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A comparative multidimensional evaluation of conservation agriculture systems: A case study from a Mediterranean area of Southern Italy

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ABSTRACT

To avoid the current paradoxes of the global agro-food system it is necessary to define and implement a viable agricultural sustainable model, combining satisfaction of food needs and land preservation. A possible solution can be found in a holistic production system consistent with a sustainable development model, designed to satisfy diverse "local" economies. The conservation agriculture (CA) could be a part of this model, as it includes a set of best practices available to preserve agrarian soil and its biodiversity. Briefly, we cover the CA background in Europe followed by the evaluation of its impact in terms of private/public interest, using the sustainability's metric.

To 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; ii) in Mediterranean agricultural areas CA has yield advantages especially during dry years, when conservation techniques increase water supply to crops; iii) public support is needed to direct farming choices in fact without financial incentives these practices would be not widely accepted and diffused; iv) European policy makers have to recognized the positive benefits of CA and pay them as ecosystem services in the framework of Good Agricultural Environmental Conditions and the present CAP subsidies.

1. Introduction

Global agro-food outlook has been recently reshaped by two landmark agreements, i.e. the Sustainable Development Goals (in 2012) and the Paris Climate Change Agreement (in November 2015). The challenge is hunger eradication and fair exploitation of terrestrial ecosystems keeping global warming below 2 °C by 2030.

Human activity has been the dominant cause of observed warming since the mid-20th century. The last Intergovernmental Panel on Climate Change assessment report confirmed that each of the last three decades has been successively warmer at the earth's surface than any preceding decade since 1850 (IPCC, 2014).

In the near future, this trend can be slowed only if a more sustainable growth path is undertaken.

The adoption of soil conservation practices is one of the tools that the European farmers could exploit 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).

The roots of this production approach have to be found in the USA – in the 1930s – to combat soil desertification caused by wind and water erosion (Holland, 2004).

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

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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 (Reicosky, 2015).

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

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 practices based on minimal soil disturbance, permanent soil cover and crop diversity (ECAF, 2013).

Past studies about the adoption of conservation agriculture in Europe have been mainly focused on: *i)* the results achieved from the agronomic and soil point of view and *ii)* the related economic advantage – i.e. the reduction in production costs (e.g. less labour hours, less chemicals, less fuels) compared with any yield reduction.

From our point of view, to improve the evaluation of CA as a sustainable production system 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.

It is therefore necessary to evaluate not only the effects of the adoption CA in terms of the balance between costs and benefits but also their impact with respect to the private and the public interest.

Given this scenario analysis our study proposes: 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 are given political intervention considerations for CAP future perspectives as well as are proposed suggestions for future researches (Section 4).

2. Conservation agriculture and its contribution to sustainable development in Europe

2.1. Conservation agriculture in Europe: background

Conservation agriculture production systems are used throughout the world. At present, 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).

There are currently over 7 Mha of arable cropland under CA system in Europe, – 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).

Various studies have reported (Bash et al., 2015; Kertész and Madarász, 2014; Friedrich et al., 2012) that the worldwide adoption of CA systems has increased at an average rate exceeding 7 Mha/yr, compared to the past millennium, and at the rate of some 10 Mha/yr since 2008/2009 (Kassam et al., 2015). Comparing the previous decades, 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, the first attempt towards CA in the form of no-tillage was done in the UK in 1955, followed in the '60 s by the Netherlands, Germany, Belgium, Switzerland and Italy. France experienced CA in 1970, while Spain and Portugal in the early '80s. In most countries, the use of conservation tillage practices was 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).

2.2. Impact of conservation agriculture on sustainable development in Europe

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.

The substantial change of CA from a collection of conservation tillage methods to an integrated production approach is marked by a report released by FAO in 2001, emphasizing the need of a novel approach to agriculture production, geared to a better use of agricultural resources, compared to conventional agriculture; this approach is based on the integrated management of available soil, water and biological resources such that external inputs could be minimised (Knowler and 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).

Basically, the results of different soil management practices had been previously 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. Moreover, 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 2013). 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.

The impact on private interests is definitely positive in terms of reduction of costs (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 a negative effect on costs (e.g. see rows: 14, 17). The negative environmental impact on the public interest is basically related to the use of chemicals.

The distinction of the level of incidence of CA action on the local, national/regional and global scale is relevant for the application of supporting programmes and policy interventions.

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

In general, the trade off in favour of private/public interest can be