Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Available online at www.inia.es/sjar

Spanish Journal of Agricultural Research 2008 6(3), 320-332
ISSN: 1695-971-X

Price trends in greenhouse tomato and pepper and choice of adoptable technology

M. C. García-Martínez[1]*, P. Caballero[1] and M. A. Fernández-Zamudio[2]

[1] *Departamento de Economía y Sociología Agrarias. Instituto Valenciano de Investigaciones Agrarias (IVIA). Ctra. Moncada-Náquera, km 5. 46113 Moncada (Valencia). Spain*

[2] *Fundación de la Comunidad Valenciana para la Investigación Agroalimentaria (AGROALIMED). Ctra. Moncada-Náquera, km 5. 46113 Moncada (Valencia). Spain*

Abstract

Currently, intensive horticultural production in the Spanish Mediterranean region is strongly influenced by the liberalization of markets, which means farms must become more competitive and focus on consumer demands, such as product quality and health. The goals of the present work are to determine how the current economic situation of the tomato and pepper are reflected in the origin price, and to carry out an assessment of the technology available in the greenhouses. This study focuses on three principal Spanish regions of greenhouse horticultural production, located in Almería, Murcia and the South of Alicante (South-East Spain). Trend and seasonality of origin prices have been determined, and the ARIMA models have been used to predict pepper prices in Almería. Our analysis resulted in the following: the development of purchasing power, based on the price trends of the studied varieties; seasonal indices are developed to assist decision-making with respect to production schedules, choice of varieties and use of heating; finally, prediction is used to assist in planning the productive and commercial activity for the following season. There are two major determinants of technology adoption which include the fundamental elements of the equipment (heating and substrate) and the different production modes, like integrated production in different certified modes, and ecological production.

Additional key words: ARIMA models, greenhouse equipment, intensive horticulture, price analysis, time series.

Resumen

La evolución de los precios en tomate y pimiento de invernadero y elección de la tecnología adoptable

Actualmente, la producción hortícola intensiva de las regiones mediterráneas españolas está muy condicionada por la liberalización de los mercados, que obliga a elevar la competitividad de las explotaciones, y a cumplir con las exigencias de los consumidores en cuanto a la calidad y sanidad de los productos. Los objetivos del presente trabajo fueron determinar cuál es la incidencia de los precios percibidos por el agricultor en la situación económica del tomate y pimiento, y efectuar una valoración de la tecnología disponible en los invernaderos. El estudio se centró en las tres principales zonas españolas de producción hortícola en invernaderos, localizadas en Almería, Murcia y Sur de Alicante (sureste español). Se ha determinado la tendencia y la estacionalidad de los precios en origen, y se ha efectuado una predicción de los precios del pimiento en Almería aplicando modelos ARIMA. Tras el análisis se ha deducido: a partir de la tendencia, la evolución del poder adquisitivo en las variedades estudiadas; los índices estacionales facilitan la toma de decisión respecto a calendarios de producción, elección de variedades y usos de calefacción; finalmente la predicción ayuda a planificar la actividad productiva y comercial en la campaña siguiente. La valoración de la tecnología indica que existen dos vías a considerar en la adopción: una en elementos fundamentales del equipamiento (calefacción y sustrato) y otra en formas diferenciadoras de la producción, como la producción integrada, con sus diversas modalidades de certificación, y la producción ecológica.

Palabras clave adicionales: análisis precios, equipamiento invernaderos, horticultura intensiva, modelos ARIMA, series temporales.

* Corresponding author: garcia_mcamar@gva.es
Received: 18-10-07; Accepted: 30-06-08.

All authors are members of the SECH.

Introduction

The current situation of European horticulture is highly conditioned by the liberalization of markets, as well as by demands for quality, traceability and environmental sustainability factors imposed by big retail chains and consumers, which obliges farmers to keep competitive farms.

To respond adequately, farmers must increase the technological level of their farms, improving structure and equipment in the greenhouse, increasing levels of technical and biological management, extending the degree of environmental control, and even adopting fundamental changes like soilless culture.

The growth in horticultural production in countries in the Mediterranean region, including Morocco, Egypt or Turkey, and ease of export to European Union (EU) markets, oblige Spain to strengthen its competitiveness. The main way to do so is to increase the level of technology, given that the labour costs are much lower in the aforementioned countries.

Adopting technology is fundamentally a business decision, impacted by technical, social and economic factors. The main aim is to increase the potential profits and reduce risks.

The demand for technical changes includes modifying productive processes (for example, those that are imposed by demands like disinfection of soil and virosis) and the characteristics of technology and equipment (structure and greenhouse equipment, plant material, etc). Social aspects encompass numerous factors, which affect family issues and those of socio-economic character, like the variation in market structure and consumer preferences. Finally, among economic factors, prices are the most relevant.

The prices farmers receive for their production directly influence the technology they adopt on their farms. On one hand, they affect the choice of production techniques, varieties, schedules and, consequently, the most suitable equipment for each greenhouse. On the other hand, prices determine income and define income levels for agricultural producers as well as their incentives to invest in new technology.

The main objectives in this research are to determine how the current economic situation of the tomato and pepper are reflected in the origin price, and with respect to the information obtained about prices, make an assessment of the technology that can be adopted in Spanish greenhouses.

To develop these objectives, we analyze the price series over a wide time-period, which allows for reliable predictions to be made. Price analysis contributes to the rationalization of business decision-making, which is based on concepts, results and predictions about information concerning a long time-period, rather than precipitously and founded on conjunctural situations.

This study considers two main horticultural species grown in the greenhouse in Spain, namely: tomato (*Solanum lycopersicon* L.) and pepper (*Capsicum annuum* L.). The reference point of this information is the main areas with greenhouse production in the Mediterranean, located in Almería, Murcia and the South of Alicante.

Technological development in greenhouses

The development of greenhouse structure and equipment has occurred gradually. The first changes involved the move from wooden structures to metallic profiles, followed by improvements focused in achieving good climatic control, which is essential to increase the yields and quality and vary the trading season.

The development of greenhouses in Spain was mainly based, during the initial years, on the installation of a type called «parral» employing a trellis hanging system, of low cost. The very rapid expansion of the covered surface area was founded on this type of flat or «shed» greenhouse (Caballero *et al.,* 2001), which has undergone continuous modifications dictated by technological requirements (Molina *et al*., 2003).

From the 90s onward, this type of greenhouse, using a trellis hanging system, has been widely used in the Spanish Mediterranean, and has been developed and improved to correct its numerous drawbacks. The main modifications in shape and structure affected the roof slope, installation of roof vents and automated control of opening and closing. Different procedures are used to reduce high temperatures, as well as using whitewash, humidification by means of evaporative panels (cooling system) and misting, which can have two modes: high pressure (fog system) and low pressure. In addition to the aforementioned procedures shading screens are

Abbreviations used: ARIMA (autoregressive integrated moving average), CPI (consumer prices index), EP (ecological production), EU (European Union), IP (integrated production), MA (moving average), SE (standard error), SMA (seasonal moving average).

often employed. To guard against cold temperatures moveable thermal screens, double-layered covering and heating systems are used. The inflated double-layer covering reduces heat loss; however, its drawback is that it reduces solar radiation influx and, therefore, one must avoid condensation forming inside the air chamber (Castilla, 2005).

Additional elements and techniques can be added to the previously described modifications in structure that complete and perfect its functioning and the productive process in the greenhouse. The main ones are: heating, soilless culture, irrigation and ferti-irrigation, informatics applied to agriculture, carbonic fertilization and recirculation of nutrient solutions.

Heating can take two forms: hot air, to avoid momentary drops in temperature and avoid the risk of frost, and hot water, which maintains a stable temperature and enables the productive cycle to be brought forward. In response to the increase in cost of the most frequently used fuels (diesel, natural gas or propane), the current trends, which demand lower unitary costs, are moving toward a greater consideration of alternatives, like their substitution by bio-fuels, use of solar energy, and micro-tunnels inside the greenhouses, among others.

From the technical viewpoint, the adoption of cultivation in substrate represents a very drastic change for the farmer, who must have suitable training and make a strong investment in the necessary greenhouse equipment (Caballero and Fernández-Zamudio, 2006). As well as the issue of proper technical management of soilless culture, one must also add the economic and environmental attitudes that currently prevail in food production (Fernández-Zamudio *et al*., 2006).

Irrigation and ferti-irrigation are mainly applied by high-frequency drip-irrigation systems, with due planning based on electronic and informatics technology. Informatics is applied to agriculture to achieve the ideal management practice of the crop when it is necessary to use control systems and to help in decision-making and make the best choice of environmental conditions, growing techniques and crop planning (Baille and González-Real, 2001). Currently, there is the extra advantage of being able to connect these systems to Internet, which enables control at a distance.

Carbonic fertilizer application attempts to increase CO_2 levels in the greenhouse, thus increasing photosynthesis and consequently an increase in production. Opinions put forth by technicians do not coincide with respect to the economic advantages, particularly when it is necessary to frequently keep windows open given the need for ventilation.

Nutrient solution recirculation is a possibility with soilless culture, which is a great advantage from the ecological viewpoint and can also be economical.

As well as the modifications to the greenhouse structures and to the elements that must be placed inside them, productive techniques or cultivation systems also play a decisive role. Their importance lies in the fact they do not require high fixed capital investment, rather they represent the substitution of capital by production techniques, but tend to have an important effect on the prices. Integrated production (IP) and ecological production (EP) should be highlighted as fundamental. Both of these production types require the installation of anti-insect netting, which are indispensable for the biological control. The reduction of pesticides as a consequence of IP techniques, or their almost total elimination in EP, have led to useful insects being widely used. This, as well as grafted plants, an aspect that was resolved some time ago in tomato cultivation and more recently for pepper.

Information and methodology

It is common to use historical price registers to construct a time series in economic studies, within a wide variety of analytical topics, which focus on evaluating previous periods and current time, or making predictions.

To analyse the historical development as well as the current situation, trend and seasonal indices are applied in this work. The autoregressive integrated moving average (ARIMA) models have been used to make predictions, from the series of origin prices.

An interesting treatment of trend analysis is that of Makridakis and Wheelwright (1978), whose method has been incorporated into calculus programs (Statgraphics). Given their accuracy and simplicity, the trend has been used to calculate the variation in agricultural income by means of the prices, within the period of years that the series spans. With this objective, the works by Caballero *et al.* (1992) and De Miguel *et al.* (1994) regarding different fruit and vegetable species, and Caballero and Fernández-Zamudio (2003) applied to the loquat are remarked. Other applications of the trend can be found in Hinojosa *et al.* (2003), who evaluated the international markets of cocoa and organic banana and Arias (2002) who evaluated tractor sales in Spain. The methodology on seasonal indices has been developed by numerous authors, among whom Lange (1974) and Uriel (1995) stand out. The works of Benedicto and Caballero (1983), Caballero *et al.* (1992) and Noguera (1996) used the determination of seasonal indices of price series in fruit and vegetable growing; while Guigó (2004) applied it to the prices of barley.

ARIMA models are widely used in the field of forecasting prices and there are numerous publications applying this method and checking its validity. In terms of methodological contribution the works by Box and Jenkins (1976) and Peña (2005) are remarked. To apply this methodology to empirical studies of time series in agriculture, some highlighted works include studies by Albisu *et al.* (1984) in the wine sector, Romero and Balasch (1986) in the evaluation of the effectiveness of the struggle against hail, Cases (1994) in citriculture, Douvelis (1994) in predicting the prices of sunflower seeds in the USA. Within the production area, Arias and Alonso (2000) focus on predicting the surface area sown with beetroot in Castilla-León, while Chambers (2004) forecasts the price of grain for animal fodder and Najeeb *et al.* (2005) predicting the area and production of wheat in Pakistan.

The information gathered takes as reference the main regions of greenhouses on the Mediterranean, located in Almería, Murcia and the South of Alicante, and encompasses the records of origin prices that figure in the periodical publications of the Agricultural Councils of Andalucía, Murcia and Comunidad Valenciana (Junta de Andalucía, 2006; Gobierno de la Región de Murcia, 2006; Generalitat Valenciana, 2006). To fully develop this work, technical and economic information was collected in the regions under analysis, by means of interviews made at farms and agricultural cooperatives.

Prices were taken fortnightly at the periods indicated in Table 1. The types studied were ribbed and round tomatoes, which in Almería coincide with the long-life variety, as well as green and red peppers.

The computer software Statgraphics Plus version 5.1 has been used to carry out the calculations for the three concepts included in the concepts: trend, seasonal indices and prediction.

Once the time series were constructed, with the updated periods and dates indicated in Table 1, the following determinations were carried out:

a) *Trend* analysis, which shows the economic behaviour of the different species with respect to the prices and the current perspective. When the trend is growing, this gives very sure perspectives; in the event it is decreasing, it is worth carefully checking whether it is due to a slow decline in the purchasing power of a particular variety, which although inevitable is bearable, or whether it is a sharp and unrecoverable drop given the technical and economic characteristics that affect it. Finally, a very common situation is one concerning new variety that begin at very high prices in the first years, giving rise to extraordinary profits, and drop to normal profit margins in the following years.

The trend expresses the general movement of a series in the long run. For this analysis, the movement is separated from the cyclical, seasonal and residual variations that, according to classical theory, are considered in a time series. The values of the series have been time-adjusted using a linear equation, which although being the simplest, satisfactorily covers the trend of the price series.

b) The *seasonal indices* show the relative level that prices have reached, with respect to an average value 100, in the seasons that are encompassed in the series. With these data, it is possible to optimize the income, taking into account the expected productions, and consequently, based on climatology, greenhouse characteristics and available technical means.

To obtain the seasonality indices, a seasonal break down has been carried out on the original price series according to the multiplicative method. Following this procedure, the seasonal variations (E_{ik}) can be isolated from trend components (T_{ik}), cyclical variations (C_{ik}) and residual variations (R_{ik}) (Pérez, 2002). This leads to the result that $Y_{ik} = T_{ik} * E_{ik} * C_{ik} * R_{ik}$, where Y_{ik} is

Table 1. Periods corresponding to each series according to crop type and zone, indicated in fortnights (f.)

	Ribbed tomato	Round tomato	Green pepper	Red pepper
Almería[1]	1st f. Oct'92-2nd f. Jul'06	1st f. Oct'97-2nd f. Jul'06	1st f. Oct'92-2nd f. Jul'06	1st f. Oct'92-2nd f. Jul'06
Murcia[2]	—	1st f. Oct'92-2nd f. Sep'06	2nd f. Mar'92-1st f. Aug'06	1st f. Apr'92-1st f. Sep'06
Alicante[1]	1st f. Sep'98-2nd f. Aug'06	1st f. Sep'92-2nd f. Aug'06	2nd f. Mar'90-1st f. Oct'06	2nd f. Apr'90-1st f. Oct'06

[1] Prices updated August 2006. [2] Prices updated September 2006.

the time series, i takes the values $1,2,...,n$ (represents years) and k takes the values $1,2,...,m$ (represents fortnights).

c) *Prediction using ARIMA models*, for which information has also been obtained regarding their statistical validity, has enabled an estimation of prices and their development in the following season, within a probability interval. However, the limitations of this prediction technique are the nature of the series, on one hand, and above all, the low number of years for which a prediction can be made (Cases, 1994).

The ARIMA models, with prediction for one year, can be more useful for commercial horticultural crops, where short-term decisions are important. Likewise, these models offer the possibility of providing, for the coming season, planning regarding the techniques and production factors that are most advisable to use, like the choice of variety, production schedule, disinfections, grafting, etc.

In the identification and estimation of the ARIMA models, the methodology developed by Box and Jenkins (1976), which is used to analyse univariate models of time series, was followed. In these models, a dynamic variable that fluctuates over time (in the current case, the price), is explained using just one variable, the historical record and its past values (Uriel and Peiró, 2000).

To apply the ARIMA methodology, it is essential that the time series is stationary. To do this, it is necessary to know a series of terms, which are defined below.

A stochastic process is a succession of random ordered variables Y_t, where t can have any value between $-\infty$ and $+\infty$, and represents the passing of time, when dealing with time series, as in the case. The stochastic processes can be defined specifying the average and the variance for each Y_t. Of interest to us are:

— The stochastic process with an average zero, constant variance and where the random variables are independent for different values of t (covariance null). This stochastic process is known as white noise.

— The stationary stochastic process, which occurs when the distribution functions together are invariate with respect to a time lag.

In the univariate ARIMA models one works from the initial consideration that the time series has been generated by a stochastic process and specifically the elaboration techniques of the ARIMA models try to identify the model generating the observations which, once estimated and validated, in an iterative process, are used to predict future values of the time series (Uriel and Peiró, 2000).

Below is the description for a general Box-Jenkins model with a stationary series:

$$(1-\phi_1 L-\phi_2 L^2-\ldots-\phi_p L_p)(1-L)^d Y_t^\lambda = \\ = (1-\theta_1 L-\theta_2 L^2-\ldots-\theta_q L^q)\, a_t$$

Being L the lag operator, so that, multipling L by the variable in t, the value of this same variable in t–1 is obtained; d is the number of differences to change the series into a stationary one; λ is the parameter of the Box-Cox transformation (they take values 0 and 1); ($\phi_1, \phi_2, ..., \phi_p$) are the autoregressive coefficients and ($\theta_1, \theta_2, ..., \theta_q$) are the moving averages coefficients.

This equation is usually abbreviated using the ARIMA terminology (p,d,q), where p is the degree of the autoregressive part; d is the number of differentiations in the regular part and q is the degree of the part of moving averages.

A model is defined as autoregressive if the variable Y_t can be expressed as a linear combination of its past values adding an error term.

The general expression of an autoregressive model would be as follows:

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots + \phi_p Y_{t-p} + a_t$$

where a_t is the sequence of deviations distributed identically and uncorrelated, called white noise, which corresponds to the ready defined stochastic process with average zero and constant variance.

A model of moving averages explains the value of a specific variable in a period t in terms of an independent term and a succession of errors that correspond to the preceding periods, suitably weighted. Thus, a model with q error terms is expressed as follows:

$$Y_t = \mu + a_t + \theta_1 a_{t-1} + \theta_2 a_{t-2} + \ldots + \theta_q a_{t-q}$$

In time series with a seasonal component, the appropriate model is an ARIMA (p,d,q) × $(P,D,Q)_s$ with the general formula:

$$Y_T = \phi_1 Y_{T-1} + \phi_2 Y_{T-2} + \ldots + \phi_{Ps+p+Ds+d} Y_{T-Ps-p-sD-d} + \delta + \\ + U_T + \theta_1 U_{T-1} + \ldots + \theta_{Qs+q} U_{T-sQ-q}$$

where s is the seasonal period, P is the degree of the autoregressive part of the seasonal component, D is the number of differentiations in the seasonal component and Q is the degree of the part of moving averages of the seasonal component.

Applying the ARIMA model in the calculus

To look for an ARIMA model for a particular time series, the following steps are taken.

Identification

First of all, the series must be stationary. There are two forms of stationarity:

— Stationarity on average: if the series is nonstationary on average, one must differentiate the series until the trend disappears. The number of times that it is differenced is the value of *d*.

— Stationarity in variance: by means of the observation of the graphic representation of the series, one can see whether or not the dispersion is maintained around the existing level at each moment. If one observes that the level increases in line with the increase in dispersion, it is said that there is stationarity in variance, and one must carry out the Box-Cox transformation. In this way, a natural logarithm must be applied to the series if $\alpha = 1$, when the relationship between typical deviation and the average is: $\sigma = k{*}m\alpha$, and thus establish variance.

The terms *p* and *q* are determined by using the functions of estimated autocorrelation and partial autocorrelation of the series. Next, we compare them with the functions of autocorrelation or correlograms of the following theoretical models: a) autoregressive model of order *p* [AR(p)]; b) moving average model of order *q* [MA(q)]; or c) autoregressive moving average model, with *p* autoregressive terms and *q* moving average terms [ARMA(p,q)]. In this way, an ARIMA model can be geared towards the appropriate time series that most closely identifies the data generating process.

Estimate

If the process is identified, the parameters of the autoregressive part and of the moving averages part are estimated for both the regular and seasonality components.

By contrast, if the process is not well identified, a new estimation must be carried out. Therefore, this is an iterative system, where the analysts experience is fundamental, in order to carry out proper critical contrast of the results at each stage (Peña, 2005).

Validation

The objective of the validation phase is to demonstrate that the model found is the one that best represents the behaviour of the series under study, which, in turn, is that which fulfils the following requirements to the greatest extent: a) the coefficients of the model must be statistically significant; b) the residuals of the estimated model must approximate the behaviour of a white noise, to do this the coefficients of the functions of the estimated autocorrelation and the estimated partial autocorrelation must not differ significantly from zero; c) the estimated model is stationary; and d) the prediction is adequate.

Results

The *trend* analysis has been carried out adjusting the series to a time function with a linear equation. After obtaining the trend equation, it is subjected to tests carried out on the residuals of the linear model to determine how well the model fits the data. These tests are to check the difference in the average between the 1st half and the 2nd half of the series and in the difference in the variance between the 1st half and the 2nd half of the series. If the model passes the tests, it infers that the difference is not statistically significant ($p \geq 0.05$), and therefore, the equality between the 1st half and the 2nd half of the series is verified, both on average as in variance.

The trend was applied to evaluate the economic situation of the product in terms of price development over a large time span. The results are shown in Table 2 regarding the annual percentage variation. The series follow a trend that can be represented graphically. As an example, for the present work, Figures 1 and 2 have been included, in which the equations of the trend can be observed for the round tomato in Murcia and green pepper in Almería. For the other plant types the same analytical procedure is followed.

Figure 1 shows a very stable trend with a descending slope of 34% over 14 seasons (2% annually).

The linear model passes the test for the difference in variance between the 1st half and the 2nd half of the series and the test for the difference in the average between the 1st half and the 2nd half, as these differences are not statistically significant ($p \geq 0.05$), thus verifying the equality of variance and average between the 1st and 2nd half of the series.

Table 2. Analysis of the trend of origin prices

Types of product	Almería[1] Eq. of the trend	Almería[1] Annual variation (%)	Murcia[2] Eq. of the trend	Murcia[2] Annual variation (%)	Alicante[1] Eq. of the trend	Alicante[1] Annual variation (%)
Ribbed tomato	p = 1.0119 + 0.0017 f *	2% increase	—	—	p = 0.7966 + 0.0030 f*	5% increase
Round tomato	p = 0.7031 – 0.0005 f***	1% decrease	p = 0.85 – 0.00086 f*	2% decrease	p = 0.5227 + 0.0006 f*	2% increase
Green pepper	p = 0.9020 – 0.0012 f*	3% decrease	p = 1.0598 – 0.0018 f**	2% decrease	p = 0.7462 – 0.0006 f**	1% decrease
Red pepper	p = 1.1597 – 0.0015 f*	2% decrease	p = 1.2506 – 0.0055 f*	2% decrease	p = 1.1159 – 0.0026 f*	3% decrease

[1] Prices updated August 2006. [2] Prices updated September 2006. p: price per period for each series (€ kg^{-1}). f: period of the series (fortnights). * Significance level = 1%. ** Significance level = 15%. *** Significance level = 20%. *Source:* Own calculations.

Figure 2 gives an example of the graphic behaviour of the trend lines for the pepper and corresponds to the trend line followed by the prices of the green pepper in Almería. The results from this analysis show that the descending linear trend has a 37% drop over 14 seasons, which means 3% annually. In this linear model the equality of the average between the 1st and 2nd half of the series is verified.

Table 2 shows the trend equations obtained in the analysis of the origin prices, by production regions and product type. The first thing one might observe is that the slopes of the equations of the trend are, in most cases, highly significant, as indicated by the p-values obtained. On the other hand, there is a very low probability that the values estimated for the aforementioned slopes are given only for reasons of randomness. In other words, it is highly probable that the estimated values are true (probability of error below the level of significance).

With reference to the tomato, the ribbed type displayed an annual price increase both in Almería and Alicante, while the round variety followed a declining trend that oscillated between 1% annually in Almería and 2% annually in Murcia. The price of the pepper has also dropped in recent years with a decrease of between 1% for the green pepper in Alicante and 3% for the green pepper in Almería and the red pepper in Alicante.

With respect to the *seasonality indices*, these have been obtained on the basis of the series of data indicated in Table 1, and reflect the price oscillation over an average season in percentage terms. Table 3 shows all the indices calculated; moreover, it indicates the average price of the last season analysed for each product, to serve as the reference value.

Production cycles exhibit similar patterns in Murcia and Alicante but are somewhat different in Almería. The effect of *seasonality* on the prices can also be observed graphically. Thus, as an example, the figures

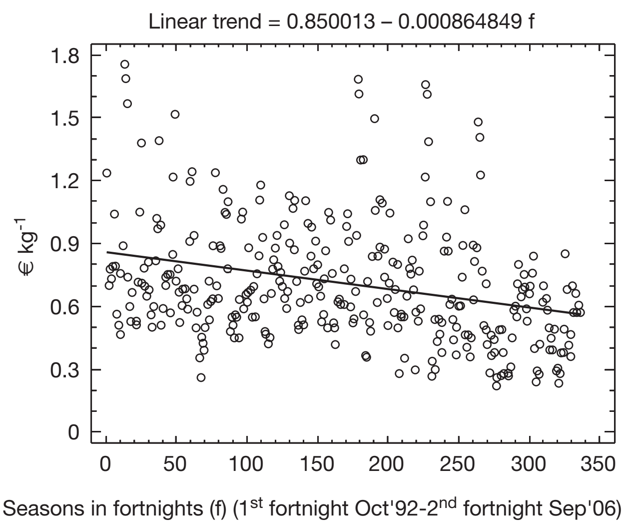

Figure 1. Round tomato prices series in Murcia.

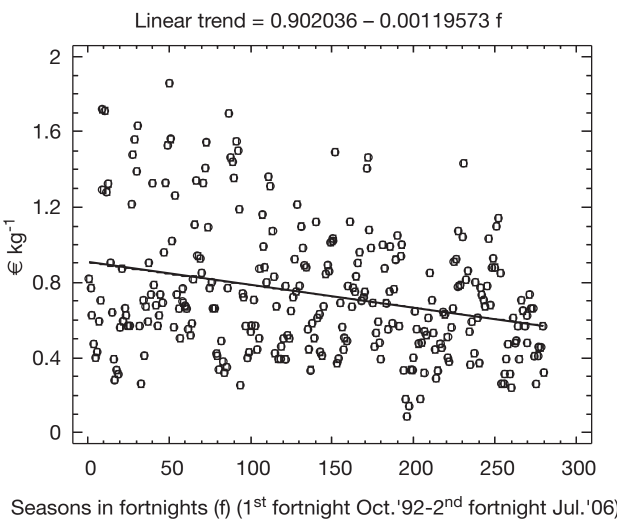

Figure 2. Green pepper prices series in Almería.

Table 3. Seasonality indices of the series of origin prices in percentage

Fortnights (f.)	Almería				Murcia			Alicante			
	Ribbed tomato	Long-life tomato	Green pepper	Red pepper	Round tomato	Green pepper	Red pepper	Ribbed tomato	Round tomato	Green pepper	Red pepper
1st f. Sep.	—	—	—	—	101.87	—	67.17	81.63	74.44	61.08	68.78
2nd f. Sep.	—	—	—	—	118.91	—	—	105.08	89.66	53.24	62.31
1st f. Oct.	53.10	88.26	93.12	86.55	135.49	—	—	135.10	107.32	49.67	58.52
2nd f. Oct.	53.68	112.00	86.42	83.02	117.59	—	—	156.94	112.44	—	—
1st f. Nov.	77.61	113.05	78.99	87.36	101.32	—	—	110.76	103.27	—	—
2nd f. Nov.	104.55	92.89	72.77	94.66	101.61	—	—	115.83	98.54	—	—
1st f. Dec.	149.84	127.06	90.02	105.78	97.61	—	—	132.09	111.88	—	—
2nd f. Dec.	124.62	128.51	110.59	99.53	108.09	—	—	128.45	114.22	—	—
1st f. Jan.	100.71	94.52	131.93	99.07	85.04	—	—	86.95	89.25	—	—
2nd f. Jan.	115.29	115.59	125.01	111.45	81.71	—	—	91.35	91.63	—	—
1st f. Feb.	105.57	103.44	137.32	136.42	88.89	—	—	101.41	85.48	—	—
2nd f. Feb.	114.33	99.67	136.83	133.57	100.42	—	—	113.54	98.61	—	—
1st f. Mar.	120.15	125.96	166.52	143.96	124.74	—	—	106.82	138.10	—	—
2nd f. Mar.	154.03	137.33	148.30	135.07	129.09	153.87	—	112.71	133.32	213.78	—
1st f. Apr.	145.00	120.29	118.41	115.64	131.98	150.39	169.65	123.97	155.00	162.94	—
2nd f. Apr.	176.18	126.10	86.93	90.61	143.48	128.18	177.73	129.32	164.55	130.56	191.04
1st f. May.	146.48	104.49	67.81	106.40	106.23	105.24	163.58	89.16	111.87	113.76	177.73
2nd f. May.	108.05	78.30	68.61	87.30	71.05	82.56	107.16	65.10	86.01	104.90	129.75
1st f. Jun.	58.18	53.32	57.95	77.01	65.19	93.64	82.44	72.30	68.46	108.67	100.04
2nd f. Jun.	35.15	54.42	75.93	66.87	70.85	88.13	80.70	90.84	89.46	105.50	92.79
1st f. Jul.	28.11	61.68	66.30	63.37	64.15	69.34	60.36	72.04	80.09	85.34	87.11
2nd f. Jul.	29.36	63.11	80.24	76.36	71.34	68.19	59.05	68.59	70.17	80.25	90.16
1st f. Aug.	—	—	—	—	87.57	60.45	65.49	53.94	63.40	68.23	71.26
2nd f. Aug.	—	—	—	—	95.79	—	66.68	56.08	62.82	62.04	70.51
Mean prices 05/06 (€ kg^{-1})	1.33	0.54	0.53	0.58	0.48	0.70	0.74	0.61	1.24	0.61	0.61

Source: Own calculations.

are shown corresponding to the round tomato in Murcia and the green pepper in Almería (Figures 3 and 4).

Figure 3 gives the values of the seasonal indices for the prices of the round tomato in Murcia which clearly displays that the highest prices are obtained in the autumn months and at the end of spring.

The seasonality indices, reach a maximum of 143.48 in the fortnight 14 (month of April). After this point, it drops to a minimum of 64.14 in fortnight number 19 (month of July).

In the case of the pepper, the example taken for the seasonal behaviour of prices is that of the green pepper in Almería. In Figure 4 one can see that all the seasonal indices exceed the value of 100 between the second fortnight of December and the first fortnight of April, reaching a maximum of 166.51 in the fortnight number 11, and then dropping to a minimum of 57.95 in the fortnight number 17 (month of June).

Table 4 presents the periods of the season where the highest values are obtained for the seasonal indices of prices. One can also observe the similarities between Murcia and Alicante and how in Almería the seasonal peaks come forward in the case of the pepper.

Finally, this work is completed with a *prediction* obtained by applying the *ARIMA models* to the time series of prices for the green and red pepper in Almería. In these series of fortnightly periods, the time period studied encompasses the years 1992 to 2006. First of all, the series were adjusted so they would be stationary on average, differentiating them once in the regular part (d = 1) and in the seasonal part (D = 1), and the transformation natural logarithm was applied to stationarize them in variance.

The autocorrelograms obtained are shown in Figures 5, 6, 7 and 8, in which the X axis represents the lags corresponding to time movement of a time unit (in this

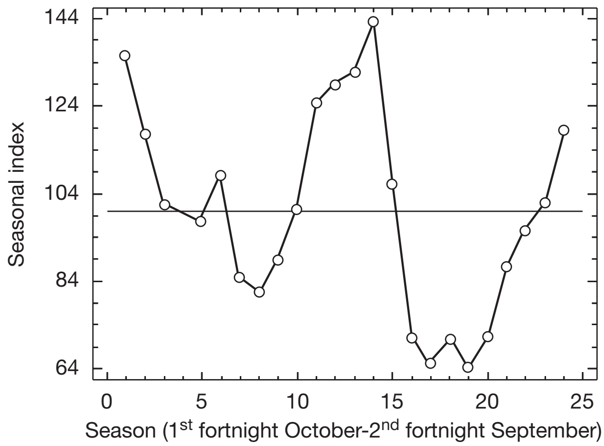

Figure 3. Seasonality of the round tomato prices in Murcia.

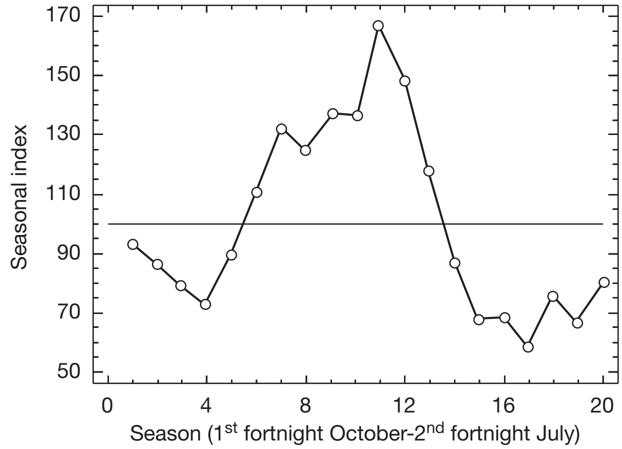

Figure 4. Seasonality of the green pepper prices in Almería.

Table 4. Period of the season with the highest seasonality indices of the origin prices

Types of product	Almería	Murcia	Alicante
Ribbed tomato	Dec.-May.	—	Oct.-Dec.
Round tomato	Mar.-Apr.	Oct. and Mar.-Apr.	Oct.-Dec. and Mar. - Apr.
Green pepper	Jan.-Mar.	Mar.-Apr.	Mar.-May.
Red pepper	Feb.-Mar.	Apr.-May.	Apr.-May.

Source: Own elaboration.

case, fortnights), which occurs when the autocorrelation is carried out. The analysis of these autocorrelations, reflects the consideration of a moving averages of degree two [MA(2)] and a seasonal moving averages of degree one [SMA(1)], therefore, the series were modelized using an ARIMA $(0,1,2)\times(0,1,1,)$ 20.

Estimated coefficients for each model are shown in Table 5. The moving average coefficients for degrees 1 and 2 as well as the moving average from the seasonal component, SMA(1), are both statistically significant (p-value < 0.05).

To validate the model, the residuals were checked to ensure they followed a white noise process (distributed approximately as a normal, average zero and constant variance) as well as the following tests, for which statistically insignificant p-values were obtained (p-value ≤ 0.05):

— RUNS = Test for excessive runs up and down.

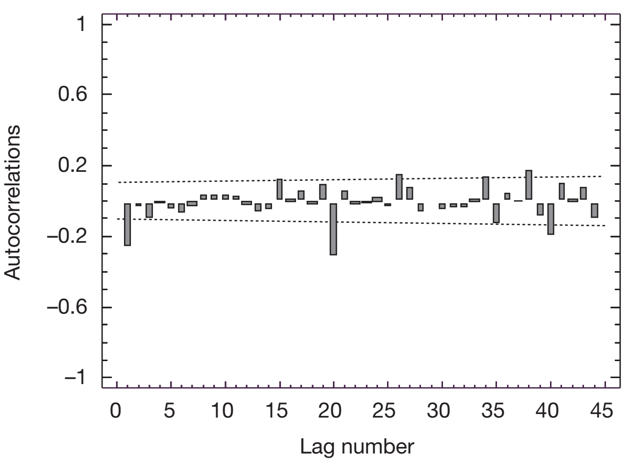

Figure 5. Estimated autocorrelations of green pepper in Almería.

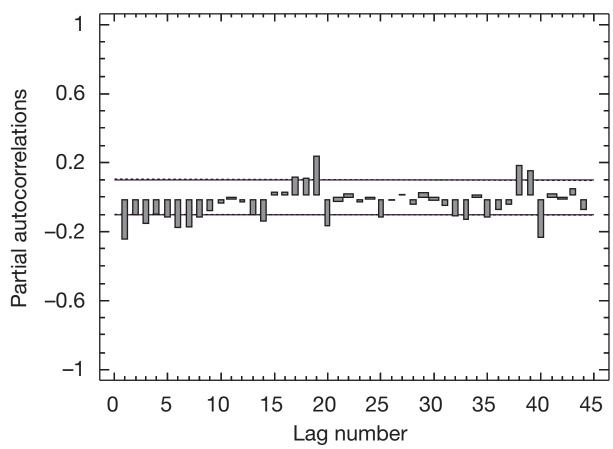

Figure 6. Estimated partial autocorrelations of green pepper in Almería.

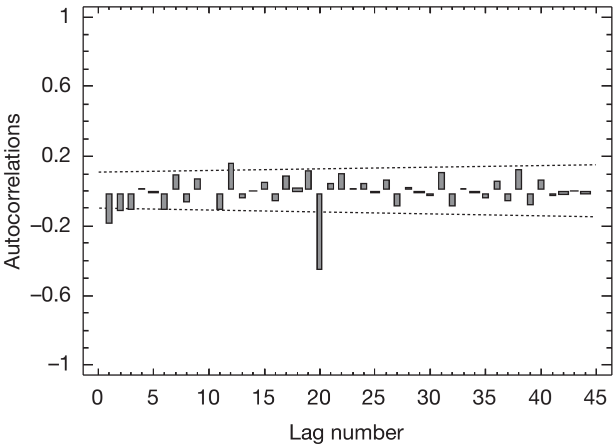

Figure 7. Estimated autocorrelations of red pepper in Almería.

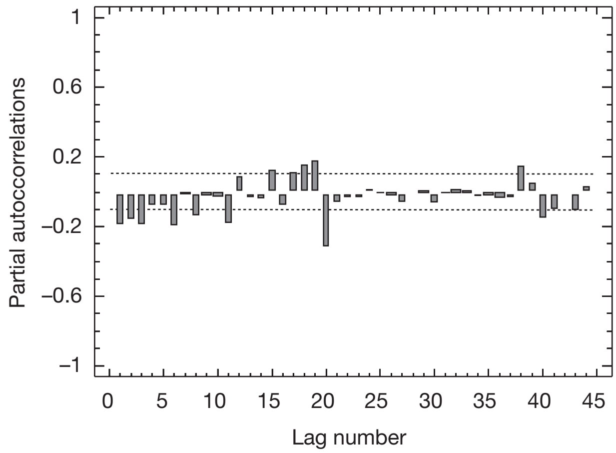

Figure 8. Estimated partial autocorrelations of red pepper in Almería.

— RUNM = Test for excessive runs above and below the median.

— AUTO = Box-Pierce test for excessive autocorrelations.

— MEAN = To test the difference in average between the 1st and 2nd half.

— VAR = To test the difference in variance between the 1st and 2nd half.

Figure 9 shows the results of the price forecasts obtained using this model, for the green pepper and red pepper in Almería. Deviations between predictions and the real prices are small, and the behaviour of both series is very similar throughout the campaign. All the values fall within the limits defined by the lines of the confidence intervals obtained from the prediction.

The main deviation to be found, between the end of November and the beginning of January, may be due to a commercial disturbance caused by the appearance of non-authorised residues, which on being detected in some European markets caused a sharp drop in prices (Junta de Andalucía, 2007). On correcting this incident, the prices recovered after January, which is more noticeable in the green pepper.

Concerning the green pepper, the prediction values show, in accordance with those obtained in the seasonality analysis, that the highest prices would be recorded between the months of January and March. The greatest price drop occurred in the season spanning the 1st fortnight in March and the 2nd fortnight in April.

The predictions for the price series corresponding to the red pepper in Almería are shown in Figure 9B. In this case, also coinciding with seasonality, the forecast for the highest prices occurred between the months of February and March, while the greatest price drop in the season would take place between the 2nd fortnight of March and the 1st in June.

Together with the analysis of the origin price trends, an assessment has been made of the technology and equipment to be found in greenhouses, thus offering the possibility of providing economic orientation to help in decision-making.

One of the main strategies followed to achieve higher prices is to obtain special products like the ribbed tomato, on-the-vine tomato, cherry tomato, different coloured peppers or the Wonder type etc, and to do so

Table 5. Results of the estimation of the ARIMA (0,1,2) × (0,1,1) models

Models	Parameters	Estimated coeff.	SE	t statistic	P-value
Green pepper	MA (1)	0.5431	0.0598	9.09	0.0000
	MA (2)	0.3075	0.0602	5.11	0.0000
	SMA (1)	0.8916	0.0193	46.11	0.0000
Red pepper	MA (1)	0.4246	0.0605	7.02	0.0000
	MA (2)	0.2573	0.0604	4.26	0.0000
	SMA (1)	0.8879	0.0182	48.63	0.0000

SE: standar error. MA: moving average. SMA: season moving average. *Source:* Own elaboration.

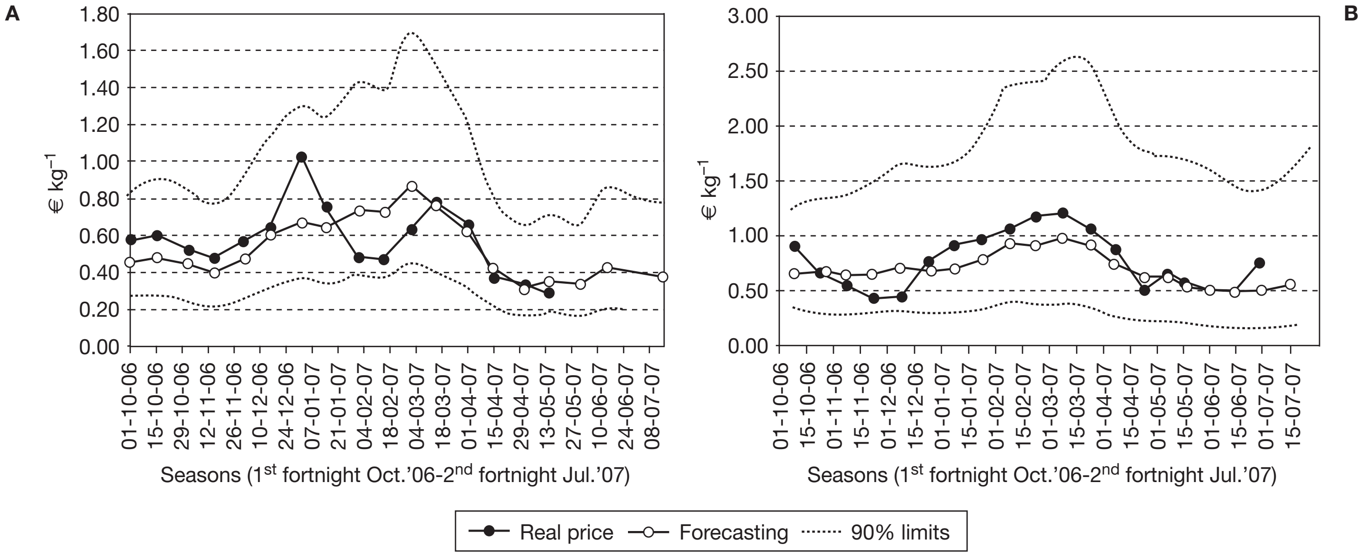

Figure 9. Forecasting *vs.* real prices for green pepper (A) and red pepper (B) in Almería.

it is necessary to carry out improvements in greenhouse structure and equipment.

When price trends do not give the farmers favourable perspectives, this leads to situations in which low-levels of fixed capital are used, as happens in the case of greenhouses covered only by netting, particularly in tomato growing.

Another consequence of the decreasing price trend on the most common production, is that important modifications, like soilless culture, are being implemented slowly or even reaching a standstill. Thus, since the year 2000, the area dedicated to soilless culture has not exceeded 20% in Almería.

Despite this, it is necessary to adopt more technology if growers want to improve quality and adapt their production system to the seasonal maximum of the prices; in fact, when the greenhouse is better equipped, even with some form of heating system, it is easier to reach high price levels, and bring forward the natural market cycle that normally takes place in summer and autumn.

Besides the size and equipment in the greenhouse, there is a direct relationship between the product prices, other production modes, which include IP and, in recent years, EP.

On the other hand, cultivation using IP systems with biological control techniques, which always demand a higher level of technology, contribute to improving the commercial image of the product. Nowadays, it is still difficult to quantify the economic differences favouring IP, except the priority of choice in the marketing phase.

Discussion

The price series analyses have included the concepts of trend and seasonal indices, within the period encompassed in each series. For the pepper, also included is a price forecast for the following year.

Bearing in mind the wide range covered by the series and the fortnightly period of the prices, a high number of data are included. Therefore, the resulting trend gives very solid information as an expression of average price behaviour. As the values are updated to the Consumer Prices Index (CPI) corresponding to the last date of each series, one can easily calculate the increase or decrease in purchasing power for a given product and deduce the influence this has on the farmer's income.

According to the results of the trend analysis of the prices it can be concluded that:

— There is a standstill or slight decline in price of the round tomato in the main producing regions, like Almería and Murcia. However, in Alicante a positive trend is recorded for this product, which could correspond to the differences in the marketing process.

— Concerning the differentiate type, the ribbed tomato follows a positive price development, both in Almería and in Alicante. This is because it is a special type of tomato and it is therefore necessary to find a niche in the market where higher prices can be obtained, which is possible with differentiated products.

— For the red and green pepper, and in the three growing regions studied, the development of the price series displays a downward trend that is not very great, common to products that started off at very high price levels, and as production has increased, the prices have followed a slight downward trend or stabilized.

The results obtained using the seasonal indices provide highly valid information regarding the relationship between the production schedules and prices, and what should be done in terms of choice of variety, production techniques, greenhouse equipment and decisive aspects like heating.

The ARIMA models are shown to be valid for short-term forecasts of one season. Nevertheless, the results provided are of great interest in crops like the pepper grown in the greenhouse, where the response obtained in production and prices is evident with respect to the techniques and means employed.

Heating has an effect on the production schedule and seasonality of the products, improved quality and, in its turn, affords greater security against the risk of low temperatures. However, there are certain limitations to its use due, to a great extent, to the increasing price trend of commonly used fuel. For its temporary and permanent use, strict technical and economic controls are demanded.

In contrast to what often happens in the sale of products with IP techniques, when products of ecological origin are marketed there is a favourable discrimination in the prices. This is a consequence, on one hand, of the current consumer demands with respect to food safety and health, and on the other, the guarantees that are attributed to the Ecological Production label.

Acknowledgements

This study was part of the research project INIA-RTA 04-072, funded by INIA and by the European Funds FEDER.

References

ALBISU L.M., VALLÉS J., ALONSO P., 1984. Comportamiento de los precios del vino en España. An INIA: Ser Econ Sociol Agr 9, 11-27. [In Spanish].

ARIAS P., 2002. Análisis temporal de las ventas y estimación del valor residual de tractores en España. Rev Esp Estud Agrosoc Pesq 192, 195-222. [In Spanish].

ARIAS P., ALONSO R., 2000. Análisis de las variables que inciden en la superficie a sembrar de remolacha en Castilla-León. Actas del VII Congreso de Economía Regional de Castilla y León. Soria, Spain, November. pp. 784-800. [In Spanish].

BAILLE A., GONZÁLEZ-REAL M., 2001. Modelos de simulación en materia de control y de ayuda a la decisión. In: Incorporación de tecnología al invernadero. Cajamar, Almería. pp. 73-90. [In Spanish].

BENEDICTO J.L., CABALLERO P., 1983. Las cámaras frigoríficas en la comercialización de los agrios. An INIA: Ser Econ Sociol Agrar 7, 209-300. [In Spanish].

BOX G.E.P., JENKINS G.M., 1976. Time series analysis. Forecasting and control. Holden day, 2nd ed. San Francisco, USA. 575 pp.

CABALLERO P., FERNÁNDEZ-ZAMUDIO M.A., 2003. Loquat, production and market. Options Mediterraéens, Serie A. Seminaires Mediterranéens 58, 11-20.

CABALLERO P., FERNÁNDEZ-ZAMUDIO M.A., 2006. Valoración económica de la implantación del cultivo en sustrato. In: Cultivos sin suelo: técnicas para hortalizas en clima mediterráneo (Alarcón A., coord). Ed Horticultura SL, Reus. pp. 55-69. [In Spanish].

CABALLERO P., DE MIGUEL M.D., JULIÁ J.F., 1992. Costes y precios en hortofruticultura. Mundi-Prensa, Madrid. 761 pp. [In Spanish].

CABALLERO P., DE MIGUEL M.D., FERNÁNDEZ M.A., 2001. La tecnología en los invernaderos. Agrícola Vergel 239, 604-613. [In Spanish].

CASES B., 1994. La predicción de cosechas en cítricos. Comparación entre diferentes métodos. Invest Agrar: Economía 9(3), 411-446. [In Spanish].

CASTILLA N., 2005. Invernaderos de plástico. Tecnología y manejo. Ed Mundi-Prensa, Madrid. 462 pp. [In Spanish].

CHAMBERS W., 2004. Forecasting feed grain prices in a changing environment. Electronic Outlook Report from the Economic Research Service, USDA (FDS-04F-01), 18.

DE MIGUEL M.D., CASES B., MOYA I., 1994. La variación de las rentas en producciones hortofrutícolas mediterráneas. Invest Agrar: Econ 9(1), 95-111. [In Spanish].

DOUVELIS G., 1994. Forecasting sunflowerseed prices in the United States: the case of an ARIMA model. Oil Crops, Situation and Outlook (OCS-40), 13-15.

FERNÁNDEZ-ZAMUDIO M.A., GARCÍA-MARTÍNEZ M.C., ALCÓN F., 2006. Efectos económicos de la tecnología asociada al cultivo en sustrato. VIII Jornadas de Sustratos. SECH, Tenerife, Spain, Oct 9-10. pp. 35-40. [In Spanish].

GENERALITAT VALENCIANA, 2006. Notas agrarias semanales. Conselleria de Agricultura, Pesca y Alimentación, Valencia. Available in http://www.gva.es [30 Jun 2007]. [In Spanish].

GOBIERNO DE LA REGIÓN DE MURCIA, 2006. Informe semanal agrario. Consejería de Agricultura. Available in http://www.carm.es [30 Jun 2007]. [In Spanish].

GUIGÓ M.A., 2004. La estacionalidad en los precios agrarios durante la primera mitad del S.XIX. Un caso especial: la cebada. Cuadernos de Estudios Empresariales 14, 207-218. [In Spanish].

HINOJOSA V., STOIAN D., SOMARRIBA E., 2003. Los volúmenes de negocio y las tendencias de precios en los mercados internacionales de cacao y banano orgánico.

Agroforestaria en las Américas 10(37/38), 63-68. [In Spanish].
JUNTA DE ANDALUCÍA, 2006. Boletines Semanales de Información Agraria. Consejería de Agricultura y Pesca, Sevilla. Available in http://www.juntadeandalucia.es [30 Jun 2007].
JUNTA DE ANDALUCÍA, 2007. Valoración de la campaña hortícola almeriense 2006/2007. Secretaría General de Agricultura, Ganadería y Desarrollo Rural, Sevilla. December, 2007. [In Spanish].
LANGE O., 1974. Introducción a la econometría. Ed Fondo de Cultura Económica. 348 pp. [In Spanish].
MAKRIDAKIS S., WHEELWRIGHT S.C., 1978. Interactive forecasting, 2nd ed. Holden Day, S Francisco, CA. 296 pp.
MOLINA F.D., VALERA D.L., GIL J.A., ÁLVAREZ A.J., 2003. Evolución de los invernaderos de Almería. Revista Riegos y Drenajes del Siglo XXI, especial Almería, 58-63. [In Spanish].
NAJEEB I., KHUDA B., ASIF M., AHMAD A.S., 2005. Use of the ARIMA model for forecasting wheat area and production in Pakistan. J Agr Soc Sci 1(2), 120-122.
NOGUERA P., 1996. El patrón estacional de los precios y de las producciones hortofrutícolas. Revista Española de Economía Agraria 178, 35-72. [In Spanish].
PEÑA D., 2005. Análisis de series temporales. Ed Alianza, Madrid. 551 pp. [In Spanish].
PÉREZ C., 2002. Estadística práctica con Statgraphics. Prentice Hall, Madrid. 712 pp. [In Spanish].
ROMERO R., BALASCH S., 1986. Evaluación de la efectividad de la lucha antigranizo en Navarra: una aplicación del enfoque Box-Jenkins del análisis de series temporales. Invest Agrar: Prod Prot Veg 1(3), 360-377. [In Spanish].
URIEL E., 1995. Análisis de datos. Series temporales y análisis multivariante. Ed AC, Madrid. 433 pp. [In Spanish].
URIEL E., PEIRÓ A., 2000. Introducción al análisis de series temporales. Ed AC, Madrid. 343 pp. [In Spanish].