Adoption and diffusion of no tillage practices in Southern Spain olive groves

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***Abstract*— This paper analyses the process of adoption of no tillage in South-eastern Spain's olive groves. Olive tree groves in South-eastern Spain's mountainous areas are subject to a high risk of soil erosion, which is the main environmental problem for this crop, and have to incur in high costs of soil conservation. This results in a greater difficulty to comply with the practices required to benefit from both the single payment and agri-environmental schemes. In many high-steeped areas, farmers have opted for non-tillage practices as an alternative to other conservation practices. Using our own data from a survey carried out in 2006 among 215 olive tree farmers from the Granada Province in Southern Spain regarding the adoption of soil conservation and management practices, we model the diffusion process of no tillage practices using several specifications (logistic, Gompertz and exponential). We also estimate an ordered probit model to analyse which socio-economic and institutional factors determine the adoption of no tillage. Our results show that 90% of farmers in the area of study perform no tillage with either localized (21%) or no localized (69%) application of weedicides. The diffusion process of no tillage has been very intense since the middle nineties, and has been based on the interactions among farmers in the area of study rather than in external factors such as EU policies or extension services. Among other relevant factors that positively affect the adoption of no tillage practices in general, such as farm size and irrigation, the probability of a farmer adopting no tillage with non-localized application of weedicides increases when there is a relative that will continue with the farming activity, what causes the farmer to incorporate long term effects in his farming decisions, when the farmer is only a manager or when he bought the farm rather than inherited it (i.e. on more professionalized farms), and with his educational level. These results confirm some findings from previous studies in other nearby areas.**

***Keywords*— Spanish olive groves, soil erosion, no tillage.**

I. INTRODUCTION

This paper analyses the process of adoption of no tillage in Southern Spain's olive groves using our own data from a survey carried out in 2006 among 215 olive tree farmers from the Granada Province in Southern Spain regarding the adoption of soil conservation and management practices. We model the diffusion process of no tillage practices using three different specifications (logistic, Gompertz and exponential) and we estimate an ordered probit model to analyse which factors determine the adoption of no tillage.

II. FACTORS RELATED WITH THE ADOPTION OF SOIL EROSION PRACTICES

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

An important group of factors influencing the adoption of soil conservation practices relate to 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 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 factor is the relationship between potential erosion, land productivity and conservation practices. 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 to be related with the adoption of soil conservation practices are the level of non-farming income, machinery and/or labour availability, land tenancy (property incentives adoption and investment), 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.

III. ADOPTION OF SOIL CONSERVATION PRACTICES IN SPANISH OLIVE GROVES

Soil conservation practices are being increasingly adopted in Spanish olive groves. According to the Spanish Ministry of Agriculture, 700,000 hectares of agricultural land are not ploughed, most of them extensive, olive and almond trees, and 850,000 hectares of trees use cover crops, most of them olive and almond trees.

Several EU schemes include soil conservation programs in their requirements to farmers (single payment scheme, Rural Development Programs, Agri-environmental schemes), but tend to neglect important factors that affect the adoption of certain soil conservation practices.

Calatrava et al. (2007) analyse the adoption of soil conservation practices in the Spanish Southern provinces of Granada and Jaén, using data from a survey to 223 olive farmers. They find that the main soil conservation practices in the area are no 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 increased 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. (2007) 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.

IV. METHODOLOGY

The diffusion analysis of no tillage practices has been performed for both the number of adopting farmers (inter-farms diffusion) and area where this technology has been adopted (global diffusion). Two “internal influence” models (logistic and Gompertz) have been estimated as the observed pattern of diffusion is approximately logistic, typical of diffusion processes where the imitation effect predominates. However, also an exponential “external influence” model has been estimated.

The decision to adopt or not no tillage practices was analysed by estimating an ordered probit model.

Data used comes from a survey to 215 olive farmers in the Alto Genil Basin, in the Granada province, one of the main olive producing areas in Spain. The survey asked for farm characteristics (area, slopes, yields, ownership, etc.), perception of soil erosion by the farmer, conservation practices, use of advisory systems, participation in agricultural policy programmes, managerial and farm planning issues and socio-demographic characteristics (age, education, agricultural training, risk attitudes, etc.). 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 no tillage. Variables not related were discarded and not included in the estimated models. Table 1 shows the variables used in the multivariate probit model, as well as their different levels.

Table 1: Variables used in the ordered probit model

Variables	Definition	Mean
DEPENDENT VARIABLE		
NLHORD	0= Tillage; 1= No tillage with non localized application of weedicides; 2= No tillage with localized application of weedicides	1.1069
EXPLANATORY VARIABLES		
HAOLIV	Area of the olive grove (ha)	37.4936
LADER	Farm is located on a hillside (1=Yes; 0= No)	0.9069
REGAD	Farm is irrigated (1=Yes; 0= No)	0.1395
ANTIG	Oldness of the farm (years being cultivated)	482372
HERED	The farmer inherited the orchard from relative (1=Yes; 0= No)	0.5162
EROG	Perception of the gravity of soil erosion problem by the farmer: 1= Not serious; 2=Quite serious; 3=Very serious	2.1535
CONTIN	Some relative will continue with farming activity (1=Yes; 0= No)	0.6837
ESTA	Farmer has only got primary studies (1=Yes; 0= No)	0.5721

V. RESULTS

Farms surveyed include both irrigated (14%) and non-irrigated olive groves. The average farm size is 37.5 hectares (5.65 hectares if we exclude 12 farms that are greater than 500 hectares). A vast majority of farms (94%) are owned by the farmer. The average farm slope is greater than 15% for 42% of surveyed farms, between 8 and 15% for 43% of farms and less than 8% for 15%. Only 3% of olive groves are located in terraces, while 88% are located in slopes without terraces and 9% in flatlands.

The main soil conservation practice in the area is no tillage with application of weedicides, adopted by 90% of the surveyed farmers. No tillage applying herbicides non-locally is performed by almost 69% of farmers, while 21% do it on a localized way. The remaining 10% farmers that plough their land do some kind of conservation tillage. Other practices, such as vegetation covers or hedges are only adopted by a minority of farmers.

Both logistic and Gompertz models show greater goodness of fit than the exponential one (Table 2). This implies that the diffusion process has been mostly based on the interactions among farmers. In fact, most of those farmers that use the local extension services did it only to solve bureaucracy related with EU subsidies schemes. Moreover, their two main sources of technical information are other farmers (80% of farmers) and/or their agricultural cooperative (70% of farmers).

Table 2 Estimated diffusion models of no tillage

Type of no tillage (NT)	Type of Diffusion	Estimated parameters (Standard error in brackets) M Maximum level of adoption	a Integration constant	b Coefficient of diffusion	R^2
Estimated logistic diffusion model: N(t) = M / (1+exp(a-b*t))					
NT with localized weedicides	% Adopters	29,522 (2,814)	5,241 (0,268)	0,246 (0,021)	0,989
	% Hectares	47,581 (44,093)	4,487 (0,524)	0,165 (0,051)	0,884
NT with non-localized weedicides	% Adopters	81,150 (3,339)	4,874 (0,228)	0,270 (0,017)	0,992
	% Hectares	88,564 (4,635)	4,177 (0,337)	0,266 (0,028)	0,977
Estimated Gompertz diffusion model: N(t) = M * exp(-exp(a-b*t))					
NT with localized weedicides	% Adopters	61,039 (20,361)	2,105 (0,129)	0,082 (0,017)	0,986
	% Hectares	100,000 (168,833)	1,851 (0,122)	0,054 (0,040)	0,888
NT with non-localized weedicides	% Adopters	100,000 (10,565)	2,279 (0,189)	0,133 (0,017)	0,987
	% Hectares	100,000 (9,151)	2,031 (0,216)	0,145 (0,022)	0,976
Estimated exponential diffusion model: N(t) = M – exp(a-b*t)					
NT with localized weedicides	% Adopters	94,309 (236,357)	4,604 (2,352)	0,010 (0,027)	0,844
	% Hectares	89,288 (254,475)	4,545 (2,686)	0,010 (0,030)	0,809
NT with non-localized weedicides	% Adopters	100,000 (53,361)	4,783 (0,404)	0,040 (0,030)	0,839
	% Hectares	100,000 (28,160)	4,830 (0,187)	0,057 (0,025)	0,881

Regarding only results from the logistic and Gompertz models, the maximum level of adoption is quite lower for no tillage with localized application of weedicides that is the most costly practice, but also a more environmentally-friendly one.

Logistic models of inter-farms diffusion show the greatest growth rate at the end of the nineties and beginning of the new century, when more than 40% of farmers adopted non-localized no tillage. Global diffusion models show the greatest growth rate at the middle nineties. On the other hand, for the localized no tillage case, global diffusion has been slower than inter-farm diffusion, with a time lapse of approximately 6 years. Figures 1 to 4 show the estimated diffusion paths for the two no tillage practices considered.

Figure 1 Estimated diffusion process of no tillage with localized weedicides (% of farmers)

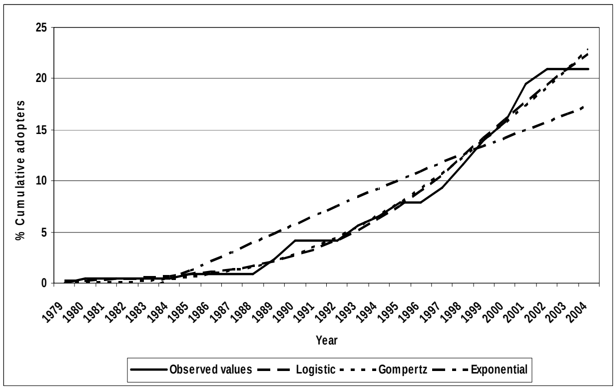


Figure 2 Estimated diffusion process of no tillage with localized weedicides (% of area)

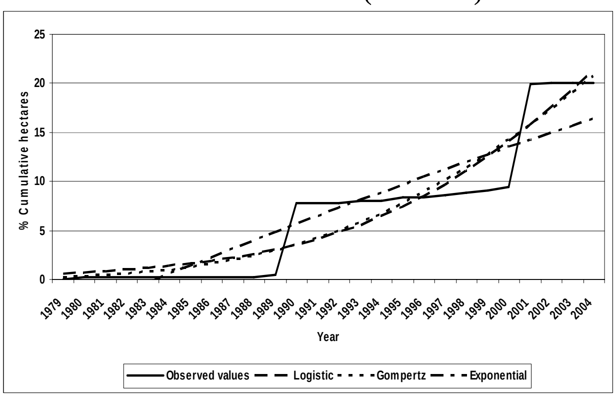


Figure 3 Estimated diffusion process of no tillage with non-localized weedicides (% of farmers)

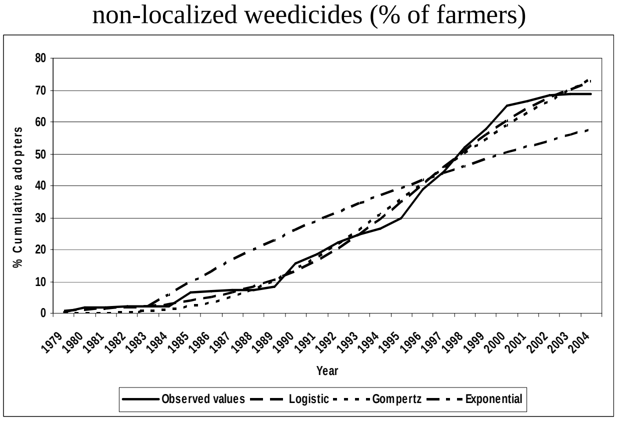
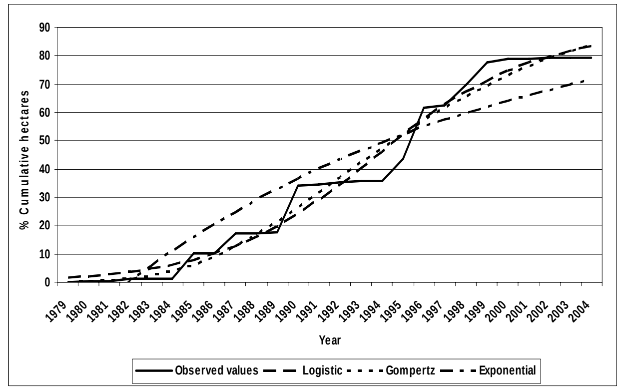


Figure 4 Estimated diffusion process of no tillage with non-localized weedicides (% of area)



The ordered probit model estimated is shown in table 3. The likelihood ratio test indicates that model is significant. A high percentage of sampled cases (81.14%) were correctly classified, what indicates a good fit and a high discriminant performance.

Table 3 Estimated Ordered probit model of adoption of no tillage with weedicides

Explanatory variables	Coefficient	p-value
CONSTANT	-1.2118	0.0143
HAOLIV	0.0014	0.0386
LADER	0.8796	0.0053
REGAD	1.4336	0.0000
ANTIG	0.0105	0.0081
HERED	-0.3827	0.0556
EROG2	1.1327	0.0002
EROG3	1.3714	0.0001
CONTIN	1.0628	0.0000
ESTA	-0.5407	0.0061
Likelihood ratio	80.8326	0.0000
Mu (1)	2.6709	0.0000
% of correct predictions	81.14	
% of correctly predicted 0s	27.27	
% of correctly predicted 1s	95.95	
% of correctly predicted 2s	60.00	

Results for the ordered probit model indicate that the probability of the farmer adopting a practice with a better soil conservation impact increases with farm size (HAOLIV variable), when farms are located on hillsides (LADER variable), for irrigated farms (REGAD variable), for older orchards (ANTIG variable), when the farmer expresses a greater concern for the soil erosion problem (EROG variable), when there is a relative that will continue with the farming activity (CONTIN variable). On the other hand, the probability of adoption decreases when the farmer inherited the farm from a relative (HERED variable) and when farmer has a primary education level (ESTA variable).

VI. CONCLUSIONS

The adoption of no tillage practices among the surveyed olive tree farms in the Alto Genil Basin, a mountainous area in Southern Spain, is quite high. In fact, 90% of farmers perform no tillage with application, either localized (21%) or no localized (69%), of weedicides. This figure is larger than found for olive orchards in other studies in near areas where average slopes are lower. In areas with higher slopes the costs of tillage are greater, what seems to incentive the adoption of no tillage. The remaining 10% of farmers that do not adopt no tillage perform tillage following contour lines, which 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), and most of them also conservation tillage to comply with requirements in the agri-environmental soil erosion scheme.

No tillage was a marginal practice in the eighties, but the number of adopters started to grow slowly in the early nineties and faster in the late nineties. Results show that the diffusion process has been based on the interactions among farmers in the area of study rather than in external factors such as EU subsidies or extension services. The estimated maximum level of adoption is quite lower for no tillage with localized application of weedicides that is the most costly practice, but also the one with lower environmental impact.

Among other relevant factors that positively affect the adoption of no tillage practices, such as farm size and location or irrigation, the probability of a farmer adopting no tillage with non-localized application of weedicides increases when there is a relative that will continue with the farming activity, what causes the farmer to incorporate long term in his farming decisions, and when the farmer is just a manager, i.e. on more professionalized farms. On the other hand, the probability of adoption decreases when the farmer inherited the farm from a relative, with respect to the case in which he bought the farm, and when farmer has a primary education level. These results confirm some findings from previous studies in other nearby areas.

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