Analyzing supply response of fruit tree products in Tunisia: The case of peaches

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Abstract

In Tunisia, peaches have a significant place in the fruit tree sector. Planted areas have been expanding ever since the eighties as a result of irrigation water extension and the use of better yielding varieties. These factors resulted in high production levels and fruit exports thereof. However, important seasonal and annual variation of fruit supplies continues to characterize prices at both wholesale and consumption levels. To study the response of peach production an econometric model was developed. Modelling was carried out in two stages. First area variation was explained through new plantings and removals and second yield variation was analyzed. The methodological approach followed takes into account the characteristics and specificities related to perennial crops. Weak response of supply to variations in expected prices was obtained. Supply price elasticity was estimated about 0.13 suggesting a high degree of inelasticity.

Key words: *Supply response, modelling, price expectations, peaches*

Introduction

Along with dates and citrus, which represent the main fruit tree commodities produced and exported in Tunisia, peaches have an important place in the fruit sector. This crop has been expanding since the eighties due to the introduction of new varieties and the increase in the areas equipped with modern irrigation techniques. As a result, production and exports have increased significantly during the last few years.

The evolution of planted areas shows an important increasing trend during the last two decades. Planted areas increased from 9,500 ha during the eighties to 16,880 ha in 2004 (MAHR, 2005). Peach plantations are located in the North of the country (54%), followed by the Center and the South. Despite their increase, these areas remain limited as compared to other fruit crops. The wide regional distribution has implications in terms of transport costs and post harvest marketing costs, leading some farmers to sell their production on the farm, in order to satisfy financial considerations and as a hedge against climatic risks.

The production of peaches registered a remarkable increase during the 2000-2004 period, going from 73,000 tons in 2000 to 100,000 tons in 2004 (MAHR, 2004). Despite

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the extension of irrigated areas, the volume of production still depends for the most part on climatic conditions. Furthermore, and in spite of its remarkable increasing trend, production still remains characterized by a strong seasonality. Production is then exposed to the competition with other fruit products marketed during the same period. Fruits that are destined to domestic consumption are increasing and the exported share remains low. Being a perishable product, peaches are also harvested during the same period with other tree fruits (apples, apricots, pears, grapes, etc.). This spatial-temporal diversification in the fruit supply induces competition between peaches and other fruits and leads to consequences on quantities supplied as well as prices.

This calls for a strategy to cope with the constraints that can hinder the development of this sector. Previous studies that dealt with this sector examined mostly technical aspects. The purpose of this study is to shed some light on other dimensions related to the economics side of the development of the sector and makes appropriate recommendations.

This study focuses on the supply side of the market for peaches in order to better understand the producer's behaviour regarding variations in economic factors and their decisions related to plantations and removal. To better understand the supply determinants, the supply response of peaches will be analysed. In fact, the supply response for perennial crops differs from annual crops due to the time factor, besides other aspects related to plantations and removals. The main characteristics of these crops are as French and Matthews (1971) state it: i) a long gestation period between initial input and first output, ii) an extended period of output following from the initial production or investment decision, and iii) eventually a progressive deterioration of the productive capacity of the plants.

This analysis will simulate not only the planting decisions but also those related to removal as well as renewal. It will also consider time lags between the planting and first production. In this context, the aim in analyzing farmers' behaviour towards economic variables is to determine the elasticity parameters characterizing the sensibility of supply. These parameters capture possible changes in areas as well as produced quantities and those supplied on the market as some exogenous factors, such as prices, vary. Therefore some approaches will be elaborated to develop a constructive basis to analyze the supply response taking into account various variables that may characterize perennial crops. Indeed, identifying the main determinants of peach supply will allow us to characterize its main causality. Hence, it is necessary in a first step to determine the set of economic variables (price, investment, etc.) potentially explaining economic behaviour in the peach activity.

The present paper is structured as follows. Following the introduction of the subject and the setting of the objectives, the theoretical background and the methodological approach are presented. The third section describes the econometric modelling of the supply response of peaches. First a general description of the model is provided. Then we describe the data sources and the estimation procedure. Third, we present the empirical results and discussion. The final section summarises the major findings.

Theoretical background and methodological approach

A major specificity of the supply response of agricultural products is the non simultaneity between production decisions and those related to marketing. Producers' expectations about prices are crucial in this regard. In this context, cobweb models constitute the most basic assumption simulating such behaviour. Cobweb models stipulate that expectations are based on lagged prices by only one time period. In Nerlove's empirical work (1958) dealing with price expectations in agricultural markets, expected prices were expressed as a weighted sum of past prices, in which the weights decline as one goes back in time. In such case, only information on past prices is taken into account by economic agents.

Perennial crops have certain characteristics making necessary new approaches that take into account the time that is required by plants before entering into production and the decrease of returns due to the deterioration of the productive capacity of plants. Hence, an important problem needs to be captured in the case of perennial crops, the time lag in the production process which requires a long enough time series allowing a reasonable number of degrees of freedom for estimation purposes (Nerlove, 1979).

The Nerlove model, traditionally used in empirical work on supply response, seems to be unsatisfactory to analyze supply response for fruit tree products. Two limits must be underlined: the existence of a delay due to biological factors and technology (Pierani, 1996).

An important feature, in the case of tree crops, is the investment decision as discussed by several authors (French and Matthews, 1971; French et al., 1985; Hartley et al., 1987). In particular, Akiyama and Trivedi (1987) explained investments by the error correction model. A model built by Davidson et al. (1978) put together the analysis of time series and econometrics, in order to empirically verify economic properties and to underline the importance of an approach that distinguishes between the different production phases: the period of entry into production and the role of technical change (Pierani, 1996).

Such models represent an important theoretical development, where estimation procedures require adequate statistical instrumental tools. Thus, in the case of perennial crops, the lack of data constitutes a constraint when studying a given sector; consequently, many authors limit their studies to elasticity analysis. Besides, given some limits of the Nerlovian approach in supply response modelling of tree crops, almost all recent studies undertaken until the seventies were based on simplified relations (Nerlove, 1979).

French and Matthews (1971) proposed a general system of supply to deal with fruit tree productions which they applied to asparagus, a perennial vegetable crop. This model is structured in five equations. The authors tried to separately estimate the equation of new plantations, areas in production and yields. The lack of time series on plantations, removal and age distribution of plantations, led them to estimate a supply function in a reduced form, which results from an adjustment equation of planting area and yield. The planting area variation is given by the following equation:

$$A_t - A_{t-1} = (1 - b)N_{t-k} - R_{t-1} + v_t \qquad (1)$$

where,

A_t: planted area in year t;

A_{t-1}: planted area in year t-1;

N_{t-k}: New plantations in year t-k;

R_{t-1}: removed area in year t-1;

k: Time interval (in years) between plantation and entry in production;

b: Proportion of plants removed because of diseases during the period k;

v_t: error term.

Modelling supply response of peaches will be undertaken while taking as a starting point the methodological framework developed by French and Matthews (1971). This model allows to break up the product supply into two components corresponding to plantation and removal.

Modelling the supply response for peaches in Tunisia

Model Specification

The production of perennial crops, contrary to annual crops, depends on the time factor. It depends also on factors related to plantation and removal. Indeed, the production of perennial crops differs from that of annual crops by the long period between the first input and the first production. In addition to the extended period of production starting from the initial decision of investment (period of full production which can reach 20 years), there is a progressive deterioration in the productive capacity of trees. Such period of decline may extend on 10 to 15 years.

The model suggested for this work aims at explaining not only the planting process but also tree removal and renewal. The main characteristics of the model is that it refers to farmers as a group with a similar behaviour, all facing the same product and factor prices, the same production technology and they all aim at maximizing economic profit.

The model comprises five equations, following French and Matthews (1971): i) two equations explaining the produced quantity and the desired level of plantations by farmers, ii) a new planting equation defined by the adjustments which would shift areas towards the desired level, iii) an equation which explains the removed area each year, iv) an equation which explains relationships between unobservable and observable variables, and v) an equation which explains variation in the average yield values. The changes in planted areas from year to year are obtained by combining the second and the third equation relating to the new plantations and removals. The total production is obtained by multiplying planting equation by the yield equation.

Given, the desired level of planted area S^*_t, the new plantation is the area that will adjust the area at the desired level. This desired area is not immediately achievable; it needs k years, where k is the interval between the date of plantation and the date of entry in production.

$$N^*_t = S^*_{t+k} - S_{t-1} + E^e_{k\,t} - N_{k\,t-1} \qquad \{N^*_t \geq 0\} \qquad (2)$$

where,

N^*_t: New plantation area desired in year t;

S^*_{t+k}: Desired level of planted area after k years.

S_{t-1}: Area covered by productive plantations in year t-1;

k: Time interval (in years) between plantation and entry in production (period of installation from 3 to 5 years and intermediate period from 1 to 5 years).

$E^e_{k\,t}$: Area expected to be removed after k years.

$N_{k\,t-1} = \sum_{i=1}^{k} N_{t-i}$: Total planted area after t-k-1 years.

The value of $E^e_{k\ t}$ introduces two components: the first one represents the young plantations or old plantations of few years but removed because of diseases or damage caused by insects and the second represents the plantations removed because of the significant decrease of productivity, we obtain then:

$$E^e_{k\,t} = a_0 S^0_{t-1} + a_1 (N_{kt-1} + S_{t-1} - S^0_{t-1}) + u_t \quad (3)$$
$$= a_2 S^0_{t-1} + a_1 N_{kt-1} + a_1 S_{t-1} + u_t$$

where,

S^0_{t-1}: Area of plantations that reached a significant decrease in productivity;

a_1: Small proportion of plantations removed because of diseases or damage caused by insects during the period k.

u_t: error term;

$0 < a_0 < 1$

The actual plantations N_t are different from the desired ones in view of many factors. The model takes into account the nature of this difference as a function of the relationship between the actual value and the desired value. Thus, an adjustment relation is specified as follows:

$$N_t - \beta N_{t-1} = \alpha (N^*_t - \beta N_{t-1}) + e_t \quad (4)$$

which is equivalent to:

$$N_t = \alpha N^*_t + \beta (1- \alpha) N_{t-1} + e_t \quad (5)$$

where,

$0< \alpha \leq 1$: adjustment coefficient and, $0 \leq \beta \leq 1$ is a term introduced to take into account the past residual effects for desired plantations. If $\beta =1$, equation (5) reduces to a Nerlovian adjustment relation. If $\beta =0$, there are no residual effects on future plantations or that actual plantations are just a fraction of the corresponding desired one.

The final equation for new plantations is then specified as follows (6):

$$N_t = b_0(\Pi^e_t - \Pi^*_t) + b_1 \Delta R^e_t + b_2 S^0_{t-1} + b_3 N_{k\,t-1} + b_4 S_{t-1} + u_t \quad (6)$$

The real removed plantations are expressed as follows:

$$E_t = c_0 + c_1 S^0_t + c_2 S^0_t (\prod^c_t - \prod^*_t) + c_3 Z_t + c_4 S_t + u_t \quad (7)$$

where,

E_t: Plantations removed at the end of year t.

S^0_t: Plantations above a particular age in year t.

$\prod^e_t$: Expected long-run profitability.

$\prod^c_t$: Expected short-run profitability.

$\prod^*_t$: Long-run profitability per unit of product.

Z_t: Institutional or physical factors.

S_t: Planted area in year t.

ΔR^e_t: Variation in expected yield.

The total change in areas from one year to another is given by:

$$S_t - S_{t-1} = (1 - a_1)\, N_{t-k} - E_{t-1} + v_t \qquad (8)$$

Where k and a_1 are as previously defined and v_t captures the possible unpredictable losses caused by diseases.

By substituting (6) and (7) in (8) we obtain:

$$S_t - S_{t-1} = d_0 + d_1(\Pi^e_{t-k} - \Pi^*_{t-k}) + d_2 \Delta R^e_{t-k} + d_3 S^0_{t-k-1} + d_4 S^0_{t-1} + d_5 S^0_{t-1}(\Pi^c_{t-1} - \Pi^*_{t-1}) + d_6 Z_{t-1} + d_7 N_{k\,t-k-1} + d_8 S_{t-k-1} + d_9 S_{t-1} + u_t \qquad (9)$$

As data series related to production costs are not available, an alternative for an approximation of the expected profitability Π^e_t is developed. This approximation is derived for the adaptive expectation model, as developed by Nerlove (1956, 1958):

$$P^e_t - P^e_{t-1} = \beta[P_{t-1} - P^e_{t-1}] \qquad (10)$$

where,
$0 \leq \beta \leq 1$, β is the expectation coefficient, P^e_t is the expected price in year t, P^e_{t-1} is the expected price in year t-1 and P_{t-1} is the real price in year t-1.

A relevant approach would be that to assume the expected profitability Π^e_t as being the average of the last two prices of period t-1 and t-2 (Nerlove, 1956). This assumption implies the following expectations model:

$$P^e_t - P^e_{t-1} = \alpha[P_{t-1} - P_{t-2}] \qquad (11)$$

where $|\alpha| \leq 1$

Thus, Π^e_t which is approximated by $\left(\frac{pt}{wt}\right)^e$ is given by:

$$\Pi^e_t = \left(\frac{pt}{wt}\right)^e = \frac{1}{2}\left(\frac{P_{t-1}}{W_{t-1}} + \frac{P_{t-2}}{W_{t-2}}\right) = \frac{1}{2}\left(P_{1t-1} + P_{1t-2}\right) = P_{2t-1} \qquad (12)$$

where,
P_t : wholesale price.
W : labour index.

Short-run expected profitability Π^c (in t+1) is measured in a similar way, excepting that:

$$\left(\frac{pt}{wt}\right)^c = \left(\frac{pt}{wt}\right) = P_{1t} = \Pi^c \qquad (13)$$

An alternative would be to measure Π^c as being the average of P_{1t} and P_{1t-1}; however the value for one year seems to be suitable since farmers make their short-run predictions based on the most recent experience. Under perfect competition conditions, pure economic profit can be assumed to get close to zero.

The area of old plantations S^0 is observable on a practical level, while the lack of data forces us to use some approximations. An approach is to assume that the area S^0 is proportional to total area S_t, then $S^0_t = \alpha_1 S_t$. Another approximation would be to consider that S^0_t is proportional to the average area over the last five years: $\overline{St} = \alpha_2 S_t$'.

The lack of an observable variable that may replace ΔR^e (expected yield deviation) led us to eliminate this variable from the yield final equation (9) and the correlation between S_{t-k-1} and S_{t-1} may be avoided in the final equation to estimate (French et Matthews, 1971).

Substituting expected variables by their observed values in (6), (7) and (9) we obtain the estimable equations of new plantations, removals and area:

$$N_t = b_0 P_{2t-1} + b_1 \overline{S}_{t-1} + b_2 N_{kt-1} + b_3 S_{t-1} + u_t \tag{14}$$

$$E_t = c_0 + c_1 \overline{S_t} + c_2 \overline{S_t} P_{1t} + c_3 Z_t + c_4 S_t + u_t \tag{15}$$

$$S_t = d_0 + S_{t-1} + d_1 P_{2t-k-1} + d_2 \overline{S}_{t-k-1} + d_3 \overline{S}_{t-1} + d_4 \overline{S}_{t-1} P_{1t-1} + d_5 Z_{t-1} + d_6 N_{k\,t-k-1} + u_t \tag{16}$$

The yield of a perennial crop varies with plant age, technology (farming techniques, varieties, etc.), climate and other biological factors. In some cases, current yields could be related to those of the past. The effect of technical change may be measured by a trend variable. The effect of climate and other biological factors can be represented by a random disturbance term. Yields equation to be estimated takes the following form:

$$\ln R_t = \alpha_0 + \alpha_1 \ln S_t + \alpha_2 T + \alpha_3 \ln Pluv + v_t \tag{17}$$

Where, R_t: Yield in year t, S_t: Productive area in year t, T: Trend variable which represents technology and Pluv: Average rainfall of the period t and t-1.

Data Sources

Taking into account the availability and the continuity of time series, annual data covering the period ranging from 1980 to 2004 were used. Data come from different sources: agricultural statistics yearbook of MAHR (areas, rainfall and wholesale prices) and the Official Journal of the Republic of Tunisia (Guaranteed Minimum Agricultural Wage "SMAG"). Rainfall was given on the basis of regional distribution of the areas planted to peaches over the period 1980-2004.

Results and discussion

Estimation of the various equations was carried out according to the Ordinary Least Square method (OLS). In what follows we will expose, first, the results related to the equations of new plantations, removals and yields, and then we will present the results of acreage equation which was deduced from the various estimated equations.

D.W. close to 2 indicates that residuals are not correlated for all of the estimated equations. Heteroscedasticity was tested using the White test. Calculated values nR^2 are lower then those of Chi-Square. Thus the null hypothesis of homoscedasticity cannot be rejected.

Most of the variables used to explain investment decisions in peach crops are significant at 5% level and the estimated parameters have the expected sign. Equations were estimated without the intercept term, following French and Matthews (1971) formulation.

An inrease in expected prices, reflecting the ratio between peach prices and labour price index (here the SMAG) induces an increase in the new plantations area. If farmers expect higher product prices they will seek to increase their productions. Farmers' response to price increases leads to new investments and renovation of orchards that show a fall of productivity. Indeed, the need for replacing the less productive plantations becomes necessary if the farmer is looking for increasing or at least maintaining his production levels.

Removal relationships estimated as suggested by equation (15) are summarized in table (1). All estimated parameters are significant and with expected signs. There is a positive correlation between removals and plantations whose productivities started to fall. On the other hand, productive plantations are negatively correlated with removed areas. An increase in areas occupied by old plantations implies their removal to be replaced or substituted by another crop. Thus, the farmers may choose to replace old plantations that have a low production level by new plantations that are unproductive during the first three years. The decision of removal is strongly related to expectations made about peach prices. Hence, the removal of the plantations is accelerated when farmers expect a price increase in the short run.

Table 1. Estimate of the equations " new plantations "," removals " and " yield "

Equations		Coefficient	T Student	R^2	$\overline{R^2}$	F	DW	White Test
Eq 1 : New plantations (N_t)				0.90	0.89	60.89	1.94	8.63
	P_{2t-1}	9533.874	1.8*					
	$\overline{S}_{t-1}$	0.815	3.52**					
	N_{kt-1}	- 0.495	-3.95**					
	S_{t-1}	0.056	1.85*					
Eq 2 : Removals (E_t)				0.68	0.63	14.88	2.12	6.34
	Intercept	-911.164	-0.8					
	$\overline{S_t}$	2.225	2.19*					
	$\overline{S_t}\, P_{1t}$	13.419	3.48**					
	S_t	-0.366	-3.27**					
Eq 3 : Yield ln (R_t)				0.86	0.84	42.37	1.54	7.11
	Intercept	0.83	0.24					
	ln S_t	-0.30	-1.95*					
	T	0.04	8.26**					
	ln *Pluv*	0.44	2.69**					

Note : P_{2t-1} : Average of prices for years t-1 and t-2 divided by SMAG of the same period, $\overline{S}_{t-1}$: Area of old plantations for the period t-1, N_{kt-1} : Total area planted after t-k-1, S_{t-1} : Area of productive plantations for the period t-1, $\overline{S_t}$: Area of old plantations for the period t, $\overline{S_t}P_{1t}$: Area of old plantations for the period t multiplied by the short run expected price, S_t : Area of productive plantations for the period t, R_t: Yield in year t, *T* : Trend variable which represents technology and *Pluv*: Average rainfall of the period t and t-1, k = 3 years, F : Fisher test, DW : Durbin-Watson test, T : Student test. **, *: Significance at 1% and 5%, respectively.

In the yields model, all parameters were statistically significant at 5% level and with the expected signs as well. Technology and rainfall are positively related to yield level.

Productive areas are negatively correlated with yield. Thus, an increase in productive areas induces a reduction in yield. Indeed, during the first years, new plantations generate low output, which results in low average yields and consequently, productive areas show a negative relationship with yields. However, on average, yields increase by 0.04% each year due mainly to the use of new highly productive varieties, use of water saving techniques, etc.

The rainfall variable has a significant and positive parameter. A 1% increase in rainfall involves 0.44% output increase in the short run. In spite of the extension of the irrigated areas which reached 12,000 hectares in 2005, the production of peaches remains dependent on climatic conditions (MAHR, 2005).

Parameters of the acreage equation can be derived from new plantations and removals equations. This leads to the following results:

$$S_t - S_{t-1} = 911.164 + 8580.486 P_{2t-k-1} + 0.733 \overline{S}_{t-k-1} - 2.225 \overline{S}_{t-1} - 13.419 \overline{S}_{t-1} P_{1t-1} - 0.446 N_{k\,t-k-1} \quad (18)$$

Prices are positively correlated with planted areas. Farmers who expect an increase in prices will to tend improve their productive capacities through the renewal of old plantations and the development of new investments.

The variable representing planted areas that reached a significant decline in productivity has a positive parameter. In fact, these areas are replaced by other new plantations since farmers tend to recover their losses in the coming future. The deterioration of the productive capacity of these plantations during year t-1 involves the reduction in the productive area in year t. Moreover, the replacement of these old plantations requires at least three years, which explains the negative sign associated with this parameter.

The variable which represents the combined effect of expected price in the short run and old plantations area (lagged one period), has a negative parameter. This can be explained by the fact that the expected price in the short run does not have an effect on the variability of productive areas in view of the fact that the decision of investment can be immediate whereas the adjustment of areas to the desired level can be reached only after a number of periods required to have productive plantations. Indeed, as mentioned before, the increase in old areas leads to a reduction in those areas which are productive in year t.

Farmers' decisions to invest are strongly related to the age distribution of plantations. Thus, the increase in planted areas is also a consequence of the expectations made by farmers about the future age distribution of the plantations and the need for their renewal. In fact, the investment decision is also influenced by other factors related to capital availability. On the other hand, the decision to remove is carried out more quickly than that of planting.

The adjustment coefficient (0.55) shows that the new plantations are lower than the desired level. Indeed, several factors may contribute to limit the programs of new plantations. On one hand, the capital factor, when available would increase the speed of replacement of the less productive plantations by others which are more productive. On the other hand, the directives of the X^{th} Plan aim at reducing the programs of new plantations in the future in order to stabilize the production (MAHR, 2002). This results in a doubt when allocating factors and hence less achievements than expected.

Table 2. Short-run and long-run elasticities (calculated at sample mean)

	Elasticity
Expected areas/Price (SR)	**0.1**
Expected Supply/price (SR)	**0.07**
Expected Supply/price (LR)	**0.13**

SR: Short-run; LR: long-run.

The analysis based on elasticises shows that the price elasticity of yields in the short run is very low (0.07). This result implies that yields are non sensitive to price variations. The estimated yield elasticities with respect to areas is about -0.30. Thus, yields decrease by 3% if areas increase by 10%.

Rainfall influences also the output level. An increase in the rainfall level for the two years previous to harvest, will improve the output level. Thus, yields can be increased by 4.4% if rainfall rises by 10%. Short run elasticity of areas with respect to expected price is about 0.1. Similar results were found by Dellal and Koç (2003) for the Turkish apricot sector. Price elasticity of the productive area, measured by the number of trees was about 0.08 for the short run and 0.18 for the long run.

Short run elasticity of peaches with respect to price is about 0.07. Taking into account an adjustment coefficient of 0.55, long run elasticity is about 0.13, which indicates that the supply is inelastic. This is in agreement with most studies dealing with supply response of perennial crops which found low price elasticity values.

Concluding remarks

This empirical work aimed at examining the supply response of peaches in Tunisia. The methodological approach followed takes into account characteristics pertaining to perennial crops, on the basis of the analytical framework suggested by French and Mathews (1971). Some adaptations were made to the model when formulating price expectations.

The supply response model was represented by three equations. The first two are removal and new plantings, which were used to simulate the area variation and the third was that of yield variation. In spite of some limits related to the availability and quality of the statistical data used in the empirical analysis, the estimation of the various equations led to significant results.

Indeed, the increase in expected prices leads to a growth in planted areas through the renewal of plantations which recorded a significant decline of production and the development of new investments. This increase in the areas of new plantations leads to a competition of these fruit crops with the other fruits and vegetables crops particularly in the use of the production factors.

Farmers' decision to invest depends on the age distribution of plantations. Thus, the increase in planted areas is due primarily to expectations made by farmers about the future age distribution of plantations and the need for renovating their orchards. It should be noted that the decisions of investment are slowed down by many factors related to the fact that most of fruits production is made by small and medium farms who generally face financial problems and difficulties in accessing to credit. On the other hand, the decision of removal seems to be carried out more quickly than that of renewal of the plantations.

Several factors contributed to limit the programs of new plantations during the last few years. It is worth noting that the directives of the Xth plan aimed at limiting new plantations in order to prevent the emergence of large excess production and to support fruit crop diversification. Yields improved in a remarkable way as a consequence of a better control of cropping techniques. However, they still remain dependent on rainfall. On the other hand, supply response to price shows that elasticity is slightly positive, in line with several studies carried out on the analysis of supply response to variations in expected prices. Long run price elasticities are about 0.13.

Finally, assumptions behind the model specification as conducted in this empirical work are to be considered in a context of incomplete information, where individuals perceive market signals and partially integrate them in their decisions. However, investment decisions are conditioned by the decision maker environment. Hence, it is important to consider the possibility of extending this work in a way that allows risk integration into farmers' decisions.

References

Akiyama, T and P.K. Trivedi (1987). Vintage Production Approach to Perennial Crop Supply: An Application to Tea in Major Producing Countries. *Journal of Econometrics*, 36: 133-161.

Davidson, J.H., Hendry, D.H., Srba, F and S. Yeo (1978). Econometric modelling of the aggregate time-series relationship between consumers' expenditure and income in the U.K.. *The Economic Journal*, 88: 661-692.

Dellal, I and A.A. Koç (2003). An econometric analysis of apricot supply and export demand in Turkey. *Turk Journal of Agriculture*, 27: 313-321.

French, B.C., King, G.A and D.D. Minami (1985): Planting and Removal Relationships for Perennial Crops: An Application to Cling Peaches. *American Journal of Agricultural Economics*, 67 (2): 215-223.

French. B.C and J.L. Matthews (1971). A supply response model for perennial crops. *American Journal of Agricultural Economics*, 53(3): 478-490.

Hartley. M.J., Nerlove, M and R.K Peters (1987). An Analysis of Rubber Supply in Sri Lanka. *American Journal of Agricultural Economics*, 69(4): 755-761.

Journal Officiel de la République Tunisienne., Several years. Tunisia.

Ministry of Agriculture and Hydraulic Resources-MAHR., 2002. *Dixième Plan de Développement Economique et Social 2002-2006*. Tunisia.

Ministry of Agriculture and Hydraulic Resources-MAHR., Several years. *Annuaires des Statistiques Agricoles*. Tunisia.

Nerlove, M. (1956). Estimates of the elasticities of supply of selected agricultural commodities. *Journal of Farm Economics* 38(2): 496-509.

Nerlove, M. (1958). On the Nerlove estimate of supply elasticity: A reply. *Journal of Farm Economics* 40(3): 723-728.

Nerlove, M., (1979). The dynamic of supply: retrospect and prospect. *American journal of agricultural economics* 61 (5): 874-888.

Pierani, P. (1996). Modelli di offerta della colture poliennali : una rassegna sullo stato dell'arte. *Discussion paper 16*, progetto finalizzato RAISA, Nucleo monodisciplinare di Siena.