Conservation agriculture systems: an economic viable solution experimented in a Mediterranean area of Southern Italy

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Abstract: *The global agro-food system is facing challenges that look at the hunger eradications, the control of global warming as well as the fair exploitation of terrestrial ecosystems. Therefore, it is necessary to define and implement a viable agricultural model, combining satisfaction of food needs and land preservation. A possible solution can be found in a holistic farming system consistent with a sustainable development model, designed to satisfy diverse "local" economies. The conservation agriculture (CA) can contribute to the management of agroecological systems including a set of best practices available to preserve agrarian soil and its biodiversity. After a brief background about recent CA experiences in Europe we provide, in a unique interpretative scheme, the evaluation of the impact of CA practices in terms of private/public interest, using the sustainability's metric. We test the viability of a model based on CA in "local conditions", we compare economic performance of different conservation practices (i.e. minimum and no tillage) to that of conventional agriculture in a typical Mediterranean environment - Collina Materana – in Southern Italy (Basilicata region). Our findings suggest that: i) CA can actually be a viable alternative to conventional systems and in particular no tillage is a useful tool to support rainfed agroecological systems in dry climates; ii) CA plays a role in terms of provision of public goods; iii) public support is needed to direct business choices.*

Keywords: *Conservation agriculture systems; sustainable development; viable Mediterranean agriculture; economic assessment.*

Introduction

Recently, the Paris Climate Change Agreement (in November 2015) and the 17 Sustainable Development Goals (in September 2015) established the roadmap for the future global development strategies, promoting prosperity while protecting the planet. The role played by the global agro-food is crucial in terms of food supplier as well as guardian of natural resources exploitation and determinant for the mitigation of the climate change effects.

Soil conservation practices are one of the tools that farmers could use to implement mitigation climate change policies, while achieving environmental, social and economic benefits.

During the last decade, the Food and Agriculture Organization (FAO) and the European Conservation Agriculture Federation (ECAF) have been developing and promoting techniques that allow to conserve agrarian soil and its biodiversity, in the context of sustainable agriculture; the set of best practices developed in this field is known as "*conservation agriculture*" (CA).

Conservation agriculture is defined by ECAF "as a sustainable agriculture production system comprising a set of farming practices adapted to the requirements of crops and local conditions of each region, whose farming and soil management techniques protect the soil from erosion and degradation, improve its quality and biodiversity, and contribute to the preservation of the natural resources, water and air, while optimizing yields".

Conservation agriculture was introduced by the FAO (2008) as a concept for resource-efficient agricultural crop production based on integrated management of soil, water, and biological resources combined with external inputs.

In 2011, FAO proposed the paradigm of "sustainable production intensification" in which was included a set of soil-crop-nutrient-water-landscape system management practices that are effectively the core of CA.

In recent years, awareness has grown that CA can play a significant role in achieving the main objectives of common agricultural policy revision (CAP 2020). The reform requires a production process that respects the environment and uses available knowledge and technology to optimize current production, while preserving natural resources to the benefit of the future generations. This approach mainly relies on the application of a realistic sustainable agriculture model combined with CA principles based on minimal soil disturbance, permanent soil cover and crop diversity (ECAF, 2013).

For the reasons aforementioned, our point of view to improve the evaluation of CA as a sustainable production system is that the analysis should include: a) the whole of the economic and environmental aspects and their effects on social welfare; b) the impact level on the private vs. the public interest. This new perspective allows the analysis of not only of the effects of the adoption CA in terms of the balance between costs and benefits (i.e. the reduction of production costs compared with any yield reduction) but also their impact with respect to the private and the public interest.

Our analysis proposes that the adoption of conservation agriculture practices can be a viable alternative to conventional production systems and could represent a farming solution to drive European agriculture to contribute towards the needed sustainable development worldwide. To proof our thesis we offer: an update on information about the CA in Europe and the impact of its adoption - in terms of costs and benefits – with respect to sustainability dimensions, impact levels on private and public interest and area of incidence (section 2); a comparative economic assessment of wheat production with different conservation tillage practices, in Collina Materana, in Basilicata region (Southern Italy) - where is produced high quality durum wheat (section 3); in the final part of the study, political and economic considerations are given to support future CAP programs and the differentiation of products with a CA origin which, jointly to already recognized qualitative characteristics (e.g. varieties with higher gluten content, absence of glyphosate residues, higher protein content) should help farmers get a premium price (section 4).

Conservation agriculture: role and impact on European sustainable development

At present, conservation agriculture production systems are used throughout the world; the total area under CA is estimated around 157 Mha - mainly in North and South America (around 76.6% of the worldwide CA area) - corresponding to about 11% of field cropland (FAO, 2016). The worldwide adoption of CA systems has increased at an average rate exceeding 7 Mha/yr, compared to the past millennium (Bash et al., 2015; Kertesz & Madarasz, 2014; Friedrich et al., 2012) and since 2008/2009 at the growth rate has been, in some countries, of 10 Mha/yr (Kassam et al., 2015).

Europe is one of the areas in which CA has a faster adoption rate also as a result of the reinforced technical role of the ECAF, which brings together fourteen national associations promoting - among Europe's farmers - CA soil management "best practice" aspects and the preservation of biodiversity of agrarian soil in the context of sustainable agriculture. In Europe, there are currently over 7Mha of arable cropland under CA system, - corresponding to about 4.4% of the worldwide CA area - mainly located in Russian Federation (around 64% of the total European CA area), followed by Spain (11.3%), Ukraine (10%) and Italy (5.4%) (FAO, 2016).

In Europe, the first attempt towards CA in the form of no-tillage was done in the UK in 1955, followed in the ’60s by the Netherlands, Germany, Belgium, Switzerland and Italy. France experienced CA in 1970, while Spain and Portugal in the early ’80s. In most countries, conservation tillage practices have been driven by research institutions, while in Denmark and Finland the adoption process was farmer-driven (Basch et al., 2015). Finland is the EU country with the highest rate of CA of arable land (almost 9%). Here successful farmer-driven adoption has been sustained by the combined effort of an intensive research programme and a knowledge transfer process (Soane et al., 2012). Until the end of last century, the adoption of CA in Europe was generally very low and mainly based on reduced tillage (minimum and/or zero tillage) practices. One of the reasons was the perceived economic loss due to the decrease in production in the short run.

In 2001, FAO released a report that marked the substantial change of CA from a collection of conservation tillage methods to an integrated production approach. This approach is based on the integrated management of available soil, water and biological resources such that external inputs could be minimized (Knowler & Bradshaw, 2007). The technical core of this approach was found in CA practices based on the maintenance of a permanent/semi-permanent cover which protects soils from natural events and creates a biotic community that provides biological tillage playing the same functions as conventional tillage (FAO, 2001).

Previously, the results of different soil management practices had been analysed as an individual farmer’s choice evaluating the private profitability of a pure soil tillage system rather than the potential public benefits from the improvement of the whole system. Instead, this integrated approach allows assessing the results of the CA not only with respect to yield results but also with respect to the reduction of costs and the long run impact on the environment.

Table 1 shows the benefits and costs of the adoption of CA, as emerging from an extended review and synthesis of recent researches (FAO, 2001; ECAF, 2016; Vastola et al., 2017). For each benefit/cost, the sustainability dimension (i.e. economic, environmental and social, as in the Brundtland Commission Report, 1987) has been indicated, as well as the scope and sign of its impact, both at geographical level and on public and private interest.

In terms of reduction of costs the impact on private interests is definitely positive (e.g. see rows: 1, 2 and 3) and yield increase (row 4). Public benefits are related to the reduction of the environmental impact (e.g. see rows: 2, 7 and 13). The adoption of innovative practices has, on average, a negative effect on costs (e.g. see rows: 14, 17) even if it is not to be undervalued new machinery markets realization (e.g. South America and Europe). The negative environmental impact on the public interest is basically related to the use of chemicals.

It is relevant for the application of supporting programmes and policy interventions the distinction of the level of incidence of CA action on the local, national/regional and global scale. As well as, it is interesting to further subdivide benefits and costs of CA in relation to different dimensions of sustainability. Most costs relate the economic dimension of sustainability, whereas the benefits mostly affect the environmental and hence social dimensions.

This analysis highlights two main findings: *i*) the trade-off between the costs of conservation agriculture adoption paid by farmers and the social benefits (Knowler & Bradshaw, 2007); *ii*) the global environmental and social effects of conservation agriculture.

Table 1. Benefits and costs associated to CA: dimensions of sustainability, impact levels on private/public interest and area of incidence

	Benefits/Costs	Dimensions of sustainability	Impact level	Area of incidence		
				Global	National/Regional	Local
1	Labour savings in perennial crops	Ec/So	1			x
2	Fuel savings in perennial crops	Ec/Env	3			x
3	Cost-savings in annual crops	Ec	3			x
4	Increase of yields	Ec/So	3	x	x	x
5	Reduction of off-site problems	Ec/Env	2		x	x
6	Improvement of soil properties	Env	3		x	x
7	Increase of biodiversity	Env	2	x	x	
8	Less erosion	Ec/Env	3		x	
9	Less CO2 emissions	Env/So		x	x	x
10	Increase of the CO2 sink effect of the soil	Env/So	2	x	x	x
11	Less contamination of downstream water	Env	2		x	
12	Less floods and landslides	Ec/Env	3		x	
13	Less landscape diversity loss	Ec/Env/So	3	x	x	
14	Purchase of specialized planting equipment	Ec	-1			x
15	Short-term pest problems due to the change in crop management	Ec	-1			x
16	Farmer needs new management skills – requiring farmer's time commitment to learning and experimentation	Ec	-1			x
17	Application of additional herbicides	Ec/Env	-3		x	x
18	Formation and operation of farmers' groups	Soc	-2		x	x
19	High perceived risk to farmers because of technological uncertainty	Ec	-1		x	x
20	Development of appropriate technical packages and training programmes	Ec/So	0		x	x

Note: Ec=economic; Env= environmental; So= social. 1=positive impact on private interest; 2= positive impact on public interest; 3= positive impact for both; 0=no impact; -1=negative impact on private interest; -2=negative impact on public interest; -3=negative impact for both

Different studies based on crop performances evaluated from measured crop yields, long-term reviews and field results lead to the conclusion that in Europe: a) in general no-till gives crop yields within 5% higher of those obtained under conventional tillage, given the influence introduced by soil, crop and weather; b) increasing yield levels under drier conditions have been reported (Fernández-Ugalde et al., 2009); c) lower yields during the first two years from the adoption are often the consequences of the previous soil compaction, the relatively short time for the improvement of soil biodiversity, insufficient available N to meet crops' need (Soane et al., 2012); d) the possible initial decrease in yield is compensated, on average, after 3 years, through the improvement of soil properties (e.g. aggregate stability, pore structure, organic matter and biological activity), increased N and water availability in the soil; e) a proper economic assessment must also take into account the quality of production, because strict quality standards are extremely relevant for grain crops grown for industrial uses and animal feed as well as in case of perennials crops and main crop rotation systems (as proofed in Southern Spain with wheat-sunflower production); g) looking at CA effects in the long run (more than 10 years), it is possible to observe an improvement of the physical characteristics of the soil and therefore on the productions and, in particular, if all three conservation agriculture principles are implemented (Pittelkow et al. 2015). As regards the overall effect on agro-ecosystems and on ecosystems in general, there are not enough studies to confirm the benefits (Palm et al. 2014). ECAF (2016) has reported that the effect of erosion is to increase agricultural production costs by about 25% each year and that erosion risks could increase due to changes in climate with a greater number of rainstorms. CA practices fights the effects of erosion and for this reason mitigate its impact on farmers' costs. Additional benefits are coming from the reduced water needs when no-tillage and/or minimum tillage practices are adopted. In drier years this implies better yields than those obtained with conventional practices.

Finally, but not less relevant, it is the role played by CA in terms of lower landscape diversity loss. The positive effect is due to: *i*) the application of the third principle of the CA - soil cover - which recreates the biological balance necessary for the development of agricultural ecosystems that are vital, fertile and therefore capable of generating environmental benefits; *ii*) the increase of biodiversity and therefore the lack of destruction of habitats/landscapes of great value not only environmental but also social and cultural (e.g. Italian agricultural landscapes as Langhe and Collio have been mentioned as UNESCO heritage patrimony). Each territory is represented by a typical agricultural landscape, often referred to as a cultural landscape, and it is a strategic asset in improving the well-being of society given its high aesthetic, ecological and economic value (Sayadi et al., 2009; Van Berkel and Verburg, 2014). However, due to agricultural intensification processes, the cultural landscape is turning into ways that negatively affect the provision of eco-systemic cultural services (Zimmermann, 2006). Therefore, any agricultural landscape must be preserved and improved through sustainable farming practices.

The comparative economic assessment of conservation tillage in a Mediterranean area of Southern Italy: the case study of Collina Materana

Characteristics of study area and methodology

Collina Materana is located in Southern Italy – in the province of Matera and in Basilicata region - and the landscape is characterised by areas with sub-flat to undulated morphologies and sandy-conglomerate lithology given the origin from Lower Tertiary sandstones and clay soil, merging with Pliocene clay hills (Eastern part of Lucanian Apennines). Soils are mostly calcareous and highly permeable, although the presence of clays in some areas may provoke landslides. Precipitation follows a Mediterranean pattern, characterised by summer minima and winter maxima, and a very high variability with a difference exceeding in some years 800 mm of rainfall. The total annual average rainfall is ranged between 642 and 885 mm. The average temperature is 12.4 °C and January is the coldest month while July and

August are the hottest months. The difference between day and night temperatures is 18.9 °C, so the climate may be classified as transitional from continental to intermediate.

In this area the cultivation of high quality durum wheats is extremely relevant for the production of well-known pasta's brands. Nevertheless, cereal yields are quite low (between 2 and 3 t/ha) compared to other more suitable areas of the region and the low unit productivity has negative impacts on farm accounts, causing a progressive abandonment of agricultural holdings and rural depopulation.

The methodology focuses on a comparative economic assessment concerning three different crop production systems, related to different soil management systems: a) *conventional tillage* (CT); b) *minimum tillage* (MT) and c) *no tillage* (NT); and durum wheat (*Triticum durum*) is the reference crop.

Economic assessment: total production and cost determination

The economic analysis included crop production costs (operating farm machinery, seeds, etc.) and the total output (revenues). Comparing the two categories, costs and revenues, it is possible to determine the operating income, i.e. the economic result achieved through management over a period (conventionally equal to one year). Yet, as climate variability previously described has a negative impact on productivity, the analysis was carried out on a three-year time frame.

To quantify the costs of farming practices, a survey has been conducted, via a questionnaire given to a sample of farm contractors working in the area under study. The interviews have been conducted, during March 2015, with fifteen medium-size (from 15 ha to 50 ha) cereal farms that apply CT as the main crop production system. Since 2012, ten of them conducted experimental fields adopting MT while five farms adopted NT. Farming practices for the three crop production systems are indicated in table 2. The validation of survey data has been obtained comparing the costs of the main farming practices with the values reported in Basilicata price list of public works (years 2012, 2013 and 2014).

Table 2. Farming practices

Farming practice	Conventional Tillage	Minimum Tillage	No tillage
Plowing operation	40 cm of deep tillage	-	-
Tooth harrow	x	x	-
Disk harrow	x	x	-
Pre-Weed control	-	-	x
Pre-Fertilization	x	x	x
Traditional seed	x	x	-
Sod seeding	-	-	x
Post-fertilization	x	x	x
Post-Weed control	x	x	-
Threshing	x	x	x

To determine other costs - including seeds, fertilisation and weed treatments – another survey was conducted among the main companies marketing agricultural products across the region. In detail, the estimated seeding rate for durum wheat was 200 kg/ha for all three cropping systems. Fertilization included a pre-seeding application of 150 kg/ha of diammonium phosphate (18% nitrogen and 46% phosphorus pentoxide) and a top dressing treatment with urea (46% nitrogen) at the rate of 170 kg/ha (80 units/ha). Weed control involved a pre-seeding treatment with 2.5 l/ha glyphosate in the *no tillage* system, and a top dressing in the two other systems, using a broadleaf and narrow-leaf herbicide.

Table 3 shows, for each crop production system, the costs referred to the three-year period were evaluated based on the costs incurred on farming practices and the expenditure for durum wheat production. Results show an average cost for the three marketing years equal to 798.96 €/ha for *conventional tillage* against 635.63 €/ha for *minimum tillage* and 485.13 €/ha for *no tillage*.

Table 3. Total costs of conventional tillage, minimum tillage and no tillage (period 2012-2015)

Marketing year	**Cultivation system**	**Plowing operation (40 cm)**	**Tooth harrow**	**Disk harrow**	**Pre-Weed control**		**Pre-Fertilisation**		**Traditional seed**		**Sod seeding**		**Post-fertilization**		**Post-Weed control**		**Threshing**	**Total**
		€/ha	***€/ha***	***€/ha***	***Herbicide (€/ha)***	***Spraying machine (€/ha)***	***Fertiliser (€/ha)***	***Manure spreader (€/ha)***	***Seed price (€/ha)***	***Seed planters (€/ha)***	***Seed price (€/ha)***	***Seed planter (€/ha)***	***Fertiliser (€/ha)***	***Manure spreader (€/ha)***	***Herbicide (€/ha)***	***Spraying machine (€/ha)***	***€/ha***	***€/ha***
	CT	183.33	60.00	53.33			79.20	23.33	86.40	60.00			69.36	23.33	55.50	23.33	76.67	**793.78**
2012-13	MT		60.00	73.33			79.20	23.33	86.40	60.00			69.36	23.33	55.50	23.33	76.67	**630.45**
	NT				25.00	23.33	79.20	23.33			86.40	73.33	69.36	23.33			76.67	**479.95**
	CT	183.33	60.00	53.33			86.40	23.33	79.68	60.00			66.91	23.33	55.50	23.33	76.67	**791.81**
2013-14	MT		60.00	73.33			86.40	23.33	79.68	60.00			66.91	23.33	55.50	23.33	76.67	**628.48**
	NT				25.00	23.33	86.40	23.33			79.68	73.33	66.91	23.33			76.67	**477.98**
	CT	183.33	60.00	53.33			77.76	23.33	109.4	60.00			65.28	23.33	55.50	23.33	76.67	**811.30**
2014-15	MT		60.00	73.33			77.76	23.33	109.4	60.00			65.28	23.33	55.50	23.33	76.67	**647.97**
	NT				25.00	23.33	77.76	23.33			109.4	73.33	65.28	23.33			76.67	**497.47**

In our analysis, the total production (TP) – basically the total output obtained in the farm - is represented by durum wheat output sold at local prices; while straw, considered a secondary output, is not evaluated due to the low economic value assumed in recent years.

Wheat yield and its quality are extremely variable from year to year and largely dependent on soil and climate conditions and on the cropping practices applied (crop rotations, fertilisations, etc.) as reported by different studies (Ahmad et al., 2013; Ruisi et al., 2014; Imran et al., 2013; Wozniak, 2013; Bilalis et al., 2011; Al Ouda, 2011; De Vita et al., 2007; Pisante & Basso, 2000) conducted in Mediterranean environments and semiarid areas. However, as carried out from other tests and as confirmed by our results: the rain fallen is the variable that mostly affects crop yields and the subsequent economic viability of a cropping system compared to another one. De Vita et al. (2007) pointed out the link between rainfall and crop yields in trials run on durum wheat in the Foggia province. Their tests showed that below 300 mm annual precipitation, *no tillage* system is more cost effective than conventional tillage. *No tillage* actually reduces water evaporation from the soil to the benefit of the crop, with positive effects on crop yields and quality.

To calculate the potential estimate of resulting durum wheat yields, given the experimental data lack about the yields obtained with the different crop systems, we used De Vita's equations (De Vita et al., 2007: p.74) for no tillage and conventional tillage, considering the rainfall recorded in the three-year period (2013-2015) in the area of Collina Materana. Moreover, to take into account the differences in the pedoclimatic conditions of the study area compared to the area where De Vita conducted the tests, our results were corrected based on the yield levels obtained by Pisante and Basso (2000) in the neighbouring municipality of Guardia Perticara, where soil and climate conditions are similar to those in the area under study.

As resulting from the trials conducted by Pisante and Basso (2000), the potential yields concerning *minimum tillage* related to the area under investigation have been calculated from the per cent differences observed between CT and NT, and equal to 26.09%.

The potential yield levels of the three-year period (2012-2013, 2013-2014 and 2014-2015) for the three cropping systems in the area of *Collina Materana* are shown in table 4.

Table 4. Crop yields in *Collina Materana*

Year	November-May rainfall (mm)	Conventional tillage (t/ha)	No tillage (t/ha)	Minimum Tillage (t/ha)
2013	292.2	**1.19**	**0.91**	**0.87**
2014	653.0	**3.47**	**1.71**	**2.56**
2015	394.6	**1.83**	**1.14**	**1.35**

Results point out that *conventional tillage* shows the highest yield levels as compared to *no tillage*, with values ranging respectively between 1.19 t/ha and 3.47 t/ha in the first case and between 0.91 t/ha and 1.71 t/ha in the second case. For the comment of final results, it is relevant to point out that as rainfall decreases, the differences observed between cropping systems tend to disappear, while they increase with precipitation, in favour of the conventional system and in line with the outcome of many studies.

Finally, the crop yields for the three cropping systems were estimated, revenues were assessed on the basis of the prices of durum wheat for the period 2013-2015. To this purpose, reference durum wheat prices were taken from the price list applied in Foggia (www.mercatigrano.it/quotazioni). On the basis of the average prices recorded in the three-year period 2013-2015, revenues were quantified (table 5).

Table 5. Revenues for the three cropping systems

Year	Conventional tillage		No tillage		Minimum Tillage	
	Yields (t/ha)	Revenue (€/ha)	Yields (t/ha)	Revenue (€/ha)	Yields (t/ha)	Revenue (€/ha)
2013	1.19	324.54	0.91	248.18	0.87	237.27
2014	3.47	1,107.28	1.71	545.66	2.56	816.90
2015	1.83	656.89	1.14	409.21	1.35	484.59

Source: our elaboration

Results

In general, our results confirm the better performance of no-till crops in southern European countries with respect those of northern Europe (Bash et al. 2015). From our findings emerge that a higher cost effectiveness of *no tillage* and *minimum tillage* in particularly dry years, whereas the traditional system is more profitable in rainy years (see table 6). The good economic performance of the three cropping systems under analysis is clearly shown in the marketing year 2013-2014, in which higher rainfall has positive effects. The negative result observed in the other marketing years is mainly due to the exclusion of the single CAP premium from the financial analysis. Actually, the significant CAP payments play a major role in sustaining agricultural activity especially in marginal rural areas, including Collina Materana, where low crop yields and poor revenues from sales of farm products have negative impacts on the farm's total economic balance sheet. For this reason, an additional evaluation has been carried out including the CAP premium in the balance sheet. Given the differences in payment between the old CAP programming period (2007-2013) and the new one (2014-2020), an average value of € 320.00 per year was considered. Including this revenue item reverses the results, which turn out to be positive, despite the persistent differences between the three cropping systems, while still confirming the cost effectiveness of *no tillage* and *minimum tillage* in the years with moderate levels of precipitation. To confirm this outcome, we compared the annual cash flows of the different cultivation systems – including CAP payment - with the trend of rains (figure 1) and grain prices (figure 2). The annual cash flows essentially follow the rainfall trend, which directly affects the production and therefore the revenues. However, graphs show clearly the higher sensibility of CT and MT to rainfalls with respect to *no tillage* practice that shows a trend more or less stable over time. Last but not least evidence is the positive cash flow achieved only by *no tillage* practice in 2012/2013 - period during which the lowest rainfall and prices levels have been recorded - mainly due to lower production costs. Due to the aforementioned considerations, we can affirm that the adoption of no tillage could be a viable option to the management of risks related to climate change and price instability, especially in these last years, in which farmers face different challenges mainly related to the climate change, global market instability and political decisions (Eakin, 2005; Harvey et al., 2014; Tschakert, 2007).

Drawing some final remarks, it emerges that economic benefits derive from the reduction in cropping costs mostly due to the lower intensity of farming practices. Nevertheless, costs may further fall as related to the size of the cropped area that enables reducing off-farm costs derived from the purchase of specific machines. The economic disadvantage is related to: *i)* slightly lower yields, as compared to the conventional system; *ii)* decreased output that however depends and varies according to the soil and weather conditions; *iii)* the crop type and *iv)* the soil type. In the case study area, conservative farming practices result much less sensitive to variations in productions, and this aspect should not to be underestimated because it reduces farmer's risks while ensuring a positive profit over time.

Table 6. Cash flows with (dark grey rows)/ without (light grey rows) CAP single payment

	2012-2013				**2013-2014**				**2014-2015**				**Final net value**
	Revenues	**Costs**	**CAP Payments**	**Cash flow**	**Revenues**	**Costs**	**CAP Payments**	**Cash flow**	**Revenues**	**Costs**	**CAP Payments**	**Cash flow**	
	€	**€**	**€**	**€**	**€**	**€**	**€**	**€**	**€**	**€**	**€**	**€**	**€**
Conventional tillage	324.54	793.78		-469.24	1,107.28	791.81		315.47	656.89	811.3		-154.41	-319.51
Minimum tillage	237.27	630.45		-393.18	816.9	628.48		188.42	484.59	647.97		-163.38	-379.88
No tillage	248.18	479.95		-231.77	545.66	477.98		67.68	409.21	497.47		-88.26	-260.22
Conventional tillage	324.54	793.78	320.00	-149.24	1,107.28	791.81	320.00	635.47	656.89	811.3	320.00	165.59	663.71
Minimum tillage	237.27	630.45	320.00	-73.18	816.9	628.48	320.00	508.42	484.59	647.97	320.00	156.62	603.35
No tillage	248.18	479.95	320.00	88.23	545.66	477.98	320.00	387.68	409.21	497.47	320.00	231.74	723.01

Source: our elaboration.

Conventional Tillage

Minimum Tillage

No tillage

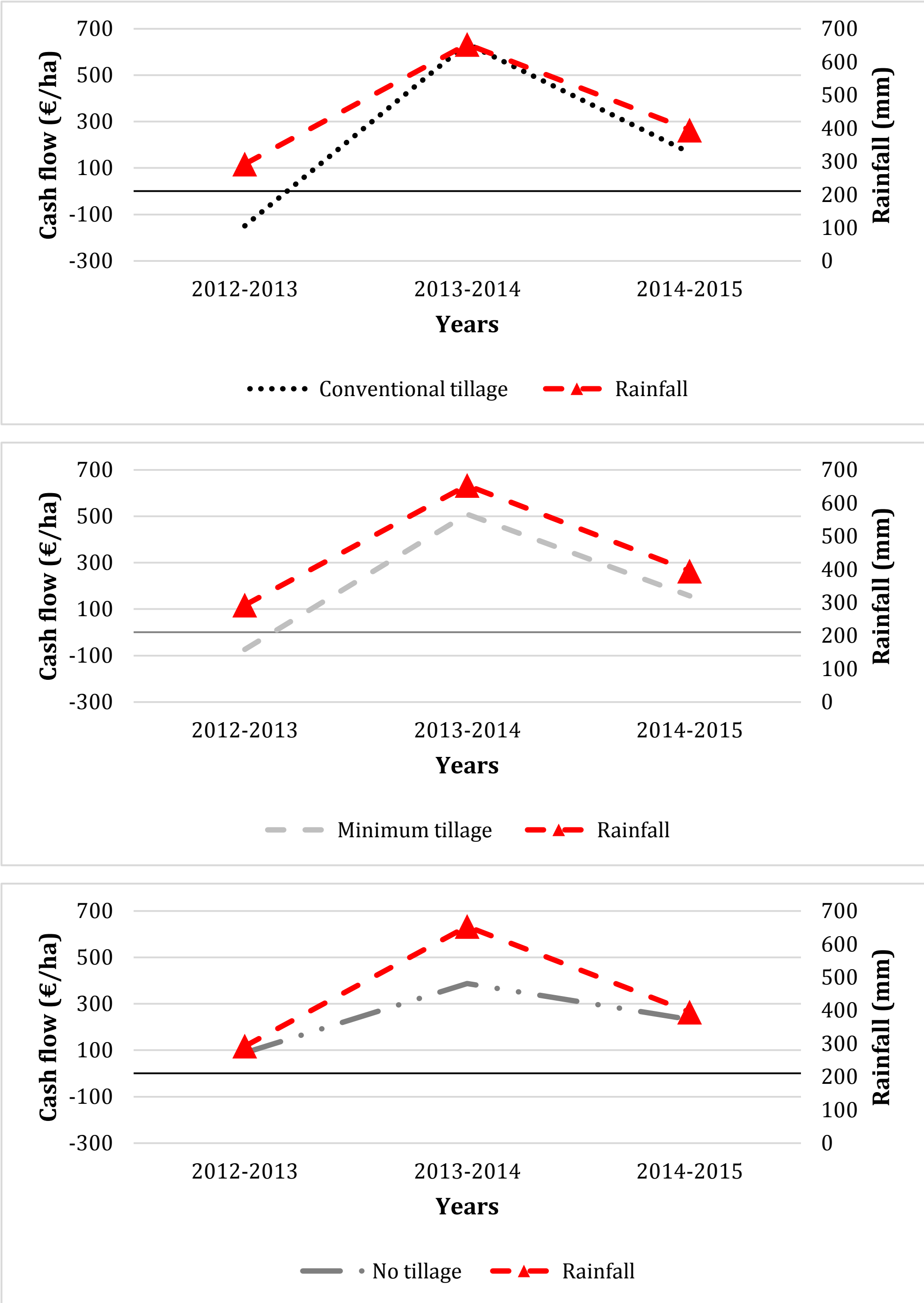
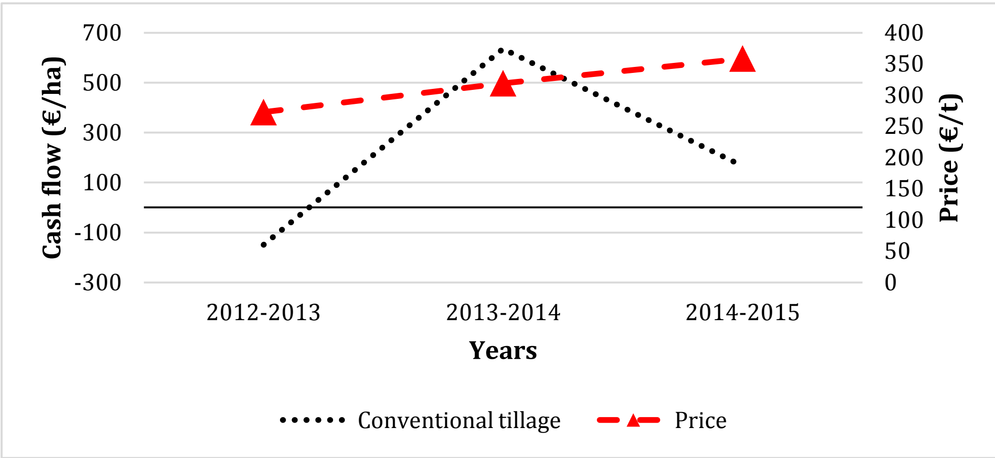


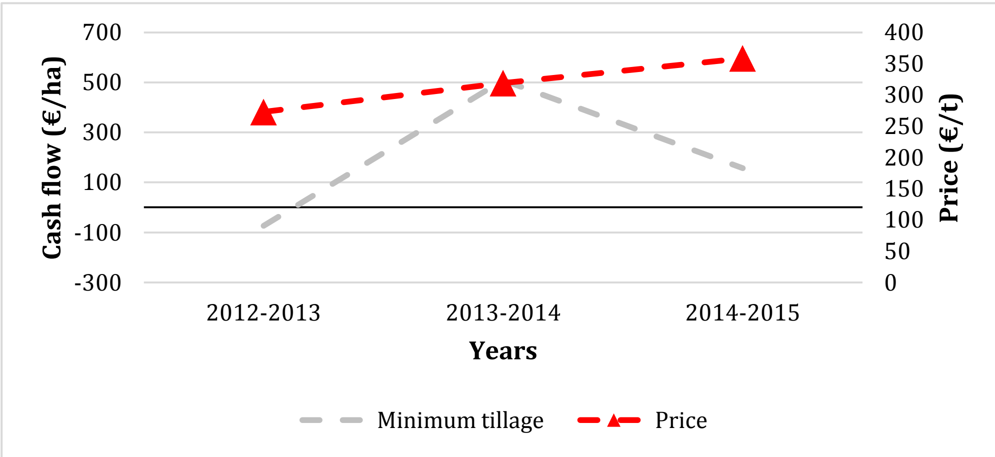
Figure 1: Comparison of annual cash flow trends with the rainfall trend for the three crop systems (conventional tillage, minimum tillage, no tillage)

The limited diffusion of CA in this territory is mainly dependent by farmers' insufficient knowledge and by their strong linkage with conventional farming practices. So, for these reasons, policies suitable to promote CA diffusion must be made available, considering the relevance of the creation of farmers-driven adoption and know-how - included in the benefits category formation and operation of farmers' group (Table 1) - but evidently in this case under evaluated. From our findings it clearly appears the weakness of a top-down approach, often driven by the academic research system, to be substituted by a bottom-up perspective in which institutions are called to provide practical solutions to organized farmers' groups.

Conventional Tillage



Minimum Tillage



No tillage

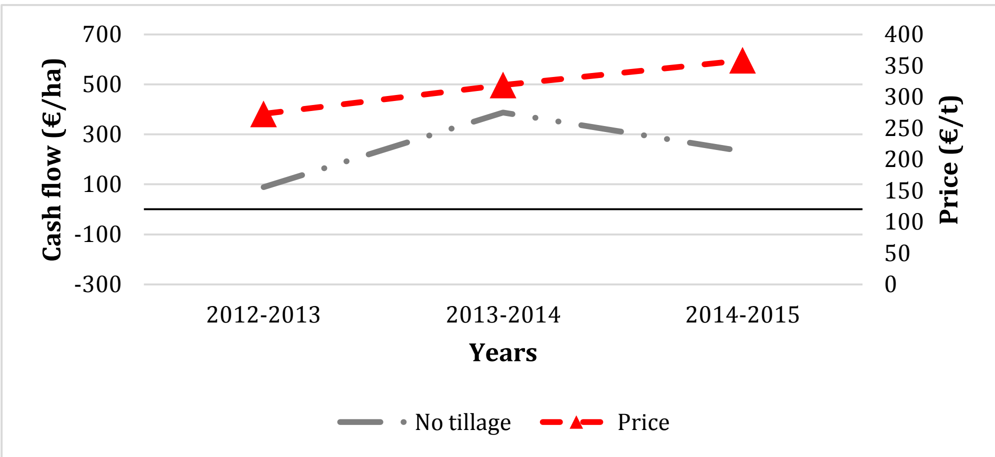


Figure 2: Comparison of annual cash flow trends with the trend of grain prices for the three crop systems (conventional tillage, minimum tillage, no tillage)

Final remarks

Soil conservation practices are one of the tools that farmers could use to implement mitigation climate change policies, while achieving environmental, social and economic benefits. However, CA knowledge and diffusion in the agricultural sector are still insufficient while policy makers are still scarcely aware of the positive role this farming system can have in a sustainable agro-food system framework.

CA has significant potentialities yet to be exploited as the results of the comparative economic assessment suggest. In fact our analysis shows yield advantages especially during dry years, when conservation techniques increase water supply to crops; this feature has a dramatic significance in the light of the expect drier seasons in the Mediterranean area. The results observable from our case study reinforce previous research findings affirming that no tillage as an effective farming practice to support rainfed agroecosystems in dry climate (Pittelkow et al. 2015).

Moreover, conservative farming practices produce more stable yields over time, that means lowering "technical" risk in producing durum wheat. This is a relevant feature, as risk management is typically one of the most important problems in managing agriculture.

Conservation systems bring a reduction in average crop yields, whose size depends on the soil, climate and crop conditions. However, from our point of view of primary relevance is the effort to make farmers aware that the possible loss of profit (e.g. the purchase of specialized technologies; application of herbicides and/or time needed to improve management skills) in the short run will be compensated after the transition period. Moreover, the adoption of conservation agriculture techniques should be linked to educational/technical assistance to accompany business choices in order to make them profitable in the medium-long run.

In the short run, EU policy should support the private profitability of this farming system providing incentives to single producers so that transitional risks can be minimised. To avoid that most farmers focusing their activities towards maximization of subsidies could loose the long-term perspective to invest in soil fertility and health (Basch et al. 2015). The payment system should be added to the conventional agricultural system (i.e. greening system of payments of the CAP first Pillar). Even if the provision of environmental public goods predicted by the policy tools of the first Pillar as the maintenance of permanent grassland, the ecological focus areas and the crop diversification are insufficient to get the goals of CAP reform proposal 2020 (Basch et al. 2012). At the same time, a widespread activity of public communication towards farmers have to be implemented, to make them aware of the advantages of CA techniques, for example, as in our case study, of the technical superiority of *no tillage* in the medium-long run.

EU policy makers have to recognized the positive benefits of CA and devise a way to pay them as ecosystem services (Hodge et al. 2015). The ecosystem approach actually represents an opportunity to reshape political interventions towards a more holistic model, in which the traditional productive service of farming is placed side by side to cultural, social and recreational ones. Moreover, CAP has recently defined conservation measures to reduce soil loss by water erosion by 20% in arable lands and the further actions should recognize the soil value as part of ecosystem services, increasing the income of land owners as well young farmers (Panagos et al. 2016). Additionally, to support the transition period towards CA the decision makers can use the link between Good Agricultural Environmental Conditions (established in 2003 and with reduced tillage farming included) and the present CAP subsidies (granted by the second pillar).

Relevant is the role of CA in terms of provision of public goods – i.e. the soil productivity and fertility preservation have a public impact in terms of food security - as well as of a number of environmental advantages (the climate change mitigation through carbon sequestration in the soil; the enhancement of below and aboveground biodiversity; the reduced CO_2 emission through less fuel consumption, the reduced use of agrochemicals, etc.).

In recent years, Italian market is willing to pay a higher price for the higher quality of grains: *a)* premiums for grains that exceed the percentage of proteins equal to 14.5%; *b)* average quality of gluten; *c)* absence of glyphosate residues (not guaranteed by extra EU productions). In fact, during the previous campaign (2016/2017) and for the one in progress, some of the largest Italian pasta companies have made agreements for the purchase of high quality Italian wheat for the production of pasta obtained with 100% Italian wheat, as a wide market segment is looking for and whose mandatory labeling is required, as recently happened for the origin of fresh milk.

For these reasons, we recommend for creating a system of environmental voluntary certifications in order to have the collective benefits generated by CA recognized by the market. The use of a quality label should be exploited by farmers as a viable solution to escape from fluctuations of commodities prices setting these grains in a differentiated market segment, while society would benefit in terms of a wider supply of more environmental sustainable products.

As a concluding remark, we suggest to increase research and development activity devoted to more environmental friendly practices and/or technologies – e.g. the use of relatively cheap drones with advanced sensors and imaging capabilities that give farmers new ways to increase yields and reduce crop damage.

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