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A renewed view of conservation agriculture and its evolution over the last decade in Spain

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ABSTRACT

The interest in conservation agriculture in Spain is evidenced by practical and institutional aspects. The practical aspect is reflected by the area cultivated under this farming system, 1.28 Mha in perennial crops and 0.57 Mha in arable crops, both for 2013. The period under review was 2009–2013 for arable crops and 2006–2013 for perennial crops. In that period, figures increased 208% for no tillage in arable crops, and 54% for groundcovers in perennial crops. The institutional support is reflected by the financial funding given to conservation agriculture farming practices by some Spanish Regional Governments, primarily through Rural Development Programs, that reached over € 200 million in the 2000–2006 period. The origins of soil conservation practices date back to the 1930s and have evolved in parallel in America and Europe. This parallelism has led to the use of different terminology for similar practices that do not always fall within the scope of conservationist practices. Consistent with the literature, and based on the results of 6 meetings with 144 Spanish experts, this paper aimed at clarifying terms and practices applied under the conditions of Spain, but could be useful for other geographies. This article also proposes definitions to clearly describe the different concepts for experts, advisers, and also for policy makers to accurately allocate funds in the European financial framework 2014–2020.

1. Introduction

Conservation agriculture (CA) is one of the so-called emerging agrosciences (Lichtfouse et al., 2010) and encompasses techniques that minimize or eliminate tillage and, thus, maintain a vegetative cover that protects soil from its degradation. CA principles emanate from conservation tillage (CT), which includes no tillage (NT), reduced tillage (RT) and groundcovers (GC) in perennial crops (CTIC, 1994). Nevertheless, CA is not the same as CT. Certainly, CA concept goes beyond CT and is defined by three linked core principles that must be jointly applied to create synergies (Kassam et al., 2012): minimum soil disturbance; permanent organic soil cover; and crop rotations. CA relies on NT as the best practice for arable crops, and on GC for perennial crops.

In some way, CA intends to go back in time in terms of soil protection, as ancient cultures based their agriculture on planting in virgin soil using sticks or other sharp tools to make small holes in which to place the seeds (Derpsch, 1998). In the early 1930s, in the central plains of the United States of America, years of extreme drought resulted in intense wind erosion events known as the Dust Bowl, and millions of tons of soil were lost. These events were captured by Pare Lorentz of the United States Department of Agriculture (USDA) in the film "The Plow that Broke the Plains", which documented the action of tillage as the main cause of erosion (Lorentz, 1936). In response, new tillage equipments to loosen the soil and control weeds without turning over the soil were developed in North America. Those new implements allowed to keep the plant residues on the surface of the soil. This method rapidly expanded throughout the dry lands in the U.S. In addition to fighting soil erosion, this practice better conserved soil moisture. Another milestone in the history of CA, was the foundation in 1935 of the US Soil Conservation Service. In the following years, the service encouraged the creation of research teams dedicated to CA in many American universities (Hill et al., 1994). Similarly, the release of the

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book Plowman's Folly (Faulkner, 1942) increased the sensitivity to the problems of excessive tillage and helped to spread the techniques of CA. During the 1940s, universities, the USDA and farming companies began an intense research plan that resulted in several advances. In 1946, the University of Purdue developed the first seeder for NT, the M-21, and in the 1950s, the wavy disc blade and treatments with atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine) and paraquat (1,1'-dimethyl-4',4'-bipyridilium dichloride) were commercially introduced. In the 1960s, NT was presented as a viable technique for farming (McKibben, 1968).

In northern European countries, the combined negative effects of excessive tillage, particularly in wet soils, with the decline in the rural population and the increased costs of machinery, led many researchers to consider a reduction of tillage and to start experiments in Germany (Baeumer, 1970), the Netherlands (Ouwerkerk and Perdok, 1994) and the UK (Christian, 1994). Nevertheless, the lack of appropriate herbicides made weeds a limiting factor for the development of these tillage systems (Allen, 1981). This problem was overcome with the emergence of herbicides such as paraquat and diquat (1,1'-ethylene-2,2'-bipyridylium dibromide), developed by Imperial Chemical Industries (ICI) in the late 1950s. These products eliminated the need of tillage to control weeds because its total action eradicated them without risk for the subsequent crop. This approach made it feasible to replace tillage by the chemical control of weeds (Hood et al., 1963; Boon, 1965). Thus, the concept of NT arose when the ability to control weeds and equipment adapted to the presence of stubble on the surface of the soil were available. Despite these advances, the idea of entirely eliminating tillage was viewed with scepticism by farmers, and NT was restricted to research projects. It was not until the mid-1960s that the agronomic and economic advantages of these new techniques were perceived by a wider section of the agricultural sector (Moody et al., 1961), and as a consequence, new programs for developing and introducing these systems were initiated in several European countries.

In Spain, the first studies on CA in annual crops date back to 1976 and were performed in the "Haza del Monte" farm in Seville. In these trials that aimed at advancing the sowing date of a second crop, the NT of soybeans over previous crop residues were evaluated (Fernández Quintanilla, 1997). In Madrid, NT trials began in 1980 on the 'The Encín' farm and were carried out based on an agreement between the Technical School of Agricultural Engineers (ETSIA) of the Polytechnic University of Madrid and the National Research Institute for Agriculture and Food Technology. The results showed that NT did not affect grain yields and reduced 80% of energy consumption (Juste et al., 1981). This type of trial was extended to other Spanish regions, including those performed by the Agricultural Research Service of Andalusia and the ETSIA of the University of Cordoba in the 'Tomejil' farm in Carmona, Seville. These trials, which began in 1982 and still continue today, resulted in higher yields in NT fields than in those with traditional tillage (TT) (González et al., 2010). TT practices comprise the common passes of primary and secondary tillage for preparing the seedbed. The primary are deep tillage passes, and are usually performed with mouldboard or chisel ploughs, whereas the secondary passes are shallower than the primary ones, and are generally performed with cultivators or disk harrows. After all those tillage passes, the soil is bare. Another good example of NT that started in 1986 and is still active today, is the Malagón farm (López-Bellido, 2014). As well, several long-term trials were conducted by the Technical and Farm Management Institute in Navarra, the Universtity of Lleida in Catalonia, the CSIC research station Aula Dei in Aragon, and the Research Institute of Castille and Leon. In some studies, it was remarkable the collaboration with the technical departments of the industry (Fernández Quintanilla, 1997). In February 1995, a group of farmers, technicians and scientists, many of them participants of the above-mentioned experiments, founded the Spanish Association for Conservation Agriculture and Living Soils. Thanks to the development of European funded projects, such as LIFE 99ENV/E/308 and LIFE 96ENV/E/338, and the support of manufacturers of NT machinery and the industry of plant protection products, a number of technology transfer activities were conducted with a high degree of regularity, still on-going currently.

Nowadays, the growing interest in soil conservation farming practices across the world is demonstrated by the expansion of NT. In 1999, 45 million hectares were cultivated using NT, whereas 125 million hectares in 2011. These figures represent about 9% of global cropland, and 14% of the cropland in the countries that have adopted NT (Friedrich et al., 2012). There is an evidence to predict a wide and imminent growth in major global economies, such as China (He et al., 2010). Globally, the reasons for this increase mainly derive from the economic benefits that NT practices entail, given the drastic reduction of mechanised operations and the subsequent drop in fuel consumption and working time (González Sánchez et al., 2010). During the expansion of CA systems, achievement of similar yield levels compared with TT has been demonstrated by multiple studies (Triplett et al., 1973; Van Doren et al., 1976; Phillips et al., 1980; Uri, 2000), and has been a major driver for farmers to shift to CA.

In Europe, CA is recognized as an effective practice to protect soil, and has been identified as a solution to serious environmental problems that affect European soils. An impact assessment, carried out in accordance with the European Commission's guidelines and on the basis of available data, shows that soil degradation could cost up to €38 billion a year (Van-Camp et al., 2004). To promote soil conservation practices, European Union's (EU) Member States have tools available, such as the National Rural Development Programmes (RDP), which are co-financed by the EU and its Member States. In Spain the RDPs supported some measures promoting CA during the period 2007–2013 (MAGRAMA, 2014a,b). In the previous RDP, which covered the period 2000–2006, the total budget was over € 1300 million. An example of annual investment is shown in Table 1. In year 2006, all agri-environmental measures slightly exceeded € 201 million, whereas 27 million for CA measures. At the end of 2006, nearly 18% of farmers who adopted any agri-environmental measure in Spain received this support for practicing CA. These farmers accounted for 4.6% of the total area that adopted agri-environmental measures and 13.4% of the budget allocated to the RDP. In addition, other initiatives aimed at promoting the adoption of CA in Spain. CA has demonstrated to help Spain's authorities to meet the targets set in the Kyoto Protocol (González-Sánchez et al., 2012). Based on the actions to establish the potential for the sequestration of CO_2 throughout the Spanish territory as a result of changes in the use of agricultural land, the Spanish Office for Climate Change suggested the use of several agricultural practices to increase the soil's sink effect. These

Table 1
Financial support of total agri-environmental measures in Spain in 2006 and support of conservation agriculture measures (adapted from MAGRAMA (2011b)).

	Number of farmers	%	Area (ha)	%	Public support (×1000€)	%
Total agri-environmental measures	98,502	100	3,034,511	100	201,996	100
Conservation agriculture measures	17,613	17.9	144,403	4.6	27,133	13.4
Perennial crops	16,943		141,190		26,959	
Arable crops	670		3213		174	