, different albeit homogeneous *olive producing regions or areas* were defined according to their productivity. These areas, known here as *diffusion scenarios*, are shown on Figure 1 and can be characterized as follows:

I. High yield olive groves (only Sierra de Génave - Northeast Jaén): Olive grove with an average yield of over 3,000 Kg. of olives/ha. Organic olive farming was first implemented in this scenario.
II. High yield olive groves (without the Sierra de Génave – Northeast Jaén) with a yield of over 3,000 Kg. of olives/ha. These do not include the precursory organic olive-growing region mentioned above.
III. Low yield olive groves: with less than 1,500 Kg. of olives/ha. These mainly comprise olive groves located in Pozoblanco and northern Cordoba.

Note that "Medium yield olive groves (average yield between 1,500 and 3,000 Kg. of olives/ha.)" is not listed. This is because it has a not significant presence in the organic Andalusian conditions.

A survey on the diffusion of organic farming was conducted between October 2000 and June 2001. 322 *organic and non-organic olive farmers* of Andalusia were personally interviewed using a structured questionnaire. The survey was stratified in proportion to the number of certified organic olive farmers in the different, previously defined homogenous olive producing regions who were registered in the official body of certification and control (the Andalusian Committee of Organic Farming).

Given that this paper is a partial result of a Research Project which had a much broader scope than, approximately the same number of surveys were conducted of organic and conventional olive farmers in each olive growing region. Specifically, our main objective was to compare organic and conventional olive growers solely in each area of study and not all of Andalusia. With this aim, we included a similar number of both types of olive growers in each region (163 organic and 159 conventional). In the present paper the responses of both types of olive farmers are aggregated to the year of knowledge. Our results show that the farming practices used by the olive growers (organic or conventional) do not significantly influence the time at which they gain knowledge of organic farming, while a larger number of those surveyed increases the reliability of the results. As concerns the year of adoption, the results shown here logically correspond to olive farmers who have adopted organic farming practices. For organic farmers as well as for conventional ones the objective of the survey was to study the selected regions and not to make inference to population.




*Source: Based on Parra López (2003).*

Figure 1. Diffusion scenarios for organic olive farming in Andalusia

The survey included the typical questions in the diffusion of innovations regarding the characteristics of the farmers and his/her farms as well as their opinions and attitudes towards organic farming (i.e., geographical location of the farm, plantation characteristics, dedication of the interviewee to agriculture, contact with sources of information, assessment of different factors as a farmer, process followed after finding out about organic practices, attitude toward organic farming and personal data). The variables analysed included the *moment of knowledge* about organic olive farming and the *moment of adoption* when appropriate. These two variables are key to our analysis.

The *theoretical models of diffusion of innovations over time* were fit to each of the defined scenarios (knowers or cumulative adopters curves). Depending on their goodness of fit, either the logistic or the exponential curve was selected.

## 3 Results

In the next section we will attempt to describe the aggregate process of diffusion over time of the knowledge and adoption of organic farming in different groups of homogeneous olive producing regions or areas (diffusion scenarios) defined previously.

Given that the process of diffusion of both knowledge and adoption are well underway in almost all of the scenarios, we hypothesise that the number of knowledgeable farmers or those who have adopted the innovation represent the maximum value in the last year ("ceiling" of cumulative functions). As will be seen, the results obtained verify this hypothesis, with the exception of the diffusion of *adoption* in the "highly productive olive grove without Sierra de Génave in Northeast Jaen). This variable could not be studied here due to the fact that the ceiling of adopters cannot yet be estimated for this group.

### 3.1 *Moment of knowledge*

The number of *cumulative* individuals who have become aware of organic farming and the year in which this occurred were related by means of least-squares regression for each diffusion scenario. Given the data available, an exponential fit was possible in the case of the "highly productive olive groves of Sierra de Génave and northeast Jaen", while a logistic fit was possible for the "highly productive olive groves without Sierra de Génave" and the "low yield olive groves".

*A) High yield olive groves (only Sierra de Génave - NE Jaen)*

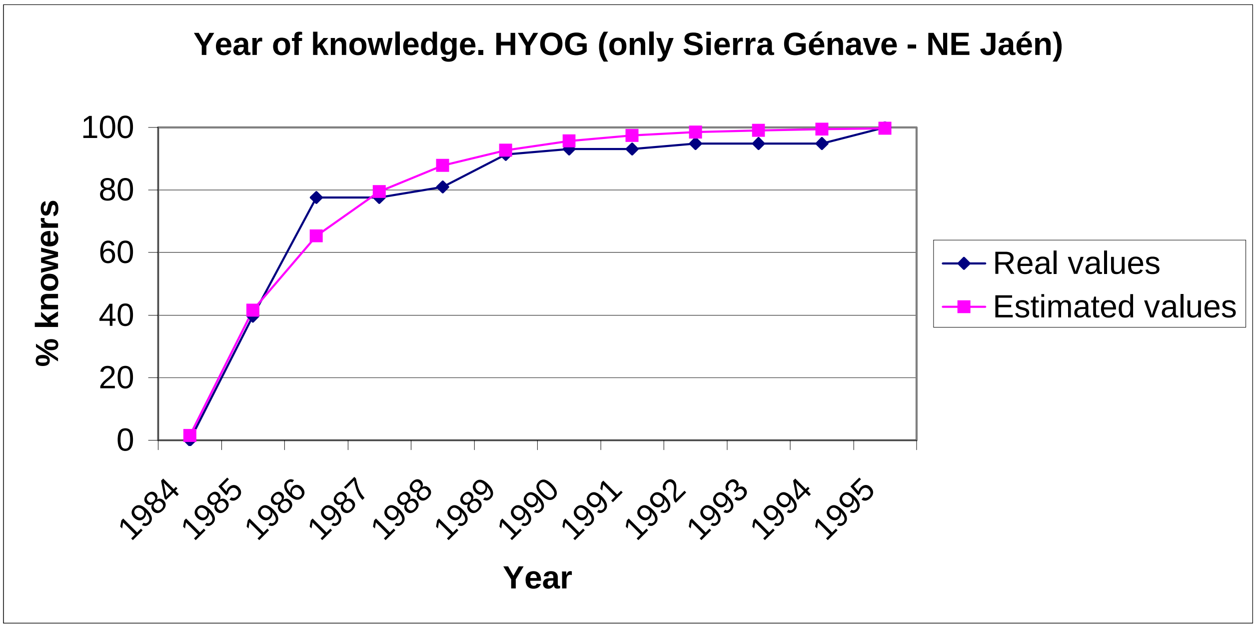
The exponential curve parameters regarding moment of knowledge in the *high yield olive groves of Sierra de Génave and NE Jaen* are:

c=-4.59; p=0.52; $R^2$=0.97; coefficients significant at 95% (for K=100%)
c=-4.05; p=0.52; $R^2$=0.97; coefficients significant at 95% (for K=58 individuals)

Hence, the diffusion over time curve for knowledge (cumulative knowers) in these regions is (see Graph 1):

$$Y(\%) = 100 - e^{-(-4.59+0.52*t)}$$

$$Y(no.individuals) = 58 - e^{-(-4.05+0.52*t)}$$




Graph 1. Diffusion over time of knowledge of organic farming in high yield olive groves (only Sierra de Génave - NE Jaén) (cumulative knowers)

In this case, the fit is very satisfactory (see $R^2$), thus confirming external influence to be the main element in the process of diffusion of knowledge of organic farming in this diffusion scenario (meanly the Department of Plant Health, Andalusian Regional Government). In this scenario, 52% (p=0.52) of individuals who did not know about organic farming gained knowledge of these practices every year solely through information received from outside sources.

*B) High yield olive groves (without Sierra de Génave - NE Jaen)*

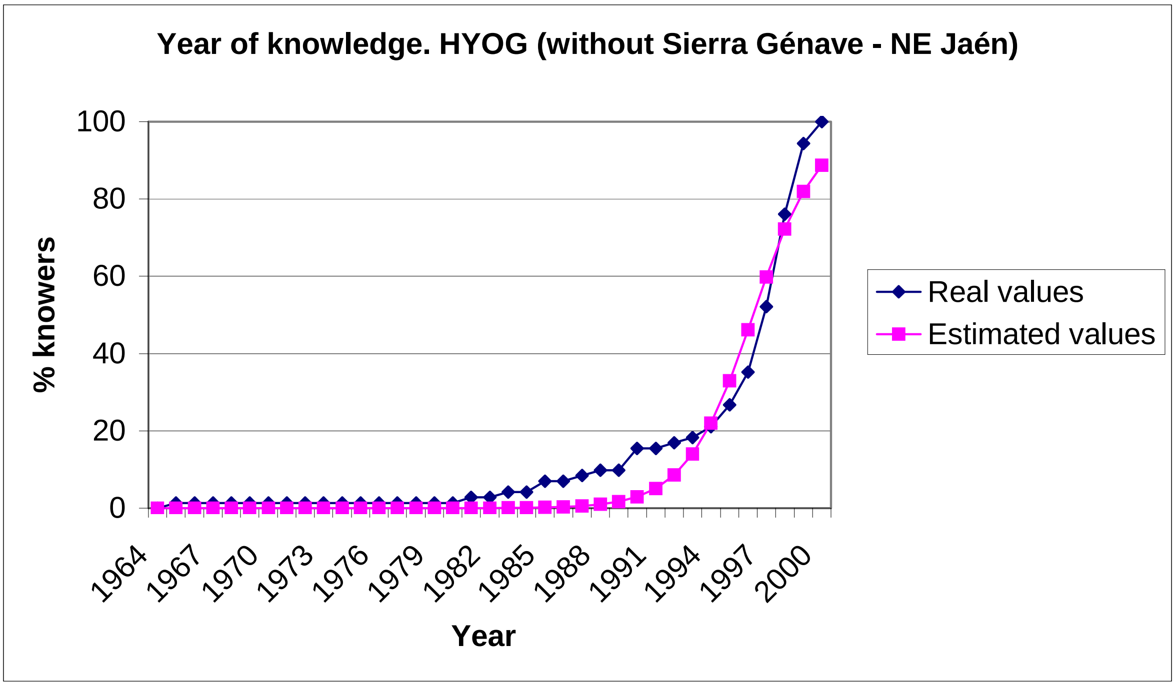
In the *high yield olive groves*, *with the exception of Sierra de Génave and NE Jaén*, the process of diffusion of knowledge over time was fit to a logistic curve with the following results:

a=-17.9; b=0.55; $R^2$=0.95; coefficients significant at 95% (for K=100% or K=71 individuals).

The diffusion curve is therefore (see Graph 2):

$$Y(\%) = \frac{100}{1 + e^{-(-17.9+0.55*t)}}$$

$$Y(no.individuals) = \frac{71}{1 + e^{-(-17.9+0.55*t)}}$$




Graph 2. Diffusion over time of knowledge of organic farming in high yield olive groves (without Sierra de Génave - NE Jaén) (cumulative knowers)

The fit achieved is high, thus demonstrating the importance of "contagion" among individuals regarding knowledge about organic farming practices in this diffusion scenario. Here, 1% of individuals who are already aware of organic practices share their knowledge each year with 0.55% (b/K=0.55/100) of those who have no knowledge. In other words, each year one individual who already knows about organic farming informs 0.77% (b/K=0.55/71) of those who have no knowledge of these farming practices.

*C) Low yield olive groves*

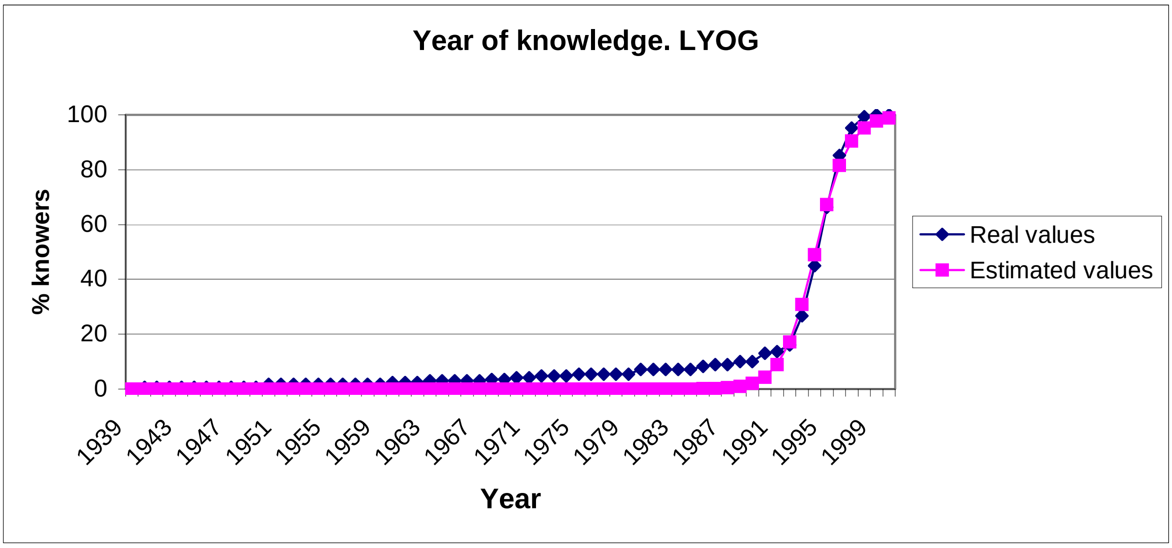
When the process of diffusion over time is fit to a logistic curve in the case of *low yield olive groves*, the following results are obtained:

a=-41.99; b=0.76; $R^2$=0.97; coefficients significant. at 95% (for K=100% or K=169 individuals).

Hence, the diffusion curve is (see Graph 3):

$$Y(\%) = \frac{100}{1+e^{-(-41.99+0.76*t)}}$$

$$Y(no.individuals) = \frac{169}{1+e^{-(-41.99+0.76*t)}}$$




Graph 3. Diffusion over time of knowledge of organic farming in low yield olive groves (cumulative knowers)

The degree of fit is high, demonstrating the importance of "contagion" among individuals. In this scenario 1% of the individuals that have already adopted pass their knowledge on to 0.76%(b/K=0.76/100) of those who have no knowledge about these practices every year. To put it another way, every year one knower of organic farming informs 0.45% (b/K=0.76/169) of unknowledgeable farmers about organic olive farming.

## *3.2 Moment of adoption*

As with the diffusion of knowledge, three different scenarios have been studied regarding the diffusion of adoption of organic farming. In the case of *low yield olive groves*, we attempt to fit the process of diffusion to a logistic curve, while an exponential curve is used in the case of *high yield olive groves in Sierra de Génave and Northeast Jaén.* As indicated above, in the case of the *high yield olive grove without Sierra de Génave –NE Jaén*, the shape of the curve leads us to believe that the process of diffusion of the adoption of organic farming has yet to conclude, making it difficult to speculate upon the process of diffusion over time.

*A) High yield olive groves (only Sierra de Génave – NE Jaén)*

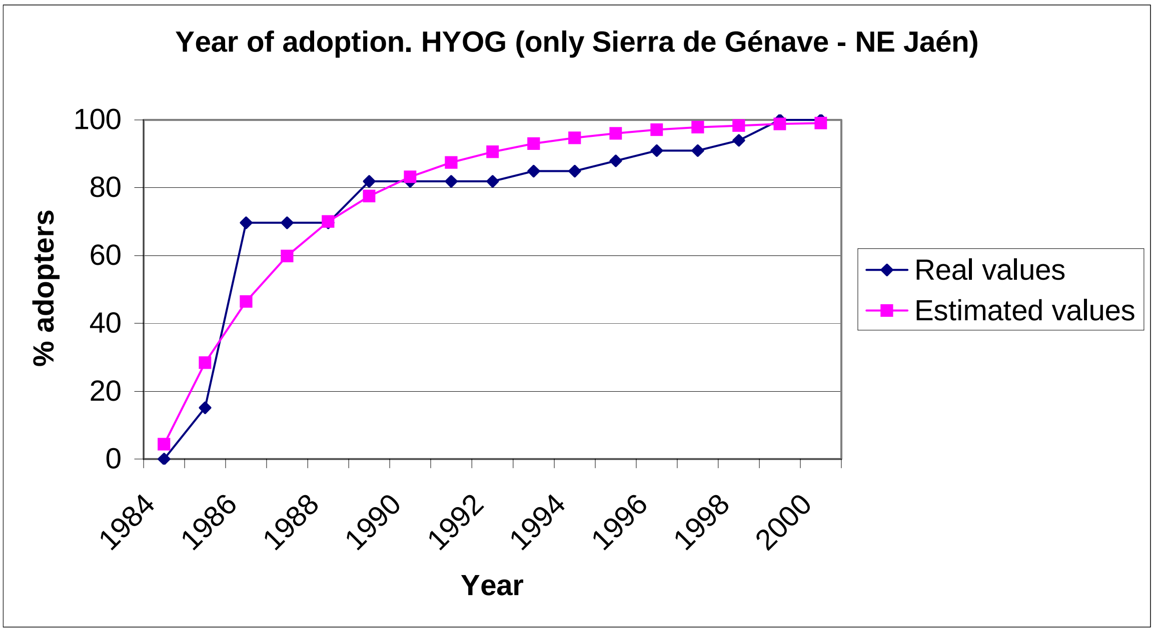
For the high yield scenario of the *Sierra de Génave area and NE Jaén*, an exponential curve was fit to the cumulative number of adopters over time. The parameters are:

c=-4.56; p=0.29; $R^2$=0.89; coefficients significant at 95% (for K=100%)
c=-3.45; p=0.29; $R^2$=0.89; coefficients significant at 95% (for K=33 individuals)

Hence, the diffusion over time curve for adoption in this region is (see Graph 4):

$$Y(\%) = 100 - e^{-(-4.56+0.29*t)}$$

$$Y(no.individuals) = 33 - e^{-(-3.45+0.29*t)}$$




Graph 4. Diffusion over time of adoption of organic farming in high yield olive groves (only Sierra de Génave - NE Jaén) (cumulative adopters)

According to this model, each year 29% of still non-organic olive farmers convert to OF simply as a result of external influences (meanly the Department of Plant Health, Andalusian Regional Government). Nevertheless, the exponential distribution fit is not very good, thus demonstrating the importance of “contagion” among olive growers. As expected, the outside influence coefficient is lower for adoption (p=0.29) than that calculated for knowledge (p=0.52) in this case. In effect, although the influence of outside sources usually leads to the rapid knowledge of the innovation, it does not seem to have as much influence on its prompt adoption. Interaction with other nearby farmers is usually a key factor to the adoption of these practices.

*B) Low yield olive groves*

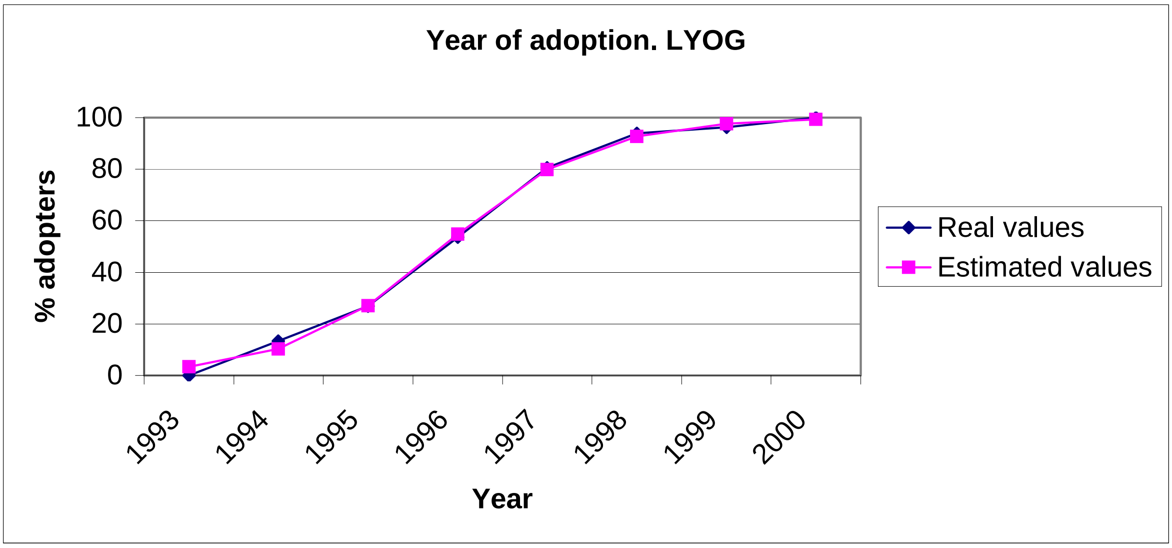
For *low yield olive groves*, the logistic curve parameters and the goodness of fit coefficient are: a=-3.35; b=1.18; $R^2$=1.00; coefficients significant at 95% (for K=100% or K=82 individuals).

The diffusion curve is (see Graph 5):

$$Y(\%) = \frac{100}{1 + e^{-(-3.35 + 1.18 * t)}}$$

$$Y(no.individuals) = \frac{82}{1 + e^{-(-3.35 + 1.18 * t)}}$$

As shown, the fit is perfect, thus confirming that in the low yield scenario, the diffusion over time of the adoption of organic farming has, until now, been the result of "contagion" among members of the same scenario. Thus each year, 1% of individuals that have already adopted informs 1.18% (b/K=1.18/100) of individuals who have not yet adopted. To put it another way, each adopter informs 1.44% (b/K=1.18/82) of those remaining to adopt.




Graph 5. Diffusion over time of adoption of organic farming in low yield olive groves (cumulative adopters)

It is interesting to note how in this low yield scenario, the rate of contagion regarding adoption (b=1.18) is greater than the rate of contagion regarding knowledge (b=0.76), as calculated above. This means that, in contrast to what is commonly thought, knowledge is spread more slowly than adoption. This phenomenon could be explained by the fact that many farmers in this scenario had previously employed similar organic farming practices for a long time (in fact they were laying the grounds for current organic farming), although their knowledge was spread very slowly. This would seem to suggest that once farmers in this diffusion scenario become aware of organic farming, they are quick to adopt these practices.

## 4 Conclusions

The following conclusions can be reached regarding the *diffusion over time of organic agriculture in olive groves* of Andalusia:

- The diffusion over time process of the organic agriculture among the main Andalusian organic olive growing regions is essentially due to an autonomous "contagion" phenomenon with a little intervention of external agents (administrations, universities, enterprises etc). However, in the last years the process has been slightly reinforced owing to the fact that the official recognition and interest in organic farming.

- In contrast to that, the *knowledge* of organic practices began to spread in Sierra de Génave (Jaén), a high yield olive region, by means of an external and official process of information (mainly the Department of Plant Health of the Andalusian Regional Government). In the rest of region the "contagion" among farmers is the key factor to explain the moment of knowledge of these alternative techniques. Nonetheless, in the region of Pozoblanco and other regions, some pioneering farmers had already laid the foundations for organic farming before the official recognition of organic agriculture.

- In a similar way, the diffusion of the effective *adoption* of organic practices in Andalusia began in Sierra de Génave and was greatly influenced by outside sources (mainly the Department of Plant Health). In the other region a "contagion" of ideas among farmers seems to be happened and the outside influence has been practically insignificant.

- In the low yield olive groves the *adoption* of organic farming has come to an almost complete standstill, demonstrating the need to strengthen or modify the mechanisms of diffusion commonly used up to this time. Thus the Administration must step up its mechanisms of diffusion in order to supplement the diffusion by contagion that has taken place until now. In contrast to that, in the high yield olive groves (not considering Sierra de Génave and NE Jaén), although data are still premature, in light of the diffusion of knowledge, it still do not appear to have reached the ceiling of adoption, meaning that organic farming may continue to spread for some years to come by means of "contagion" among farmers without the outside influence of external agents.

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