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Effects of New CAP Reform and Trends in Sustainable Olive Growing Systems in Southern Spain

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This contribution analyzes the adoption of integrated and organic olive farming, and the likely impacts of the new CAP reform on diverse olive farming systems in Andalusia, Spain. We use statistical methods for the former and a Positive Mathematical Programming model calibrated with the neutral procedure for the latter. The PMP model compares the situation of the average olive farm in base year with its position in a simulated year using two policy scenarios. Results indicate that the new rules on green payment don't incentive the adoption of sustainable systems, although they don't prevent the development of these systems whose sustained growth seems to be largely independent from market circumstances and agricultural policies. An alternative policy advocating the implementation of green payment scheme in the olive sector would lead to a better redistribution of public support from less to more environmentally-friendly farming practices, contributing to enhance the CAP aids legitimacy.

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1. Introduction

Andalusia is by far the most important olive-growing region in Spain and in the world (around 60% of growing area and 75% of olive oil production at national level, and 15% of growing area and 35% of olive oil production worldwide). Over the last decade it has experienced a significant development of sustainable olive farming, essentially integrated and organic production systems. The expansion of these systems has been largely brought about in detriment of the conventional olive production.

Meanwhile, the new Common Agricultural Policy (CAP) reform for the period 2014-2020 has been agreed recently. The negotiation outcome regarding the application modalities of the reform in Spain establishes, among other things, that all olive farming systems (conventional, integrated and organic) comply *de facto* – i.e. without further obligations - with the greening conditions that entitle to direct payments.

In this context, the present contribution investigates the adoption patterns of integrated and organic olive farming systems in Andalusia over the last years, and how this process could be affected by new CAP scenarios. The adoption process of sustainable (integrated, organic) farming techniques is explored by means of regression procedures, while the likely impacts of new CAP measures are assessed using a Positive Mathematical Programming (PMP) model calibrated with the neutral procedure and where the base year used is 2011 - the last year for which the data needed are available.

Concretely, the PMP model evaluates the impacts of the new policy (all olive farming is under greening) against the potential effect of an alternative policy considering the greening conditions fulfilled only by the integrated and organic farming systems, which admittedly are more environmentally-friendly and already are benefiting from specific agro-environmental support under the previous CAP regime.

The PMP is a technique widely used to study the impacts of public policies on the agricultural sector. However, it does not allow for capturing changes in the surface area distribution of crops that are not due to policy changes, like moves in prices, yields or costs. Therefore it cannot be used to study the crop evolutions due to the process of adoption of new technologies such as are in our case the integrated and the organic olive growing systems.

Section 2 presents, on one hand, the data used to analyse the evolution in the last years of the integrated and the organic olive production systems as well as the variables (essentially prices, yields and costs) that can explain this evolution and, on the other hand, the base year data and the policy scenarios established for the simulations performed with the PMP model. Section 3 describes the methodology followed in this research. It details first the statistical methods used to analyse the evolution of sustainable olive farming systems, and subsequently the characteristics (objective function, equations and calibration procedure) of the PMP model applied. Results are presnted in section 4 and conclusions are drown in section 5.

2. Data and policy scenarios

2.1. Data to analyze the development of the integrated and organic farming systems

Table 1 shows olive producer prices, yields and costs per hectare from 2002 to 2011 in Andalusia. Prices and yields are provided by the Ministry of Agriculture, Food and Environment (MAGRAMA, 2013). Costs are those estimated for the year 2000 in Andalusia by Garcia *et al.* (2008) updated for the following years using the MAGRAMA index of prices paid by farmers. It should be noted that olive oil yield is obtained by multiplying olive yield by 0.213 (transformation coefficient from olives into olive oil).

With respect to farming system areas, Table 2 shows the series from 2002 to 2011 for irrigated and non-irrigated area of the integrated system, and the non-irrigated area of the organic system. The conventional irrigated and non-irrigated area is obtained by subtracting the sum of organic and integrated area from the total area (irrigated and non-irrigated) grown with olive. It should be remarked that the original data sources for conventional and integrated area do not differentiate between irrigated and non-irrigated. As a consequence, we assume for both systems the same percentage distribution of dry and irrigated as is stated for the total area.

2.2. Data for the PMP model

In order to measure the impact of the new CAP 2014-2020 independently from other variables (in particular prices, yields and costs) on the different olive farming systems, the results of the representative PMP farm model described below for the base year 2011 will be compared with the results obtained by simulating new agricultural policies, keeping constant the other variables.

2.2.1. Characteristics of the modelled farm in the base year

Table 3 summarises the characteristics of the average olive farm in Andalusia in 2011. The total irrigated and non-irrigated areas of the average farm correspond to those of the average farm growing olive grove (table olive area is excluded) in Andalusia according to the last Spanish agricultural census of 2009 (INE, 2011). The distribution of the irrigated and non-irrigated land of the different farming systems has been estimated as equal to the proportion of these systems in the irrigated and non-irrigated total area of olive grove in Andalusia, as can be obtained from Table 2. Prices, yields and costs/ha in the conventional farming are those shown in Table 1 for 2011. The yields of integrated and organic productions are considered the same as in the conventional production (Guzman Casado *et al.,* 2002). The olive price is assumed to be for organic 1.2 times and for integrated 1.1 times the conventional, following the studies by Alonso Mielgo and Guzmán Casado (2004) and Alonso *et al.* (2008). According to these studies, the variable costs per hectare of organic and integrated are respectively 1.1 and 1.05 times the conventional[1].

2.2.2. Agricultural policy scenarios

Table 4 shows the agricultural policy measures considered to compare their impacts on the average olive growing farm in Andalusia. The basic source of the measures for the base year 2011 is Mili *et al.* (2013). For this year a reduction of 9% of the total direct payments exceeding 5000 € is applied to the farm in concept of modulation, according to the regulation in force in 2011. The suggested scenarios I and II take into account the general

[1] These characteristics evidence the advantage (higher gross margin per hectare) of organic and integrated systems with respect to the conventional system even without taking into consideration the agro-environmental aids received by the former tow systems.

rule established in the new CAP reform (European Commission, 2013a, 2013b), where only 70% of the total decoupled direct payments existing in the base year are kept in all cases while the remaining 30% are received when greening practices are implemented. In scenario I it is considered - as approved in the new CAP for permanent crops including olive production- that all olive farming systems comply with the greening conditions. Meanwhile in scenario II it is supposed that only organic and integrated farming obtain systematically the 30% of direct payments reserved for greening practices.

3. Methodology

3.1. Methods to study the adoption of integrated and organic farming

The methods used to study this aspect consist essentially in the use of plots, moving averages and regression models to analyze trends in prices, yields and costs, and to investigate whether there is any relationship between them and the trends observed in the evolution of the surface area of the integrated and organic farming systems.

3.2. The PMP model

Let X_{ij} be the area in hectares for crop i (i=1: conventional olive, i=2: integrated olive, i=3: organic olive) on land type j (j=1: dry land, j=2: irrigated land). The model to simulate results with different agricultural policies, prices and costs can be represented as follows:

(3) $$\max: F = \sum_{j=1}^{2} \sum_{i} \left[p_{ij} * y_{ij} + a_{ij} - c_{ij} + \left(\alpha_{ij} + \beta_{ij} * X_{ij} \right) \right] * X_{ij} + XP1 + mod * XP2$$

(4) $$\sum_{i} X_{ij} \quad \leq A_j \quad \left(\lambda_j \right) \quad \forall j$$

(5) $$XP1 + XP2 \quad \leq DP$$

(6) $$XP1 \quad \leq M$$

(7) $$X_{ij}, XP1, XP2 \quad \geq 0$$

Where the following variables are added to X_{ij}:

$XP1$: amount, in €, of decoupled direct payments not liable to be reduced via modulation.

$XP2$*:* amount, in €, of decoupled payments above $XP1$, liable to modulation reductions. In the simulation scenarios $XP2 = 0$.

And where:

p_{ij}, y_{ij}, a_{ij}, c_{ij} : price, in €/kg of olives; yield, in kg/ha; coupled support not subject to reduction by modulation (agro-environmental aids for organic and integrated olive groves in base year to which coupled direct payments are added in simulations), in €/ha; and costs, in €/ha, of crop *i* on land type *j*.

A_j: area, in ha, of land type *j*.

DP: Decoupled payments received by the farm. In the base year and in simulations these payments are: (A_1+A_2) x decoupled payments/ha shown in Table 4.

mod: (100-% of reduction via modulation). This parameter is 0.91 in the base year, where the percentage of reduction is 9%, and 1 in the simulation scenarios where there is not reduction for modulation.

α_{ij} and β_{ij}: parameters to calibrate the model in the base year. Their expressions are shown below.

In the model, expression (3) to be maximized represents the farm's gross margin (including coupled subsidies) plus decoupled aids. It is made up of decreasing gross margin functions for each crop with respect to crop level, as corresponds to the neutral calibration procedure proposed by Röhm and Dabbert (2003)[2]. Equation (4) is the land area constraint, for both dry and irrigated farming. Equation (5) defines decoupled payment dues to the farm before modulation: $XP1$+*XP2*, and equation (6) limits the amount of this payments, *M*, free from modulation reductions. *M* amounts to €5,000 in the base year and is a positive real unrestricted number in the simulations, when no modulation takes place. The lambda in the right of the land constraints represents its dual values.

[2] This calibration procedure appeared to be the most suitable after comparison with the cost average procedure and the use of exogenous elasticities (see Mili *et al*., 2013).

Estimation of parameters α_{ij} and β_{ij}

The Kuhn-Tucker necessary conditions for the optimum solution of the model (3)-(7) at point $X_{ij} = \bar{X}_{ij}$ (with $\bar{X}_{ij}$ being the olive-growing area *i* on land type *j* in the base year) are verified if the following equation holds for all couple *i*,*j*:

$$(8) \qquad \left(\frac{\partial F}{\partial X_{ij}}\right)_{X_{ij}=\bar{X}_{ij}} = \bar{\lambda}_j$$

Where $\bar{\lambda}_j$, is the value of λ_j in the base year.

The proof for a general model can be found in Júdez *et al.* (1998), being the result subsequently used in Júdez et al. (2001) and proved with greater detail in Júdez *et al.* (2002).

Developing $\left(\frac{\partial F}{\partial X_{ij}}\right)_{X_{ij}=\bar{X}_{ij}}$ from equation (3), equation (8) becomes:

$$(9) \qquad \bar{p}_{ij} * \bar{y}_{ij} + \bar{a}_{ij} - \bar{c}_{ij} + \alpha_{ij} + 2\beta_{ij} * \bar{X}_{ij} = \bar{\lambda}_j$$

where $\bar{p}_{ij}$, $\bar{y}_{ij}$, $\bar{a}_{ij}$ and $\bar{c}_{ij}$ are the values of p_{ij}, y_{ij}, a_{ij} and c_{ij} in the base year and where $\bar{\lambda}_j$ is the opportunity cost of the land type *j* that year.

The estimate of the objective function parameters, using (9), to calibrate the model requires a previous estimate of the opportunity costs of resources (irrigated and non irrigate land in this case). In the traditional application of the PMP, this estimate is performed by means an auxiliary LP with calibration constraints in the so-called first step of the PMP (Howitt, 1995). The use of this first step has two weaknesses: i) the marginal crop (the crop with lowest gross margin) has no quadratic term in the objective function (the calibration with exogenous elasticities does not have this inconvenient), and ii) it is not possible to include *a priori* values of the opportunity cost of resources. In the present paper these problems are avoided through skipping the first step of the PMP using only the necessary conditions of Khun-Tucker (equation (9) in this case) to estimate the parameters (see Buysse et al., 2004; Júdez *et al*., 1998, 2001), considering as opportunity cost of land its yearly rental price in Andalusia for olive farming, which according to MAGRAMA (2013) amounts to 301 €/ha in 2010 (last figure available) for the non-irrigated land. For the irrigated land it has been estimated to 600.19 €/ha taking into account the relationship between the yearly rental prices of irrigated and non irrigated land considered in Mili *et al.* (2013). The yearly rental prices obtained are compatible with the necessary condition: $\bar{\lambda}_j \leq \min_i \left(\bar{p}_{ij} * \bar{y}_{ij} + \bar{a}_{ij} - \bar{c}_{ij} \right)$ to have decreasing marginal gross margin for crops in the objective function.

Now Equation (9) has two parameters to be determined, so there is an infinity number of values of α_{ij} and β_{ij} satisfying (9). To obtain a unique solution for these parameters a new equation has to be added. To solve this problem in the neutral calibration the following equation (10) proposed by Röhm and Dabbert (2003)[3] is added:

$$\alpha_{ij} + \beta_{ij} * \bar{X}_{ij} = 0 \quad (10)$$

From (9) and (10) the expressions of α_{ij} and β_{ij} are:

$$\beta_{ij} = \left[\bar{\lambda}_j - \left(\bar{p}_{ij} * \ \bar{y}_{ij} + \bar{a}_{ij} - \bar{c}_{ij}\right)\right] / \bar{X}_{ij}$$

$$\alpha_{ij} = -\beta_{ij} * \bar{X}_{ij}$$

It is to be noticed that equation (10) allows the results of the model for the base year to recover the gross margin plus the total aids existing actually this year.

4. Results

4.1. Adoption of integrated and organic farming

The results presented in this section were obtained using XLSTAT.

4.1.1. Trends in prices, yields and costs

[3] The main contribution of this paper of Röhm and Dabbert is not the proposal of the neutral calibration, but the introduction of specific calibration constraints in the linear programming model of the first step of PMP to achieve more realistic substitution between different variants (farming technologies) of a crop when other crops are present. The proposal cannot be applied in this research because the farm area can only be occupied by the different variants of olive growing.

The trends of prices, yields, and costs of Table 1, as well as in the series of revenue per hectare without aids in non-irrigated (rd=p*yd) and irrigated (ri=p*yi) area are presented in the Plots A1-A7 in Appendix 1.

The 3-years moving average of prices and yields (Plots A1-A3) evidences how prices fall when yields increase and vice-versa. Also it can be noticed that oscillations of prices and yields are transmitted to oscillations in the revenue without aids (Plots A4 and A5). However, regressions of revenues by time show horizontal lines in accordance with a stable trend in the studied period. Meanwhile, in this period costs present a constant increase as shown by the very good fit of the linear regression of costs by time (Plots A6 and A7).

Taken into account all these trends it can be asserted that, overall, olive production in Andalusia takes place in a context of stable revenue (at current prices) and increased costs. Nevrtheless as illustrated in Plots 1 and 2, the gross margin per hectare (excluding political aids) both in the non irrigated (gmd=rd-cd) and in irrigated (gmi=ri-ci) area are non-significantly decreasing due to the strong variations along the time of the revenue per hectare.

4.1.2. Trends in integrated and organic olive farming areas

Plots 3 and 4 present the evolutions of the organic and the integrated area, which corresponds to the series shown in Table 2, considering aggregated the dry and the irrigated area of the integrated farming, as well as the linear models that fit these evolutions.

The following equations (1) and (2) are the expressions of these models.

(1) $sor_t = 30302.67 + 1908.87t + e_t \qquad R^2 = 0.82$

(13.30) (5.95)

(2) $sin_t = -26146.72 + 26488.13t + 39609.42D_t + e_t \qquad R^2 = 0.99$

(-3.05) (13.07) (3.33)

Where: sor_t and sin_t are the area of organic and integrated systems, respectively, in the year t, e_t is the residual in the year t, R^2 is the determination coefficient, and in brackets are the t-statistics. D is a dummy variable such as:

$$D_t = \begin{cases} 0 & if \quad t < 6 \\ 1 & if \quad t \geq 6 \end{cases}$$

These adjustments show the sustained increase over time of both type of farming. This increase seems to be independent of prices and yield. It appears as if the more interesting gross margin per hectare of the organic and integrated farming compared with the conventional farming was driving to a continuous increase of the former two production systems, probably reflecting the process of adoption of these two new production techniques replacing the conventional farming.

Moreover, the studied period has not witnessed any relevant new regulation applying to public support to organic production system. However regulation has changed for the integrated system through the implementation of the Royal Decree 1203/2006 governing subsidy allocation modalities for environmentally-friendly agricultural production systems. This could probably explain the step in integrated production area between 2005 and 2006 described statistically by the dummy variable, D, in equation (2) (see Plot 4). It also could demonstrate that the allocation of new aids, contrary to prices and yields, affect significantly the trend of the adoption of a new production technology.

4.2. PMP model results

First it should be recalled that the results of PMP models are obtained under the hypothesis that the unit modeled (the farm in this case) is in equilibrium in the base year, i.e. the distribution of crops will not change if prices, costs, yields and policy measures remain constant. In this regard, the sustained increase observed in section 4.1 in the area of integrated and organic farming during the analyzed period - which is. independent from the over-mentioned parameters - is not taken into account in the variations of results for different simulations with respect to the base year presented in Table 5. These variations only capture the changes due to the implementation of agricultural policies simulated, i.e.

prices, costs and yields are considered constant. All PMP results were obtained using GAMS.

For scenario I (all systems benefit from the greening aids), Table 5 shows that there is no variation in the area of different farming systems with respect to the base year. The gross-margin-without-aids does not vary. The subsidies increase slightly due to the fact that the agricultural policy for this simulation does not consider the reduction for modulation (€85.29) included in the base year.

It also can be observed in Table 5 that there are in simulation II (only integrated and organic systems receive greening aids) increases of integrated and organic farming areas in detriment of the conventional farming area. This variation in the distribution of area on the farm is associated with a decrease of total aids by nearly 20% as consequence of the 30% loss of decoupled aids, being recovered as coupled aids in integrated and organic farming but not recovered in conventional farming because in simulation II it is supposed that this system does not benefit from greening aids. The consequence of this fact is a decrease in gross margin plus aids by 9%.

5. Conclusions

The present investigation shows that the area of both the integrated and organic olive farming systems in Andalusia have had a continuous increase in the period 2002-2011. This growth has been achieved in detriment of the dominant conventional system and independently of the evolution of prices, yields and agricultural policy measures. In case of the integrated farming system, it appears that new policy proposals cause a short-term boost to this growth. The evolution of the integrated and organic farming area mainly can be considered as the consequence of the adoption process of these relatively new technologies (farming practices) that are more profitable than the replaced technology (the conventional farming system).

The simulations performed show that with the new CAP establishing that all olive farming systems fulfill *ex-ante* the conditions to perceive the green payments, there will be no changes in the distribution of farm area for the three systems nor in the aids received.

Conversely, if the organic and integrated farming systems are under green payments while the dominant conventional farming cannot benefit from such support, the area cultivated under the integrated and organic systems could increase significantly with the ensuing decrease in the area occupied by the conventional system. This substitution between farming systems is associated with losses in the total aid received, which in turn cause a decrease in the farm benefits.

Arguably, the distribution rules of the green payment agreed in the new CAP do not incentivise the adoption of integrated and organic growing systems. An alternative policy advocating the implementation in the olive sector of a green payment scheme equivalent to the rest of crops - a possible scenario in prospective CAP reforms according for instance to Matthews (2014) - could have a further positive effect in terms of redistribution of aids from less (conventional) to more (integrated, organic) environmentally friendly farming practices. This would contribute to better rewarding the public goods generated through such public aids (better environment and product quality), in addition to boosting the legitimacy of the CAP financial aids. The drawback of this option is a partial loss of aids and gross margin for the olive growing sector.

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Table 1: Prices, yields and costs of olive production in Andalusia, 2002-2011.

Year (t)	Prices (€/100 kg): p	NON IRRIGATED		IRRIGATED	
		Yields (100kg/ha): yd	Costs (€/ha): cd	Yields (100kg/ha): yi	Costs (€/ha): ci
2002 (2)	39.93	20.86	565.68	40.69	828.64
2003 (3)	45.58	39.21	583.18	62.02	857.54
2004 (4)	50.12	25.39	600.59	44.12	881.90
2005 (5)	63.41	17.01	621.54	34.52	909.10
2006 (6)	77.57	27.85	646.31	49.23	949.88
2007 (7)	54.06	30.02	680.20	52.39	998.95
2008 (8)	49.67	25.72	804.95	44.77	1155.12
2009 (9)	39.55	35.69	772.45	53.75	1117.99
2010 (10)	39.81	34.94	761.35	56.01	1113.00
2011 (11)	37.72	40.16	816.66	57.76	1189.11

Table 2: Area of different farming system in Andalusia (hectares), 2002-2011.

Year (t)	Conventional		Integrated		Organic
	Dry	Irrigated	Dry	Irrigated	Dry (total)
2002 (2)	1097403	237475	31412	6798	31517
2003 (3)	1033981	261734	46597	11795	37588
2004 (4)	1015266	256041	62730	15820	40868
2005 (5)	1009438	261895	72329	18766	41516
2006 (6)	957768	248641	128258	33296	42148
2007 (7)	924174	238748	154010	39786	42336
2008 (8)	895497	234753	186068	48777	41557
2009 (9)	882689	229010	201133	52183	46648
2010 (10)	867307	234735	219164	59316	46902
2011 (11)	840688	232987	242479	67201	56023

Table 3. Characteristics of the average farm.

Farming system	Area (ha)	Yields (100 kg olives/ha)	Prices (€/100 kg olives)	Variable costs (€/ha)
Dry farming	*5.811*			
Conventional	4.288	40.16	37.72	816.66
Integrated	1.237	40.16	41.49	857.49
Organic	0.286	40.16	45.26	898.33
Irrigated farming	*1.966*			
Conventional	1.526	57.76	37.72	1189.11
Integrated	0.440	57.76	41.49	1248.57

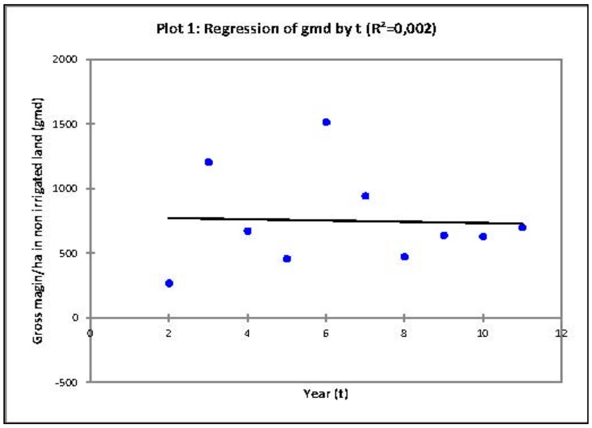
Table 4. Agricultural policy measures in base year and scenarios.

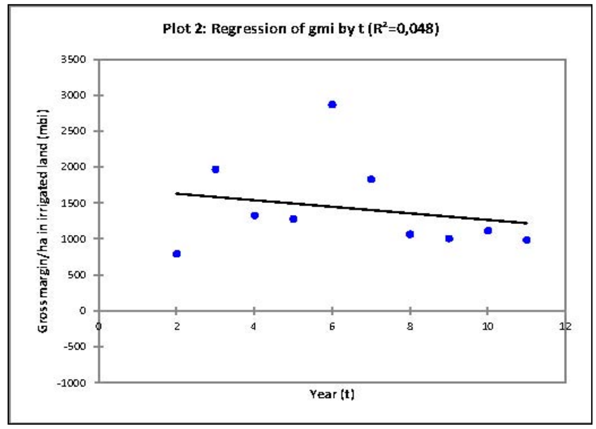
Type of support	Base year (2011)	Scenario I: all systems are under green payments	Scenario II: Only organic and integrated are under green payments
Decoupled direct payments	764.78 €/ha	535.35 €/ha	535.35 €/ha
Greening suport			
Conventional production		229.43 €/ha	0.00 €/ha
Organic production		229.43 €/ha	229.43 €/ha
Integrated production		229.43 €/ha	229.43 €/ha
Agro environmental support (coupled)			
Organic production	266.85 €/ha	266.85 €/ha	266.85 €/ha
Integrated production	49.14 €/ha	49.14 €/ha	49.14 €/ha

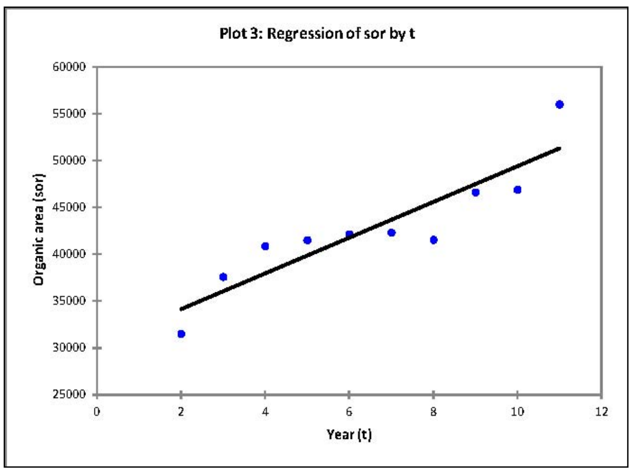
Table 5. PMP model results.

	Base year 2011	Simulations (% variation with respect to base year)	
		Scenario I: All systems are under green payments	Scenario II: Only organic and integrated are under green payments
Area			
Conventional dry farming (ha)	4.29	0.00	-5.51
Integrated dry farming (ha)	1.24	0.00	16.67
Organic dry farming (ha)	0.29	0.00	10.49
Conventional irrigated farming (ha)	1.53	0.00	-4.67
Integrated irrigated farming (ha)	0.44	0.00	16.17
Subsidies			
Coupled aids (€)	158.67	1124.55	341.89
Decoupled aids before modulation (€)	5947.69	-30.00	-30.00
Modulation reduction (€)	85.29	-100.00	-100.00
Decoupled aids after modulation (€)	5862.40	-28.98	-28.98
Total aids after modulation (€)	6021.07	1.42	-19.21
Gross margin and objective function			
Gross margin without aids (€)	6272.47	0.00	0.65
Gross margin plus aids (€)	12293.54	0.69	-9.08
Objective function (€) (1)	12293.54	0.69	-9.87
Ratios			
Total aids/ha (€)	774.22	1.42	-19.21
Gross margin plus aids/ha (€)	1580.76	0.69	-9.08
Total aids/Gross margin plus aids (%)	48.98	0.72	-11.14

(1) Gross margin plus aids with quadratic function.


Plot 1: Regression of gmd by t (R²=0,002)
Gross magin/ha in non irrigated land (gmd)
2000
1500
1000
500
0
-500
0
2
4
6
8
10
12
Year (t)


Plot 2: Regression of gmi by t (R²=0,048)
Gross margin/ha in irrigated land (mbi)
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
0
2
4
6
8
10
12
Year (t)


Plot 3: Regression of sor by t
Organic area (sor)
60000
55000
50000
45000
40000
35000
30000
25000
0
2
4
6
8
10
12
Year (t)


Plot 4: Regression of sin by t and D
Integrared area (sin)
400000
350000
300000
250000
200000
150000
100000
50000
0
-50000
0
2
4
6
8
10
12
Year (t)

Appendix 1. Trends of prices, yields, revenues and costs.