ADOPTION OF SOIL EROSION CONTROL PRACTICES IN SOUTHERN SPAIN OLIVE GROVES

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Poster **paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006**

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Abstract

This paper presents results from a survey carried out in 2005 among 147 olive tree farmers from the Alto Genil River Basin in Southern Spain regarding the adoption of soil conservation and management practices. Olive tree groves in South-eastern Spain's mountainous areas are subject to a high risk of soil erosion and have to incur in high costs of soil conservation. This results in great difficulties to comply with cross-compliance and to benefit from agri-environmental schemes. Our main objectives are to analyse the current level of adoption of soil conservation practices and to analyse which socio-economic and institutional factors determine such adoption. Three Probit models are estimated. Dependant variables are three different soil conservation practices, namely tillage following contour lines, maintaining the rests of pruning on the ground, and non-tillage with weedicides.

Key words: olive groves, soil erosion, soil conservation, cross compliance.

JEL Codes: Q12, Q24

1. The economics of soil erosion

Soil erosion is a main agricultural externality and a main threat for sustainability in agricultural systems, as it reduces the potential for agricultural production. The on-site effect of soil erosion is twofold. First, it reduces soil fertility, and therefore results in a loss of crop productivity. Second, it increases production costs to maintain the level of agricultural production in the farm. Production costs may rise because of increased costs of current agricultural practices or because increased costs due to new practices required (soil conservation, soil amendment, etc.). In both cases, soil erosion results in a land rent loss and in a productive capital loss that may result in a decline in the market value of eroded land.

Regarding the social effects of soil erosion, the main one being the pollution effect of sediment load in water courses, it is evident that there are clear social benefits from soil conservation, which reduces externalities and off-side damages (such as reduction of sediment in rivers, chemical damage to fish, etc.). These social benefits may warrant conservation even when private profitability is absent (Walker, 1982; Araya and Asafu-Adjaye 1999), and different effective instruments can be used to incentive erosion control McConnell (1983).

Farmers' perception of the problem of soil erosion, its costs and benefits, is key to determine the adoption of soil conservation practices. The literature shows that farmers are aware of the problem, although there are many factors that cause farmers not to care about soil erosion. The main reason because farmers are quite often not concerned about soil loss is that they can substitute other inputs for soil depth (Wade and Heady, 1978). This causes the failure to incorporate long term soil use benefits in their utility function (Lee, 1980). In general, the costs of conservation practices exceed benefits in the short run, though being profitable on the long run, what discourages adoption by farmers. The negative effects of soil erosion (or the benefits of soil conservation practices) take place in the long run, while the costs of conservation practices are incurred in the short run.

Farmers responses to soil erosion will depend on many diverging factors, both technical (cropping patterns, slopes, type of soil, etc) and socio-economic (farmers' age, skills, wealth, etc). One option is to do nothing, maintain the same technology, practices and level of input use, what leads to a continued soil loss and a decline in agricultural production. A second option is to intensify production substituting other inputs (such as fertilisers) for topsoil depth, what generally worsen soil loss and increases production costs. A third option is to adopt new practices to conserve soil, what may have a negative economic effect on the short run but o positive one in the long run, although ambiguous evidence exists in this sense. Last, he may regenerate topsoil, incurring in even larger costs.

Since the 1950s, a lot of attention has been paid to the factors that determine the adoption of soil conservation practices by farmers (Ervin and Ervin, 1982). Conventional adoption analysis use probit or logit models to analyse those factors that determine the decision process of whether to adopt or not, and to which extent, conservation practices (related to farm and operator characteristics, or even variables of the perception of soil erosion by farmers). Some examples are the studies by Ervin and Ervin (1982), Norris and Batie (1987), Gould et al. (1989), Lohr and Park (1995), Shively (1997), Shiferaw and Holden (1998), Lapar and Pandey (1999) and Pattanayak and Mercer (1998).

An important group of factors adoption soil conservation practices relate to the soil characteristics and the time frame of adoption. Most studies show that in deeper soils the incentive to conserve appears on the long run, as topsoil is lost and the yield function exhibits diminishing marginal returns to topsoil depth. Incentives are far more appealing for steeper slopes and more eroded lands (Walker, 1982). A second main factor is the investment costs of adopting conservation practices, that are generally lower in areas with smaller risk of soil erosion and/or less steeped slopes, where benefits usually surpass costs. In general, benefits of adoption are smaller than the costs of adoption, especially at the short run. Investment costs are also affected by aspects such as the loan repayment conditions, interest rates, etc.

Another important factor is the relationship between potential erosion and land productivity, and to which extent conservation practices affect agricultural production and farm profits. If soil erosion reduces farm profits, conservation practices are more likely to be adopted. This probability increases the more these practices reduce erosion. However, Valentin et al. (2004) found evidence for the United States of no positive relationship between the adoption of soil conservation practices and farm profitability.

Other factors commonly found in the literature to be related with the adoption of soil conservation practices are the level of non-farming income, labour and/or machinery availability, land tenancy issues (property incentives adoption and investment), the level of risk aversion, continuity of sons/relatives in farming, and the existence of public programmes. Last, lower income farmers are usually more concerned with short term survival than with the long term benefits of soil conservation.

2. Soil conservation practices in Spanish olive groves

Farmers that are eligible for their participation on the Rural Development Programmes must comply with the Good Farming Practices establishes by each country. For permanent crops, such as olive, vineyards or nut trees, the Spanish legislation establishes the obligation to plough following contour lines, to establish certain crop rotations and some area specific recommendations depending on soil type, climate, slopes, etc.

The requirements that farmers with permanent crops must comply with to participate in the Agri-Environmental soil erosion scheme established by Royal Decree 4/2001 include the Good Farming Practices above plus: maintaining natural vegetation on parcel borders, maintaining stonewalls, hedgerows, terraces, restrictions to type of plough and weed control, maintaining vegetation in rowlines (50% cover) for slopes higher than 8%, no ploughing from harvest to pre-sowing, and other bureaucratic requirements.

More recently, the European Council Regulation 1782/2003 has established the main common provisions for the Cross Compliance applicable to the direct payments regime of the European Common Agricultural Policy[1]. It establishes that any farmer receiving direct payments shall respect the provisions of 18 European Directives in the areas of public, animal and plant health, environment and animal welfare and to keep his land in good agricultural and environmental condition (Annex IV) (Varela-Ortega and Calatrava, 2004). The minimum requirements for Good Environmental and Agricultural Condition cover four issues, namely: Protecting soil from erosion, maintaining soil organic matter, maintaining soil structure, and ensuring a minimum level of maintenance and avoiding deterioration of habitats.

In the case of Spain, the Royal Decree 2352/2004 is the main legal act to address cross compliance at national level. It lists a series of detailed standards for the four main issues included in Annex IV. The Good Agricultural and Environmental Conditions related to soil conservation for permanent crops have been established as follows:

a) For the avoidance of soil erosion, ploughing must be adapted to slope conditions. That implies the prohibition of any type of ploughing on slopes higher than 15%, with exceptions for crops on terraces, conservation ploughing, maintenance of a 100% vegetation cover, and parcels of less than a hectare or with complex shapes. Vegetation cover strips transversally to the line of maximum slope must be maintained in all farms. Last, terraces must be kept in good condition.

b) For the maintenance of soil organic matter and soil structure, burning stubbles, and working or driving on swamped/flooded or snow covered land is forbidden. There will be also rules at the regional level for the removal of the remains form pruning.

Cross compliance aims to prevent further environmental damage, reinforcing legislative environmental standards, while agri-environment schemes fund maintenance and/or enhancement. Cross compliance may impose a large burden for marginal and less profitable farms, such as those in mountainous areas where the risk of environmental damage is higher. For example, in Mediterranean regions marginal costs of abatement are usually larger for more erosive lands, so cross compliance may favour agricultural land where

[1] Council Regulation (EC) No 1782/2003 of 29 September 2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers. Office for Official Publications of the European Union, Luxemburg

marginal social benefits of erosion control are smaller. Therefore, there may be a risk of increased land abandonment due to a rise of farm costs to comply with new standards.

In the Spanish southern Mediterranean regions, where erosion is the major environmental problem, cross compliance programs tend to neglect important factors that affect the adoption of certain soil conservation practices. Calatrava et al. (2005) analyse the adoption of soil conservation practices in the Spanish Southern provinces of Granada and Jaén, using data from a 2003 survey to 223 olive farmers. They find that the main soil conservation practices in the area are non-tillage (50.67%), tillage following contour lines (26.46%) and maintenance of stonewalls (18.83%). The number of farmers that have adopted non tillage in these provinces has almost tripled during the nineties, passing from 4% in 1989 to more than 50% in 2003. On the contrary, the proportion of olive farmers that practice tillage following contour lines, maintain stonewalls, or perform other less common conservation practices, has barely increased in the last decade.

Calatrava et al. (2005) also find that no tillage is more likely to be adopted by younger farmers and in those farms that rely in family labour. Similarly, ploughing following contour lines is more likely to be adopted by younger farmers that come from a family of farmers and have been always in the activity, that are good managers, well informed, users of local Agricultural Extension Services, and open to new technological innovations.

Stonewalls used to be a traditional practice in South-eastern Spain, but it is not a really profitable one. The more profitable farms are the ones more likely to maintain stonewalls, as they can bear the costs of maintenance regardless of its profitability (Calatrava et al., 2005).

The present paper shows some results from a survey carried out in 2005 among 147 olive tree farmers from the Alto Genil River Basin in Southern Spain regarding the adoption of soil conservation and management practices. Olive tree groves in mountainous areas are subject to a high risk of soil erosion and have to incur in high costs of soil conservation. This results in greater difficulties to comply with cross-compliance and to benefit from agri-environmental schemes. We analyse the current level of adoption of soil conservation practices and to analyse which socio-economic and institutional factors determine such adoption. Three Probit models are estimated. Dependant variables are three different soil conservation practices, namely tillage following contour lines, leaving the vegetal remains of pruning operations on the ground, and non-tillage using weedicides.

3. Methodology

The decision to adopt or not a particular soil conservation practice was analysed using several probit models, one for each relevant soil conservation measure in the area of study. Models were estimated using a logistic regression procedure using maximum likelihood estimation.

The primary information used in this paper was gathered from a survey to 147 olive tree farmers (82184 trees and 1258 hectares) in the Alto Genil Basin, one of the main olive producing areas in Spain. The survey questionnaire included three sections and 36 questions that asked for: characteristics of the farm (area, number of trees, slopes, yields, ownership, etc.), perception of soil erosion by the farmer, technical issues (conservation practices, use of advisory systems, etc.), participation in agricultural policy programmes, managerial and farm planning issues (labour, machinery, accounting, planning of activities, etc.), and socio-demographic characteristics (age, education, agricultural training, risk attitudes, etc.)

Farms surveyed include both irrigated and non-irrigated olive groves (11% of farms are irrigated). The average farm size is 8.56 hectares. Only a mere 9% of farms are leased, while 91% are owned by the farmer himself. The slope of parcels is high for 46% of surveyed farms, low for 15% and medium for 39%.Only 2% of olive groves are located in terraces, while 92% are located in slopes without terraces and 6% in valleys and lowlands.

The main soil conservation practices in the area are non-tillage with application of weedicides, that is adopted by 87% of the surveyed farms, tillage following contour lines (13% of the farms), and maintaining the rests of pruning operations on the soil as mulching (34% of farms). Other conservation practices, such as maintenance of vegetation covers, terrace building or maintaining stonewalls are only adopted by a minority of farmers, and have not been considered in the probit models estimated.

The number of farmers in the area that have adopted tillage following contour lines is quite low (13%), although it has doubled in the last decade, as shown in figure 1. However, it has to be taken into account that 87% of surveyed farmers in the area have adopted non tillage with weedicides, and that the remaining 13% perform tillage following contour lines.

Figure 1. Adoption process of tillage following contour lines (percentage of adopters)

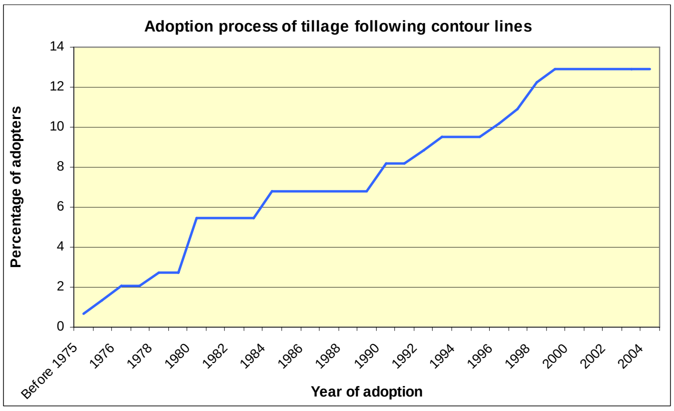
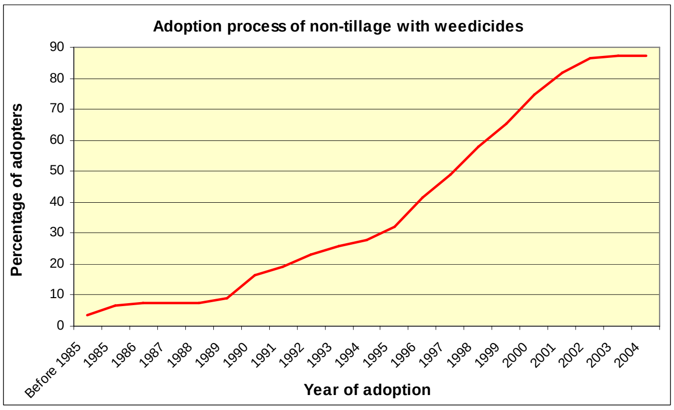
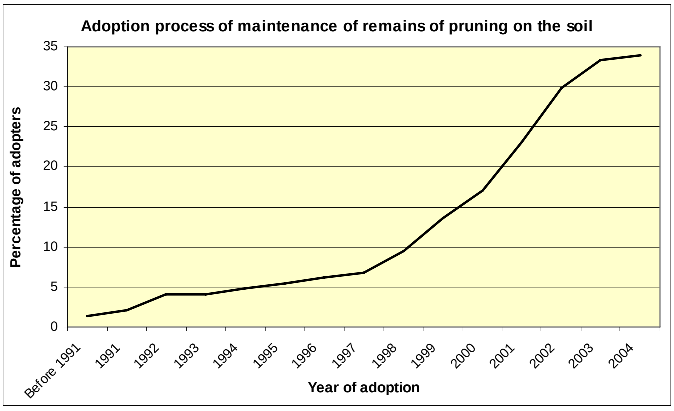


Figure 2. Adoption process of non tillage with weedicides (percentage of adopters)



The number of farmers that have adopted non tillage (with application of weedicides) has been on the rise during the nineties, as shown in figure 2. While the percentage of farmers in the area that practiced non tillage in 1989 was 9%, this figure has almost tripled in the last decade, passing from 32% in 1995 to 87% of farmers in 2005. None has ever adopted non tillage without application of weedicides.

Figure 3. Adoption process of mulching using the remains of pruning (percentage of adopters)



Regarding the adoption of mulching using the remains of pruning, the number of adopters has increased enormously during the last decade (figure 3). Barely a couple of farmers practised it at the beginning of the nineties, while only a 5% did in the 1995. In 2005, a 34% of farmers in the area have adopted this soil conservation practice.

Once the survey data was filtered and validated, a bivariate Chi-Square test analysis was conducted to see which variables were related to the adoption of conservation practices. Variables not related were discarded and not included in the multivariate probit models estimated. Table 1 shows both the dependant and explanatory variables (either continuous or dummy ones) used in the estimation of probit models, as well as their different levels.

Table 1. Description of variables used in probit models

DEPENDANT VARIABLES		Mean
RESTPOD	1= Farmer leaves the remains of pruning on the ground 0= Otherwise	0.3401
NLHERB	1= Non tillage with weedicides 0= Otherwise	0.8707
LABCURV	1= Tillage following contour lines 0= Otherwise	0.1293
EXPLANATORY VARIABLES		
HAOLIV	Area of the olive grove (continuous)	5.3908
PTE	Slope: 1= Low 2= Medium 3= High	2.3082
ANTIG	Oldness of the farm (years being cultivated)	45.8425
HERED	1= The farmer inherited the farm 0= Otherwise	0.5137
CONTB	Maintenance of farm accounts: 1= Yes; 0= No	0.7123
BFOHA	Farm profit per hectare (euros)	834.7581
EROGEN	Perception of the gravity of soil erosion problem by the farmer as: 1= Very serious; 2= Quite serious; 3= A bit serious	1.8493
SUBPOD	Cost of the practice of leaving the remains of pruning on the ground, expressed by each farmer (euros per hectare)	150.1027
SUBHERB	Cost of the practice of non-tillage with weedicides, expressed by each farmer (euros per hectare)	181.7945
SUBCURV	Cost of the practice of tillage following contour lines, expressed by each farmer (euros per hectare)	77.6027
EDAGR	Age of the farmer (years)	51.9452
DEDIC	Percentage of total farmer's income that comes from agriculture: 1= Total (more than 80%) 2= Agriculture is the main activity (50-80%) 3= Agriculture is a secondary activity (20-50%) 4= Agriculture is a marginal activity (less than 20%)	2.6027
CONTIN	1= Some relative will continue with the olive farming activity 0= None relative Hill continue with the farm	0.7603
RIESG	Risk attitude of the farmer: scale from 1 (very risk averse) to 10 (barely risk averse)	6.4932
VISIT	1= Farmer uses the local Agricultural Extension Services (AES) 0= Farmer does not uses the local AES	0.6849

5. Results

The three probit models of adoption of soil conservation practices estimated are presented in table 2. In the three cases, the likelihood ratio test indicates that models are significant (p=0.0000). A high percentage of sampled cases were correctly classified in the three models (78.08%, 92.47% and 91.1% respectively), what indicates a good fit and a high discriminant performance of the models.

Results for the first model indicate that the probability of the farmer adopting the practice of leaving the vegetal remains of pruning operations increases when the farmer maintains farm accounts (CONTB variable). On the other hand, the probability of adoption of the farmer maintaining remains of pruning decreases: 1) when the farmer inherited the farm from a relative (HERED variable); 2) the larger the cost of the practice that the farmer expresses is (SUBPOD variable).

Table 2. Estimated probit models of adoption of soil conservation practices

	Dependent variable		
	Maintenance rests of pruning	Non tillage with weedicides	Tillage following contour lines
Independent variable	**Coefficients**	**Coefficients**	**Coefficients**
CONSTANT	-4.1857 (-2.566)***	2.3685 (1.081)	-2.8528 (-1.095)
HAOLIV	0.0027 (0.171)	0.0339 (0.545)	-0.0018 (-0.030)
PTE	0.1677 (0.880)	0.7261 (2.529)***	-0.8435 (-2.486)**
ANTIG	0.0085 (1.545)	0.0176 (1.625)	-0.0158 (-1.213)
HERED	-0.5646 (-1.914)*	-0.3022 (-0.588)	0.0754 (0.133)
CONTB	1.3043 (3.279)***	0.5794 (1.267)	-0.5641 (-1.125)
BFOHA	0.0002 (0.847)	-0.0001 (-0.458)	0.0002 (0.711)
EROGEN	-0.3243 (-1.299)	-1.2609 (-2.851)***	1.6952 (3.061)***
SUBPOD	-0.0046 (-2.056)**	--	--
SUBHERB	--	-0.0054 (-1.584)	--
SUBCURV	--	--	0.0103 (3.027)***
EDAGR	0.0229 (1.597)	-0.0458 (-2.017)**	0.0517 (1.865)*
DEDIC	0.2026 (1.459)	-0.0661 (-0.312)	0.3105 (1.240)
CONTIN	0.3944 (1.229)	1.0673 (2.210)**	-1.2571 (-2.436)**
RIESG	0.1538 (1.484)	0.2997 (2.363)**	-0.5274 (-3.210)***
VISIT	0.3806 (1.150)	-0.1982 (-0.403)	-0.7230 (1.193)
Nº of observations	146	146	146
Likelihood ratio	44.81285***	46.47226***	56.03815***
Degrees of freedom	13	13	13
% correct predictions	0.7808	0.9247	0.9110

Asymptotic t-ratios in parentheses. Significance at: * p≤0.1, ** p≤0.05, *** p≤0.01

Results for the second model indicate that the probability of the farmer adopting non-tillage with weedicides increases with the following factors: 1) The slope of the farm (PTE variable); 2) the less risk averse the farmer is (RIESG variable); 3) a relative of the farmer intends to continue with the farming activity (CONTIN variable). On the contrary, the probability of the farmer adopting non-tillage with weedicides decreases with the following factors: 1) The age of the farmer (EDAGR variable); 2) the less the soil erosion problem is perceived as a very serious one by the farmer (EROGEN variable).

Last, results for the third estimated model indicate that the probability of the farmer adopting tillage following contour lines increases with the following factors: 1) the less the soil erosion problem is perceived as a very serious one by the farmer (EROGEN variable); 2) The age of the farmer (EDAGR variable).

On the other hand, the probability of the adoption of tillage following contour lines decreases with the following factors: 1) The slope of the farm (PTE variable); 2) A relative of the farmer intends to continue with the farming activity (CONTIN variable); 3) farmer's risk attitudes (RIESG variable).

5. Conclusions

The adoption of soil conservation practices among the 147 surveyed olive tree farms in the Alto Genil River Basin, a mountainous area in Southern Spain, is quite high. In fact, all farmers surveyed have adopted some measure to conserve their soil. An 87% of farmers perform non-tillage with application of weedicides. This figure is larger than that in Calatrava et al (2005), what can be explained because average slope of farms in our area of study is greater than that in the above mentioned study (the provinces of Granada and Jaén). In areas with higher slopes the costs of tillage are greater, what probably incentives the adoption of conservation tillage or no tillage. In fact, the probability of the adoption of this practice is positively related with farm slope.

Non tillage was a marginal practice in the eighties, but the number of adopters started to grow slowly in the early nineties and quite quickly in the late nineties. Some factors behind this increase are the role played by research and extension services in developing and diffusing non tillage techniques, as well as the larger increase in tillage costs in higher slopes that results form the increase in oil prices.

Non-tillage is also more likely to be adopted by younger farmers and when there is some relative that intends to continue with the activity, what causes the farmer to incorporate long term in his farming decisions. In that sense, Calatrava et al (2005) found that the probability of adoption of non tillage increases in farms where family labour is predominantly used. Favouring younger people to enter or to continue with the family farming activity may therefore incentive this type of soil conservation practice.

The remaining 13% of farmers that do not adopt non tillage perform tillage following contour lines, which is the most basic measure for soil conservation. Tillage following contour lines is one of the Good Farming Practices to be complied with to be eligible for participation in the European Rural Development Programmes (unless no tillage is practised). As this practice is performed by all farmers that do not adopt non tillage, some of the results are the opposite of those found for non tillage. For example, farm slope is negatively related with the adoption of tillage following contour lines, probably because the costs of this operation increase with slope, and because non tillage has become a preferred option for more steeped areas.

Similarly, younger and less risk averse farmers, as well as those with a relative intending to continue with farming, are less likely to adopt tillage following contour lines. This contrast with results found by Calatrava et al (2005), but our results can be explained because these farmers seem to opt for non tillage that is not a complementary technique but a purely alternative one. Furthermore, farmers that perceive soil erosion as a not very serious problem opt for tillage following contour lines, probably because they do not see the interest of non tillage, and therefore they choose tillage following contour lines to comply with the Good Farming Practices requirements.

More than a third of the farmers have adopted the practice of leaving the remains of pruning operations as mulching. Farmers have traditionally been very reluctant to this practice that has increase enormously since the late nineties probably as a consequence of European policies. The adoption of this practice can hardly be explained by the variables considered in the analysis. However, it has being found that the probability of it s adoption decreases when the farmer inherited the orchard, that is he comes from a family of farmers and, as commented before, this practice has not traditionally being as an adequate one.

Other quite effective conservation practices, such as maintenance of vegetation covers or terraces building are only adopted by a minority of farmers.

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