INTERNATIONAL
SOIL AND WATER
CONSERVATION RESEARCH

Conservation Agriculture in Europe

Á. Kertész[1] and B. Madarász[2]

Abstract

The adoption of Conservation Agriculture (CA) in Europe varies according to the ecological regions of the continent. Although Europe is behind other countries in adoption of CA, the indicators for future progress are encouraging. The area where CA is applied is growing rapidly because of increasing environmental awareness, including soil protection, and because of the need to reduce production costs. The European Conservation Agriculture Federation (ECAF) plays an important role in the adoption and dissemination of CA practices, and in discussions involving CA and the EU Common Agricultural Policy (CAP) reform.

Yield performance and stability, operating costs, environmental policies and programs of the Common Agricultural Policy (CAP), and climate change will likely be the major driving forces defining the direction and for the extension of CA in Europe. The role of agriculture in climate change mitigation in the EU is discussed in the paper.

Key Words: Conservation Agriculture, Reduced tillage, No tillage, Climate change mitigation, CAP reform

1 Introduction

Conservation Agriculture (CA) is practised on over 125 Mha around the world, covering approximately 10% of the global arable land surface. This compares to only 45 Mha in 2004 (Friedrich et al., 2012). The largest and most rapid expansion has been in North and South America, Australia/New Zealand, and some parts of Africa. The estimated annual adoption rate of CA has approximated 7 Mha yr^{-1} during the last ten years (Kassam et al., 2014, this issue).

Compared to this, the adoption and extension of CA in Europe has not been as rapid nor as extensive. According to Eurostat (2010), CA is practiced on 22.7 Mha, representing 25.8% of arable land in Europe. There has been intensive research on various aspects of no tillage (NT)[3] and reduced tillage (RT) in Europe between 1960 and 1990 (Soane and Ball, 1998), and these have been reviewed by various authors (Cannel, 1985; Soane and Ball, 1998; Rasmussen, 1999; Tebrugge and During, 1999; Holland, 2004; Deumlich et al., 2006). Recently, Soane et al. (2012) published a comprehensive review of Conservation Agriculture in Europe.

Soil erosion is a major problem throughout the world, and also in Europe, particularly in the semi-arid regions. Soil protection against erosion and degradation is an important aspect, because water erosion occurs on 12% of the total European land area and wind erosion on 4% (Oldeman et al., 1991). However, soil erosion risk varies according to the different ecological regions in Europe, with the northern, cool, temperate regions having the lowest risks, and the semi-arid Mediterranean regions having the highest. Soil erosion is serious on about 25 Mha in the Mediterranean region (De Ploey et al., 1991).

The reasons for adoption of CA in Europe have been described by Soane et al. (2012), among others. CA has application in regions where mitigation of soil erosion and land degradation are important objectives, but

[1] Professor, Institute of Geography, Research Center for Astronomy and Earth Sciences, Hungarian Academy of Sciences, H-1112 Budapest, Budaörsi út 45, Hungary. Corresponding author: E-mail: kertesza@helka. iif. hu

[2] Dr., Institute of Geography, Research Center for Astronomy and Earth Sciences, Hungarian Academy of Sciences, H-1112 Budapest, Budaörsi út 45, Hungary

[3] No-tillage and zero-tillage are used interchangeably in this paper.

also in those parts of Europe where retention of soil moisture is important to ensure economically viable agricultural production. In the latter locations, mostly the semi-arid and Mediterranean regions, retaining water in the soil provides some degree of drought proofing and some level of economically acceptable yields even during dry periods. On the other hand, CA is a useful, complementary, land management strategy for reducing surface runoff and surface water pollution, as well as mitigating the severity of flooding, mostly in northern regions of Europe with predominantly cool and wet climates and extended, long lasting, low intensity rainfall.

Adoption of CA in Europe is predicated more on improving net returns, through reduced operating, labor, and input costs, and on enhancing environmental benefits, than on mitigating soil erosion. This is typical of countries such as Finland and Germany where CA practices are spreading very quickly. Although benefits for the soil and for the environment are important issues, the introduction of CA practices in Europe has been driven mainly by economic considerations (Lahmar, 2008).

The average rate of soil loss in Europe has been estimated at about 17 mg ha^{-1} yr^{-1}, which exceeds the estimated rate of natural soil formation, about 1 mg ha^{-1} yr^{-1} (Troeh and Thompson, 1993). However, comparison of conventional and CA practices show that applying CA generally keeps the rate of soil loss under that of soil formation (Bádonyi et al., 2008; Kertész et al., 2011), thus enhancing the long term sustainability of the system. Also, besides providing protection against water and wind erosion, CA improves soil health and resilience by maintaining good soil structure, enhancing soil moisture storage, enriching soil organic matter, improving the habitat for soil micro and meso-fauna, and enhancing soil biodiversity.

The European Conservation Agriculture Federation (ECAF) was founded in 1999 with the objective to adopt CA in its member countries, and to integrate CA as the basic principle in mainstream agriculture in Europe and the EU member states (ECAF, 2005). According to ECAF (2005), Europe lags other countries in adoption of CA because: 1) there is less need to take risks in Europe because the cost reductions are not as important as elsewhere; 2) lack of technology for European conditions; 3) lack of appropriate technology transfer; 4) lack of institutional support. These conditions held true until early in the 21st century, but since then new machinery and technology have become available, and adoption has accelerated as a consequence. Also, enhanced institutional support became available from the EU authorities/institutions, while reduction of costs became considerably more important. ECAF took part in the discussion and development of the EU Soil Thematic Strategy.

2 Distribution of Conservation Agriculture (CA) in Europe

Figures 1 and 2 show the share and location of total arable land under CA and NT (no till) in Europe in 2010 (adoption is shown for the 27 EU countries (EU-27), as well as for Norway, Switzerland, Iceland, and Montenegro). The countries with the highest proportion of CA and NT are Cyprus (62.1%), Bulgaria (58.0%), Germany (41.1%), U.K. (39.2%), Finland (38.7%), France and Switzerland (36.4%), Czech Republic (34.8%), and Luxemburg (31.0%). The EU-27 country average is 26% (Eurostat, 2010). The countries are distributed among contrasting eco-regions, reflecting different driving forces for adoption of CA, as well as varying government policies and promotion.

The evolution and adoption of CA in Europe has not been consistent. According to Basch (2012), the percentage of CA/land area in Switzerland in 2005 was 43%, but declined to 36.4% in 2012; in France, the area increased from 17% to 36.4% during this period; in Germany the area increased from 23% to 41.1%; and in the U.K. the area increased from 31% to 39.2%. In general, however, the adoption of CA in Europe has been increasing continuously. It is interesting to note that the increase in area of CA in Spain, Portugal and Italy under perennial crops (fruits, vineyards and olive plantations) has exceeded the adoption rate in annual crops.

The geography and cultures in Europe are highly variable, and consequently there has been considerable variation in types of agriculture and interest in applying CA practises. The UK, Switzerland, and Scandinavia were the pioneers for CA development and adoption, and increasingly overtime, farmers changed from conventional tillage to CA. By the end of the 1970s in the UK, 8%−10% of the winter cereals was produced under no tillage or reduced tillage (Soane and Ball, 1998). However, because of unexpected problems of crop residue management and weed management, these often reverted back to mouldboard ploughing. A similar scenario occurred in Scandinavia between the 1970s and the late 1990s (Rasmussen, 1999).

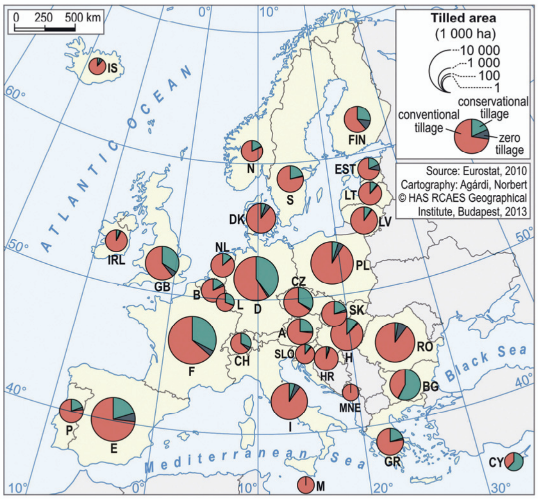


Fig.1 Arable land under various tillage systems in the 27 EU countries, as well as Norway, Switzerland, Iceland, and Montenegro (Eurostat, 2010)

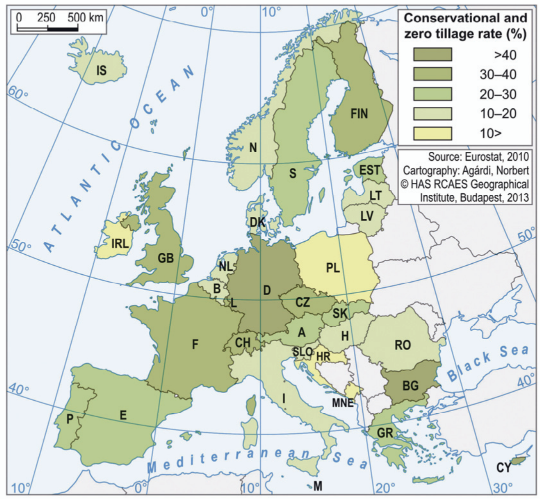


Fig.2 Arable land under conventional and zero (no) tillage (%) in the 27 EU countries, as well as in Norway, Switzerland, Iceland, and Montenegro (Eurostat, 2010)

The variation in adoption rates among European farmers is given by Lahmar (2008) and Soane (2012). In Norway, even in areas with considerable erosion risk, farmers have shifted back from reduced tillage to spring ploughing. In France, the interest of farmers grew in the 1970s because of reduced labour in CA, declined in the 1980s because of high herbicide costs, but increased again around the turn of the century when herbicide prices declined. In Italy, NT started by the end of the 1960s, but the real expansion did not occur until the 1990s (De Vita et al., 2007; cited by Lahmar, 2008).

CA practices started in Spain as early as the 1970s (Lahmar, 2008). Based on experiences from the USA, farmer cooperatives, societies and consortia, were formed as central players in CA adoption. Scientists, extentionists, and various national and international companies participated in supporting and expanding CA adoption, and provided some targeted financial assistance (Tamames, 2002). The first world congress on CA took place in Madrid in 2001, and the European Congress on Conservation Agriculture was organised in Madrid in 2010.

The Czech Republic took the lead in CA adoption in central/eastern Europe. In Ukraine (Medvedev et al., 2004), as well as in the Czech Republic (Javurek et al., 2008), and in Hungary (Kertész et al., 2010, 2011), research contributed extensively and convincingly to the dissemination of CA practices. The area under CA in Russia is 4.5 Mha, according to the FAO definition, and in Ukraine, CA is practised on 0.6 Mha (Friedrich et al., 2012).

3 Conservation Agriculture and reform of the Common Agricultural Policy

The Common Agricultural Policy (CAP), which is the central policy platform for agriculture in Europe, has been evolving continuously since its inception in the middle of the 20th century. Although originally focusing primarily on food production, the CAP has moved towards increased emphasis on environmental issues and on the linkages between agricultural and environmental policies in the last several decades. This has become manifested in the system of farm support, where payments are more and more linked with environmental issues like climate change and environmentally sensitive solutions.

The concern in the EU on agricultural production, global food security, and the environment are high priority topics for the CAP reform (Basch et al., 2012). Other, related issues include sustainable management of natural resources, mitigation of climate change, and improvement of competitiveness. The European Commission, the European Parliament, the European Economic and Social Committee, and the Committee of the Regions have developed three general objectives for the future CAP: 1) viable food production; 2) sustainable management of natural resources and climate action; and 3) territorial development. The concept of "Smart Growth" is also included in the EU 2020 Strategy, referring to better resource efficiency and competitiveness. Basch et al. (2012) set out a detailed list on the advantages of CA corresponding to the goals of the CAP revision.

The list identifies the benefits of CA, including soil conservation and environmental protection, as well as reduced production costs, optimal crop yields, and enhanced competitiveness.

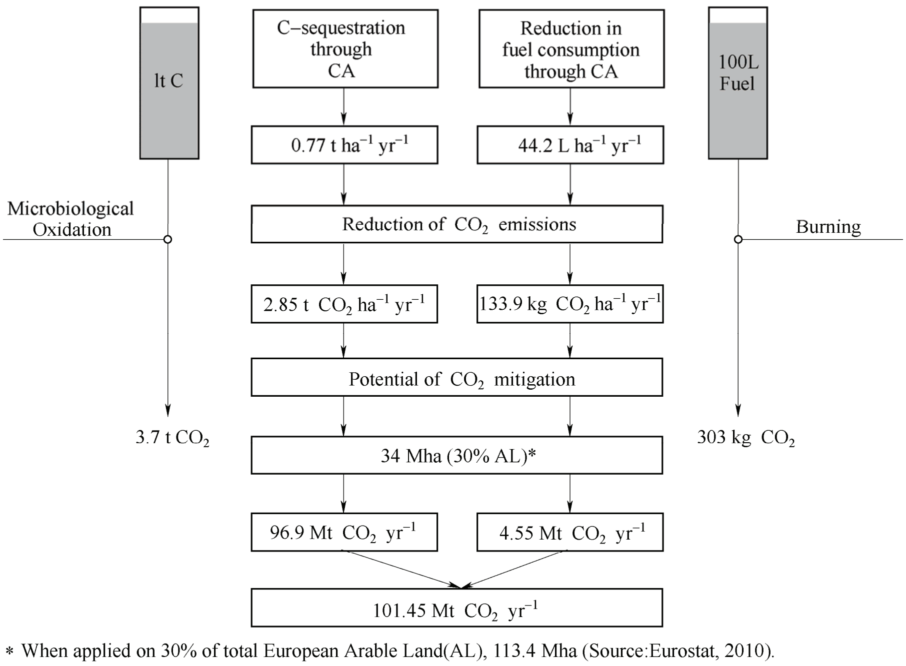
Among the objectives for the revision of CAP are the requirements for an agricultural production process respecting natural conditions and the environment, while also optimising production. CA relates closely to these objectives in that it enhances environmental protection and biodiversity, conserves energy, promotes more efficient resource use, and protects soil health and resilience. CA provides the foundation on which a healthy, consumer based agriculture and food production system can be developed for Europe and the world.

4 Conservation Agriculture and mitigation of climate change

It is increasingly accepted that the frequency and intensity of storms will increase under future scenarios of climate change (Soane et. al., 2012). Correspondingly, there will be increased risk and severity of soil erosion, with increased costs of mitigation. The IPCC (2007) estimates that agriculture, globally, is responsible for about 30% of the total greenhouse gas emissions (CO_2, N_2O and CH_4), while simultaneously being directly impacted by a changing climate. For the EU, the share of agriculture is 10% to total of EU greenhouse gas emissions (Basch et al., 2012), although burning stubble after harvest and soil organic carbon losses due to conventional ploughing are not included in the figure. Intensive, conventional tillage and soil carbon losses are strongly interrelated.

Smith et al. (1998)estimate annual carbon sequestration through no tillage at approximately 0.4 t C ha^{-1} yr^{-1}. In addition, the authors report that the added sequestration benefit gained by maintenance of 2 to 10 t ha^{-1} straw on the soil surface, is roughly 0.2 to 0.7 t C ha^{-1}. Assuming that 30% of the total area of arable land in the EU-27 is suitable for CA application, this translates to 0.77 t C ha^{-1} yr^{-1} in reduced CO_2 emissions, as well as 44.2 L ha^{-1} in reduced fuel consumption under CA (Fig. 3) (McConkey et al., 2000; Basch et al., 2012). This may, however, be an under estimate since the Eurostat (2010) reports on only 25.8% of the area in the EU-27 (plus Norway, Switzerland, Croatia, Montenegro, and Croatia).

Based on the above data, the potential carbon sequestration under CA practices in the EU-27 is 26.2 Mt CO_2 yr^{-1}, representing a total, annual CO_2 mitigation potential of about 97 Mt CO_2 yr^{-1} (Fig.3). It should be noted that the yearly amount of 4.5 Mt CO_2 saving due to less fuel consumption under CA is miniscule compared to the value of carbon sequestration. However, the reduction of CO_2 emissions and carbon sequestration, together, approximate 40% of all CO_2 emissions (266.4 Mt CO_2), which the EU-15 states agreed to decrease by 2012 (Tebrugge, 2001). It is even more striking that this amount is the equivalent to what the EU-27 could reduce between 1990 and 2010 (Olivier et al., 2001).



* When applied on 30% of total European Arable Land(AL), 113.4 Mha (Source:Eurostat, 2010).

Fig.3 Estimation of the potential reduction CO_2 emissions through the application of Conservation Agriculture in Europe (EU-27)

5 The future of Conservation Agriculture in Europe

Crop yield data in Europe generally show a positive advantage towards Conservation Agriculture. Comparing yield data of CA and conventional tillage in Hungary, Kertész, et al. (2011) show a yield increase of about 10%, although in some cases, a slight decrease was observed during the first years of applying CA practices. In northern Europe, the situation is similar, except on poorly drained, clay soil. In Ukraine, yields are estimated to increase by 5%−10% on the Chernozemic soils (De Tourdonnet et al., 2007). In southern Europe and Spain, Arrue et al. (2007) report 10%−15% yield improvement under no-tillage, especially in dry years. There are, however, differences among the regions, and Lahmar (2008) and Soane et al. (2012) report that CA does not always result in yield increases. The general trend for the future for CA in Europe, based on yield response, is optimistic.

Reduction of operating costs will continue to a major consideration in farmers' decisions to adopt CA. Previously, environmental benefits, like soil and water protection and decreasing soil erosion, did not influence farmer decisions as much as production and economic considerations, but environmental awareness and the significance of ecological management are becoming important issues for farmers. These have emerged as a result of the increasing vibrant environmental policy development in the EU. The CAP reform, and the system of financial and institutional supports that evolve are expected to impact significantly on farmer decisions to apply CA practices.

In general, CA is proving to be more popular on larger, commercial farms than on smaller farms, and it provides opportunities for more profitable winter crops. Although yield response and yield variability are important considerations in Europe, often due to the uncertainties of climate change, some reduced yields under CA may be acceptable providing that these are balanced with appreciable reductions in operating costs (Soane et al., 2012).

The environmental advantages of CA, including soil and water conservation, landscape protection, mitigation of flooding, reduced pollution of waterways from sediments and particular bound phosphorus, and improved drought proofing, will be increasingly important in the future. These issues, as well as economic issues such as marketing and agricultural competiveness, are being evaluated within the political envelope of the CAP reform, and will form the basis for the kinds and levels of future financial support for the agricultural and food industry in Europe. The CAP reform is likely to be one of the major driving forces on acceptance and adoption of CA in Europe.

The uncertainties of climate change will also be significant in the evolution of CA in Europe. In northern Europe, the evidence is towards milder winters, wetter periods in autumn and spring, and longer growing seasons. In southern and central Europe, the trends are towards drier summers and wetter winters, with increased concerns on droughts (Soane et al., 2012). These variations multiply the uncertainties in yield variability common to crop production, and complicate farmer decisions on adoption of new technologies such as CA.

Considering the variation in European geography, climates, ecology, cultures, and traditions, and the push-pull effects of EU policy and programs, the future of CA will be different in different parts of Europe. Yield performance and stability, operating costs, environmental policies and programs, and climate change will likely be the major driving forces defining the direction and for the extension of CA in Europe.

References

Arrúe, J.L., Cantero-Martínez, C., Cardarelli, A., Kavvadias, V., López, MV., Moreno, F., Mrabet, R., Murillo, JM., Pérez de Ciriza, J.J., Sombrero, A., Tenorio, J.L., and Zambrana, E. (2007). Comprehensive inventory and assessment of existing knowledge on sustainable agriculture in the Mediterranean platform of KASSA. KASSA project (Knowledge Assessment and Sharing on Sustainable Agriculture) a European Commission-funded project (DG-Research - Contract no. GOCE-CT-2004-505582). 27 pp.

Bádonyi, K., Hegyi, G., Benke, Sz, Madarász, B., and Kertész, Á. (2008). Talajművelési módok agroökológiai összehasonlító vizsgálata. *TájökológiaiLapok*, 6(1-2), 145-163.

Basch, G., Kassam, A., González-Sánchez, E.J., and Streit, B. (2012). Making sustainable agriculture real in CAP 2010. The role of conservation agriculture. http://www.ecaf.org/docs/ecaf/ca%20and%20cap%202020.pdf.

Cannel, R.Q. (1985). Reduced tillage in north-west Europe. A review. *Soil Tillage & Research*, 5, 129-177.

De Ploey, J.A., Imeson, A., and Oldeman, L.R. (1991). Soil erosion, soil degradation and climate change. In Brower, F. M., Thomas, A. J., and Chadwick, M. J. (Eds.), *Land Use Change in EUROPE* (pp. 275-292). London: Kluwer Academic Publishers.

De Tourdonnet, S., Nozières, A., Barz, P., Chenu, C., Düring, R.A., Frielinghaus, M., Kölli, R., Kubat, J., Magid, J., Medvedev, V., Michels, A., Müller, L., Netland, J., Nielsen, N.E., Nieves Mortensen, C., Picard, D., Quillet, J.C., Saulas, P., Tessier, D., Thinggaard, K., and Vandeputte, E., (2007). Comprehensive inventory and assess-ment of existing knowledge on sustainable agriculture in the European platform of KASSA. In Lahmar, R., Arrue, J. L., Denardin, J. E., Gupta, R. K., Ribeiro, M. F. F., and de Tourdonnet, S. (Eds.), *Knowledge Assessment and Sharing on Sustainable Agriculture*. CIRAD, Montpellier, ISBN 978-2-87614-646-4, 54 pp.(CD-Rom).

Deumlich, D., Kiesel, J., Thiere, J., Reuter, H., Völker, L., and Funk, R. (2006). Application of the Site Comparison Method (SICOM) to assess the potential erosion risk-a basis for the evaluation of spatial equivalence of agri-environmental measures. *Catena*, 68(2-3), 141-152.

De Vita, P., Di Paolo, E., Fecondo, G., Di Fonzo, N. and Pisante, M. (2007). No-tillage and conventional tillage effects on durum wheat yield, grain quality and soil moisture content in southern Italy. *Soil Tillage & Research*, 92, 69-78.

European Conservation Agriculture Federation. (2005). http://www.ecaf.org.

Eurostat. (2010). http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Agrienvironmental_indicator_-_tillage_practices.

Friedrich, T., Derpsch, R., and Kassam, A. H. (2012). Global overview of the spread of conservation agriculture. *Journal Agriculture Science and Technology, Special Issue* 6, 1-7.

Holland, J. M. (2004). The Environmental consequences of adopting conservation tillage in Europe: Reviewing the evidence. *Agriculture, Ecosystems and Environment*, 103, 1-25.

IPCC. (2007). Climate Change. Fourth Assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Javůrek, M., Hůla, J., Vach, M., and Kroulík, M. (2008). Impact of different soil tillage technologies on soil erosion effect mitigation. *Scientia Agriculturae Bohemica*, 39(2), 218-223.

Kertész, Á., Madarász, B., Csepinszky, B., and Bádonyi K. (2010). Conservation agriculture as a tool against soil erosion and for improving biodiversity. Proceedings of the European Congress on Conservation Agriculture - Towards Agro-Environmental Climate and Energetic Sustainability. Madrid. Spain 4-7/10/2010. VA Impresores, S.A., Madrid, Spain. pp.501-506.

Kertész, Á., Madarász, B., Bádonyi, K., Csepinszky, B., and Mika, J. (2011). Conservation tillage for rational water management and soil conservation. *Hungarian Geographical Bulletin*, 60(2), 117-133.

Lahmar, R. (2008). Adoption of conservation agriculture in Europe: lessons of the KASSA project. *Land Use Policy*, 27, 4-10.

McConkey, B., Chang Liang, B., Padbury, G., and Lindwall, W. (2000). Carbon sequestration and direct seeding. In Proceeding: direct seeding "Sustainable Farming in the new Millennium" 12th Annual Meeting, Conference and Trade Show of the Saskatchewan Soil Conservation Association, February 9-10,2000.

Medvedev, V.V., Lyndina, T.E., and Laktionova, T.M. (2004). Soil bulk density. Genetical, Environmental and Agronomical Aspects (in Russian). Kharkiv. 244 pp.

Oldeman, L.R., Hakkeling, R.T.A., and Sombroek, W.G. (1991). World Map of the Status of Human-Induced Soil Degradation. An Explanatory Note (revised ed.). UNEP and ISRIC, Wageningen, The Netherlands, 34 pp.

Olivier, J.G.J., Janssens-Maenhout, G., Peters, J.A.H.W., and Wilson, J. (2001). Long-term trend in global CO_2 emissions. 2001 report. The Hague: PBL/JRC.

Rasmussen, K.J. (1999). Impact of plough less soil tillage on yield and soil quality: a Scandinavian review. *Soil Tillage & Research*, 53, 3-14.

Smith, P., Powlson, D.S., Glendining, M.J., and Smith, J.U. (1998). Preliminary estimates of the potential for carbon mitigation in European soils through no-till farming. *Global Change Biol*., 4, 679-685.

Soane, B. D., Ball, B. C., Arvidsson, J., Basch, G., Moreno, F., and Roger-Estrade, J. (2012). No-till in northern, western and south-western Europe: A review of problems and opportunities for crop production and the environment. *Soil & Tillage Research*, 118, 66-87.

Soane, B.D., and Ball, B. C. (1998). Review of management and conduct of long-term tillage studies with special reference to a 25-yr experiment on barley in Scotland. *Soil Tillage & Research*, 45, 17-37.

Tamames, R. (2002). Agricultura de conservación. Un enfoque global. Ed. Mundi Prensa, Madrid. 207 pp.

Tebrügge, F. (2001). No-Tillage Visions-Protection of Soil, Water and Climate and Influence on Management and Farm Income. In Garcia-Torres, L., Benites, J., Martínez-Vilele, A. (Eds.), *Conservation Agriculture: A World-wide Challenge* (pp. 303-316). 1st Congress on Conservation Agriculture. Madrid, 1-5 October 2001.

Tebrügge, F., and Düring, R. A. (1999). Reducing tillage intensity: a review of results from a long-term study in Germany. *Soil Tillage & Research*, 53, 15-28.

Troeh, F. R., and Thompson, L. M. (1993). Soils and Soil Fertility. New York: Oxford University Press. 489 pp.