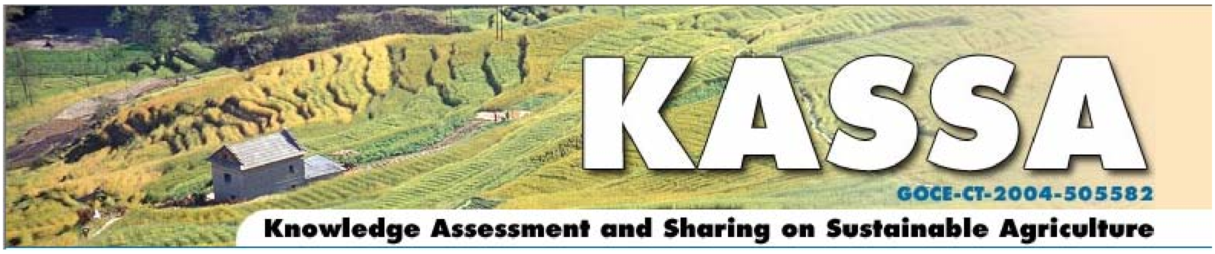

Prospects for sustainable agriculture in the Mediterranean platform of KASSA

J.L. Arrúe[1*], C. Cantero-Martínez[2], A. Cardarelli[3], A. de Benito[4], J.E. Fernández[5], V. Kavvadias[6], M.V. López[1], F. Moreno[5], R. Mrabet[7], J.M. Murillo[5], A. Onorati[3], C. Paschalidis[8], J.J. Pérez de Ciriza[9], A. Sombrero[4], J.L. Tenorio[10], E. Zambrana[10] and G. Zervakis[6]

[1]Consejo Superior de Investigaciones Científicas (CSIC), Estación Experimental de Aula Dei (EEAD), Avda. de Montañana 1005, 50059 Zaragoza, Spain
[2]Universidad de Lleida (UdL), Avda. Rovira Roure 191, 25198 Lleida, Spain
[3]Centro Internazionale Crocevia (CIC), Via Tuscolana 1111, 00173 Roma, Italy
[4]Instituto Tecnológico Agrario de la Junta de Castilla y León (ITACyL), Ctra. de Burgo, Km. 118, 47071 Valladolid, Spain
[5]Consejo Superior de Investigaciones Científicas (CSIC), Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS), Avda. de Reina Mercedes 10, 41012 Sevilla, Spain
[6]National Agricultural Research Foundation (NAGREF), Lakonikis 87, 24100 Kalamata, Greece
[7]Institut Nacional de la Recherche Agronomique (INRA), BP 578, 50000 Meknès, Morocco
[8]Technological Educational Institute (TEI), Department of Greenhouse Crops and Floriculture, Antikalamos, Kalamata, 24100, Greece
[9]Instituto Técnico y de Gestión Agrícola (ITGA), Avda. Serapio Huici 20-22, 31610 Villava, Spain
[10]Instituto Nacional de Investigaciones Agrarias (INIA), Ctra. de la Coruña, Km. 7,5, 28040 Madrid, Spain

[*] Platform Coordinator

Centre de coopération internationale en recherche agronomique pour le développement
Avenue Agropolis, 34398 Montpellier, France

www.cirad.fr

ACKNOWLEDGMENTS

The research reported here has been carried out in the context of KASSA project (Knowledge Assessment and Sharing on Sustainable Agriculture) a European Commission – funded project (DG-Research - Contract no. GOCE-CT-2004-505582) under the FP6 programme: "*Integrating and strengthening the European Research Area*"; Thematic priority "Sustainable Development, Global Change and Ecosystems", Sub-priority "Global Change and ecosystems".

Disclaimer

This publication reflects only the authors' views. It should not be construed as representing the views of the European Commission. The European Commission is not liable for any use that may be made of the information contained therein.

KASSA has been coordinated by CIRAD.
It worked between 1 September 2004 and 28 February 2006.
The KASSA Consortium assembled 28 contractors from 18 countries.
KASSA has been implemented through four regional "platforms": Europe, the Mediterranean, Asia and Latin America.
http://kassa.cirad.fr

Partners of the Mediterranean platform:

16- CSIC (EEAD & IRNAS), Spain;
17- UdL, Spain;
18- ITACyL, Spain;
19- INIA, Spain;
20- ITGA, Spain;
21- INRA, Morocco;
22- CIC, Italy;
23- NAGREF, Greece.

Scientific advice has been provided by:

Michel Griffon (CIRAD, France);
Ren Wang (IRRI, Philippines);
Jaromir Kubat (VURV, Czech Republic);
Roberto Peiretti (AAPRESID, Argentina).

This document is the deliverable D3.2 of the workpackages 1.3 & 2.3

Table of Contents

1. Introduction

The present report represents the effort made by the Mediterranean Platform Partners to synthesise the work carried out within the following Work Packages:

WP1.1. Inventory and assessment of existing knowledge on sustainable agriculture in the Mediterranean Platform region (WP1.1 draft report).

WP2.1 Joint validation of the assessment WP1.1 report at the First Mediterranean Platform Meeting (Zaragoza, Spain, 25-27 April 2005). Deliverable: **D1.2** report.

WP1.2 Learning from platform reports: critical comparative analysis of the assessment reports **D1.1,** European Platform report, **D1.3,** Asian Platform report, and **D.1.4,** Latin American Platform report (WP1.2 draft report)

WP2.2 Joint validation of the platform comparative analysis report WP1.2 at the Second Mediterranean Platform Meeting (Meknès, Morocco, 27-29 June 2005). Deliverable: **D2.2** report.

WP1.3 Refining platform findings taking into account the messages from the other platforms (WP1.3 draft report).

WP2.3 Joint validation of the WP1.3 draft report on the prospects for sustainable agriculture in the Mediterranean Platform region at the Third Mediterranean Platform Meeting (Rome, Italy, 26-28 September 2005). Deliverable: **D3.2** report.

The **D3.2** report is a synthesis of the content of Work Packages 1.2 and 1.3 following the outline suggested by the Coordination and Management Unit at its third meeting (New Delhi, India, 23-25 May 2005). In the report there have been taken into account the criticisms and messages received both the Steering Committee and the other three platform reports.

In *Section 2*, we address the local and regional socio-economic and biophysical features of the Mediterranean Platform as well as policy opportunities and constraints regarding the shifting from conventional agriculture to sustainable agriculture.

Section 3 deals with suitable alternative technologies and approaches to the Mediterranean Platform conditions, the best geographical situations and biophysical conditions for these technologies in support of sustainable agriculture, the socio-economic, cultural and policy conditions necessary for their adoption by farmers (dissemination), the socio-economic and environmental impacts expected and some proposals for appropriate local and regional policies.

Finally, in *Section 4*, the main knowledge gaps identified are outlined and, accordingly, the research topics and priorities that should be addressed in the Mediterranean region to fill those information gaps.

2. Factors influencing the shifting from conventional agriculture to sustainable agriculture in the Mediterranean Platform

2.1. Local and regional socio-economic and biophysical features

2.1.1. The Mediterranean region: climate, soil and environment

The Mediterranean Platform region (basin scale) presents a series of socio-economic and biophysical characteristics that clearly differentiates it from the other three KASSA platforms (continent scale). Thus, the Mediterranean climate is characterised by the variability of the weather conditions in the Mediterranean basin *(Emberger et al, 1963).* It can be found also in South-eastern and Western Australia and small areas in North and South America.

In the Mediterranean basin, although climate has very variable rainfall and temperature *(Elías, 1984),* there is, however, a typical pattern *(López-Bellido, 1992).* Rainfall ranges between 250 and 700 mm, is variable and erratic, with high-volume and high intensity storms. Rainfall is distributed typically with two precipitation periods in autumn/early winter and spring (this last only in the western areas) *(Le Houérou, 1993).* Winter and summer have very limited rain. Precipitation received from September to January is used for soil water recharge, which allows the development and performance of rainfed herbaceous crops. Drought is endemic in the whole region and dry spells are possible in early, mid and late seasons. Temperature is very variable and becomes continental far away from the coastal areas having extreme cold winter conditions and very hot summers with high evapotranspiration rates. Coastal areas have milder conditions and winter and summer are less extreme, which favours a wide range of crops if water for irrigation is available. In many areas, moderate winds increase evapotranspiration and consequently the drought conditions.

Soils in the Mediterranean region present an enormous variability. This soil diversity reflects differences in climate, geological origin, vegetation, land use and historical development of Mediterranean landscapes *(Paskoff, 1973, ICARDA, 1979, Roquero, 1979, Bradbury, 1981).* On average, soils have medium to poor fertility, with low organic mater contents due to low natural vegetation developed on them (rainfall influence) and because the active human activity from more that 2000 years of cultivation. Limitations to crop growth are imposed all around by soil depth (that influences soil water holding capacity), poor soil structure, salinity, alkalinity and stoniness that aggravate the drought conditions. More site-specific could be P and K levels.

Nowadays, the main environmental problems that faces the Mediterranean area are **scarce water availability** for human activity and the **soil degradation by soil erosion** due to low vegetation cover, the rainfall intensity, and cropping and livestock (over-grazing) management. Other environmental concerns are in a second term in the Mediterranean area.

In terms of Mediterranean agricultural systems, farmers practice both **extensive rainfed agriculture** and **intensive irrigated agriculture**. When practiced in soils with low organic matter contents and poor quality, and where stubble burning and over-grazing practices and lack of organic residue incorporation reduce fertility and biodiversity, extensive rainfed agriculture deteriorates the initial soil properties and quality and increases desertification problems. Intensive irrigated agriculture with excessive and inefficient water use and chemical rate applications can increase negative environmental impacts associated to soil degradation by chemical pollution and salinisation.

2.1.2. <u>Mediterranean cropping systems: soil and water management and conservation</u>

Agricultural activity in the Mediterranean basin differs among countries. Due to social and economical factors, there exist marked differences between Southern and Northern Mediterranean countries. Northern Mediterranean countries have a more developed agriculture due to a better access to technology that permitted better social and economical development with a low population involved in agricultural activities. In Southern Mediterranean countries, which historically have had less development and thus higher social and economical constraints, agriculture is a major sector of the countries' economy that consumes water and energy resources. In Northern Mediterranean countries water is the natural resource highly consumed in agriculture, being energy consumption in a second level.

The Mediterranean area has a sort of dryland farming systems from humid rainfed regions to semiarid and arid dryland areas. They are limited by weather, land topography, water resource conditions, low potential soils, intensive soil tillage management and soil losses. Overall, in this entire dryland region **water is the main constraint for agriculture**.

The most important crops in the Mediterranean area have been winter cereals (wheat and barley), because they are the best adapted, matching their growth and development period with water availability *(White, 1970; Cooper et al., 1987)).* Tree crops, such as olives, almond, nuts and vineyards, accompany winter cereals where soil conditions permit the use of available water to the crop in summer months. Other crops are grain legumes (peas, faba bean, lentils, chickpea, canola…) and forage legumes (alfalfa, sainfoin, vetches…) are present with some limitations *(Cooper et al., 1987).* Other wide range of field crops (sunflower, potatoes, sugar beet, cotton….) and all sort of horticultural crops and fruit trees as apples, peaches, pears, and citrus can be grown if there is enough available water for irrigation *(White, 1970).* Crop productivity is very variable depending on crop rotation and country, but it cannot reach the Central and Northern Europe levels because length cycle limitation and water availability. In the driest areas a complete crop failure is possible in a 20-30 % of the years.

Crop rotations are limited by water availability at sowing and filling grain periods of the crops. Long fallowing (up to 16-18 months) has been traditionally practised *(Cooper et al., 1987)*, but in many areas this practice has proved inefficient for water and fertility accumulation *(López et al., 1996; Mrabet, 2000; Lampurlanés et al., 2002).* Thus, and due to the population pressure on the use of land, continuous cropping of the more adapted crop rotations is now common. Some areas are devoted to dryland permanent pastures, mainly in highlands. Livestock (cattle, sheep and goat) interacted with pasture lands and crops as barley and wheat systems, where stubble is commonly grazed. In other cases straw is baled and used for feeding and bedding of the animals. In many places of the Northern Mediterranean countries, hog and poultry production systems are common. Application of manure and slurry are used as fertilisers to recover soil fertility but when used in excess this practice promotes pollution and contamination of soils and waters.

Bench terracing to increase soil and water availability and to avoid surface runoff and soil erosion is very common in all areas. Field herbaceous crops are based in tillage and sowing of improved landraces varieties, N-P-K fertilisation, weed control and harvesting of grain, straw and forage. Tree crops added to this, the simple technology of pruning *(Cooper et al., 1987).*

Environmental problems in rainfed areas arise from repeated, intensive or continuous tillage, the removal of crop residues and when there is reliance on excessive organic fertiliser applications (manure and slurry), which merge to increase soil erosion, N and P accumulation and pollution. Intensive production areas in irrigated agriculture are scattered and, consequently, soil compaction and soil and water pollution are still local processes. In the Mediterranean region, especially, in Southern Mediterranean countries, **desertification is becoming a critical phenomenon**.

2.2. Conservation Agriculture (CA) and Organic Farming (OF) as alternatives to conventional agriculture

2.2.1. Conservation Agriculture (CA)

Soil cultivation by intensive tillage has been traditional over the last two millennia in the Mediterranean agriculture. The 20th century marked the development of the mechanisation and tillage and all farming technologies were improved. In European Mediterranean countries tractors are fully used for tillage, however, in North African countries some farmers are still using animal drawn implements (i.e., 20% in Morocco). Intensive tillage is traditionally used for seedbed preparation and crop residues are removed, grazed or even burned. Reduction of intensive tillage in the Mediterranean region begun in the 1960's, and later in North African Mediterranean countries *(Mrabet, 2000),* with variable impact and mainly driven by the necessity for a reduction in different inputs (fuel, machinery and labour). Development and adoption of no-tillage has been very irregular in the Mediterranean region and while knowledge of this technology has not reach all places in Mediterranean countries, in some particular areas the practice of no-tillage accounts for up to 80%.

In Mediterranean countries, CA has received different names, such as Conservation Tillage, No-tillage, etc. All of these terms are referred to soil management technologies promoting soil tillage reduction. Now, CA includes conservation tillage technologies in field crops and maintenance of vegetal covers in tree crops.

In the Mediterranean area, where main concerns are soil, water and soil organic matter protection and maintenance, researchers were attracted by the environmental benefits of reduced or no-tillage systems *(González et al., 1988; Hernanz and Sánchez-Girón, 1988; Bouzza, 1990).* Thus, a number of projects aimed to design and setting up of field experiments, depending of the country, were developed focusing on **soil and water conservation** to see the possibilities to store scarce rainfall, increase the efficient use of water by crops, and avoid soil erosion and runoff and losses of organic matter, in order to obtain a higher yield stability. In this respect, it is worth mentioning the singular study done in Syria by ICARDA, in which CA is considered as a promising and feasible strategy for the Mediterranean region *(Pala et al., 2000).* Despite researchers were concerned on these studies and the general benefits for all agricultural lands that come from these ecological aspects, the general motivation of the farmers for the introduction and adoption of CA technologies has been the reduction of costs in machinery and fuel and time-saving in the operations that permit to develop other agricultural or non agricultural complementary activities. After a period of reluctance, and once the economical benefits of CA were proven, farmers recognised the mentioned environmental beneficial aspects of CA and became even more motivated and keen to use this technology *(Cantero-Martínez and Gabiña, 2004).*

Conservation agriculture has been adopted in few lands in Mediterranean region. However, there are scattered small areas with an important impact and adoption of this technology and a tendency to increase. In European Mediterranean countries development and adoption have been higher that in North African countries, despite the important effort done by researchers in some countries (i.e. Morocco). Main cropping systems, where CA is now used, are field crops as winter cereals in rotations with legumes, sunflower and canola. The use of no-tillage and cover crops between rows in perennial crops (olives, nuts and grapes) is increasing in some areas. Few experiences at research and on-farm levels are being conducted in irrigated crops such as maize, alfalfa, etc.

The main driving forces that have been acting and can lead to more adoption of CA in Mediterranean areas are: a better economy (savings on production costs), soil protection against erosion and degradation, more flexible technical possibilities (labour organisation, cropping diversification…) yield increase and stability (with livelihood improvement) due to more water availability, developing technologies and technical facilities that can come from adoption of CA and socio-economic factors (public and private sectors, farmer associations, political measures, subsidies…).

Finally, and regarding CA research and transfer of technology, site-specific experimentation and development is needed. Development of multiple technological packages (plant material, sowing densities, planting time, fertilization adjustment and weed control adapted to CA technologies) should be offered. It is still necessary to increase the efforts towards a more practical and integrated research and technology transfer activities with a larger involvement of farmers *(Cantero-Martínez and Gabiña, 2004).*

2.2.2. Organic Farming (OF)

Conceptually, OF is based on the view that agriculture is a form of agro-ecosystem management, designed to promote sustainable supply of food and other products to the home market. Thus, the farm is considered as a balanced unit, where production, environment and human activities are integrated. Chemical fertilisers and pesticides are replaced by organic forms of fertilisers and non-chemical crop protection strategies minimising pollution from the farm.

Within the European Union - EU, the differentiation between organically and conventionally produced commodities was institutionalised in the early 1990s when the European Commission introduced a specific regulation framework (*EU Regulation 2092/91*) that allows the certification, via inspecting organisations, of such commodities as “biological” or “organic” (*Van der Smissen, 2000*). This Regulation has been amended on several occasions, in particular in 1999 when the Council extended its scope to cover organic livestock production (No1804/99). In June 2004, the European Commission adopted the “European Action Plan for Organic Food and Farming” whose objective is to facilitate the ongoing development of organic farming in the EU with 21 concrete policy measures to be implemented (*Rohner-Thielen, 2005*). Since the implementation of the EU Regulation 2092/91, organic practices in the cultivation of various crops have attracted interest across EU member-states, including the European Mediterranean countries (Italy, Greece, Spain). However, despite the widespread interest in organic agriculture, in most countries OF occupy only a small portion of the utilised agricultural area. This is not surprising considering the significantly lower yields and thus household income of organic farming systems. On the other hand, OF is not yet institutionalised in Southern Mediterranean countries.

Taking into account that OF development needs integration with animal production, it appears that Greece, although started late with organic production compared to the other EU member states, has the largest potential for organic agriculture due to favourable soil and climate conditions, The more southerly European countries (France, Greece, Italy, Portugal and Spain) show a wide variety of dominant organic crops (*Duchateau, 2003*). These are pastures and meadows, forage plants, cereals and olive plantations. Vineyards represent 3% of the organic crops. The combined organic area has grown by around 70% over the period 1998-2000, with some fluctuation in the importance of the dominant crops. The internet site http://www.organic-europe.net/, which was set up by Stiftung Ökologie & Landbau, Germany in 2000, with co-funding by the EU-Commission, Agriculture Directorate-General**,** provides update relevant information on several OF aspects (news, country reports, address database, statistics, research projects, EU regulations, etc.).

Favourable soil and climate conditions, the demand of OF products of quality and high price, seed control and seed qualification and, subsidies from the European Union are major driving forces for OF adoption in the Mediterranean Platform countries.

2.3. Policy opportunities and constraints

2.3.1. On going policies for development of CA in the Mediterranean platform

Although there may still be vigorous debate in the Mediterranean basin on no-tillage systems and CA in general, most of the agronomic and engineering problems appear to have been solved leaving, apparently, economic and social constraints as the main barriers to further adoption. However, the rate of adoption has varied widely within and between countries. For countries south of the Mediterranean Sea, the on-going policies for facilitating development of CA can be summarized in important subsidies in purchasing seed drills and certified seeds. In Morocco, no-tillage systems are considered alternative package technologies to prevent desertification, conserve soil and water and cope with drought. Farmer's trial results have confirmed the importance of economic and social as well as technical and managerial constraints that are preventing more farmers adopting conservation farming and no-tillage practices (*Mrabet, 2001a*). The systems are lately proposed in most projects related to agricultural development in dry areas. In Tunisia, the no-tillage systems are spread (*Mrabet, 2003a*), with the support from government to seed companies, no-till drill import and key farmers. Herbicide companies are following the movement of no-tillage adoption by farmers.

In Northern European Mediterranean countries, some national or regional directives that have been released according to the current Common Agricultural Policy (CAP) following its reform in 2003 (**http://europa.eu.int/comm/agriculture/capreform/index_en.htm**) may indirectly support the practice and adoption of CA techniques. The application of the EU agri-environment measures (*European Commission, 2005*), which support specifically designed farming practices, going beyond the baseline level of "good farming practice" (GFP), might play a crucial role in dissemination of CA in those countries.

2.3.2. On going policies for development of OF in the Mediterranean platform

As above mentioned, and concerning the countries in the EU Mediterranean zone, the European Commission has adopted the "European Action Plan for Organic Food and Farming" (*COMMISSION OF THE EUROPEAN COMMUNITIES, 2004*). *"...Its objective is to facilitate the ongoing development of organic farming in the EU. The Commission puts forward a list of 21 concrete policy measures to be implemented, such as improving information about organic farming,* *streamlining public support via rural development, improving production standards or strengthening research. This plan comes in response to a rapid increase in the number of farmers producing organically and to a strong demand from consumers during the last years. It is based on extensive consultations with Member States and stakeholders including an online consultation in 2003, a hearing in January 2004, and meetings with Member States and stakeholder groups…"*

On the other hand, last modifications of the *EU Regulation 2092/91* (*European Union, 1991*) are very recent (*European Union*, *2005a*, *b*, *c*). Likewise, *Council Regulation (EC) No 1257/1999* as amended by *Council Regulation (EC) No 1783/2003*, and other regulations (*Council Regulations (EC) No 2702/1999, (EC) No 1257/1999, (EC) 2826/2000, (EC) No 814/2000*) currently offer the possibility of EU co-financing of information or promotion campaigns for OF.

2.3.3. Constraints

a) Conservation Agriculture (CA)

In the Mediterranean region adoption of CA is still at the early stage. Different agronomic and environmental aspects are not yet solved and efforts have to be developed locally. Main constraints for development of CA in the Mediterranean Platform are:

- Crop residue management and use is a very important focus of concern among users. Questions like how to manage the straw and stubble, amount of residue to be retained and when to remove the excess of crop residues are typical among farmers (*Catalán et al., 2001; Dorado et al., 2003a,b; López et al., 2003*);
- Pests, diseases and infestations are a common constraint although not completely generalised. Other negative aspects come from biological activity due to incidence of rodents and slugs (*Pérez de Ciriza, 2003*);
- Lack of information and technical advice about CA technologies taking into consideration site-specific social, economic and environmental aspects (*Hernanz et al., 1995, 1998; Sánchez-Girón et al., 2004; Cantero-Martínez et al., 2004*);
- Lack of information on the time needed to reach a complete adaptation or stabilisation of the CA based cropping system (transition phase). There is also a lack of information on crop rotations performance (*López-Fando and Almendros, 1995; Tenorio et al., 2002*);
- Insufficient knowledge on the evolution of soil properties. Nutrient dynamics under CA and its relationship with fertiliser use and efficiency (*Moreno et al., 1997; López-Bellido et al., 2001; López-Piñeiro et al., 2004*);
- Weed control is major constraint for the development of CA (*Dorado et al., 1998; Sombrero et al., 2004; Navarrete et al., 2002*) as well as on a lesser extent the risk of herbicide use under CA (*Calderón et al., 2000; Cuevas et al., 2001*);
- Access to CA machinery and adaptation to local conditions (*Pérez de Ciriza et al., 2000*).

b) Organic Farming (OF)

Lack of information about OF techniques (i.e. methods based on scientific knowledge), lack of money, economic risk during the transition period, management issues such as weed and pest control (e.g. in the European Platform) and even the new rules for seed certification are main constraints for OF adoption in the Mediterranean Platform. Other identified constraints are the following:

- Consumers do not have the appropriate information background;
- Majority of producers focused on a few perennial crops;
- Small dimension of farms Economic risk (fragile economic system);
- Biological and chemical contamination;
- Lack of multiplication of adapted plant material;
- Lack of local, regional and national organized markets;
- Lack of appropriate seed legislation protecting farmers' seed exchange.

3. Suitable alternative technologies and approaches to the Mediterranean Platform conditions

3.1. Approaches and technologies

3.1.1. Conservation Agriculture (CA)

a) Dryland farming systems

Main strategy: **Improving water economy** (availability and water use by crops) (*Bescansa et al., 2005; Cantero-Martínez, 2003; Cantero-Martinez et al., 2004; de Benito et al., 1998; Lampurlanés et al., 2001; López and Arrúe, 1997a; Moreno et al., 1997, 2001; Mrabet, 2002a*) **and increasing soil protection** (*de Alba et al., 2001; de la Rosa et al., 2005; Díaz-Pereira et al., 2002; Gómez et al., 1999; Imaz et al., 2004; López et al., 1999; Moreno et al., 2003; Ordoñez et al., 2001; Perea et al., 2003; Simota et al., 2005*).

Technologies:

1) Use of CA systems to increase crop residue production (amount and distribution) and optimise crop residue management (*Agrela et al., 2003; Catalán et al., 2001; López et al., 2003; López et al., 2004; López et al., 2005; Mrabet and Bouzza, 1994; Santiveri et al., 2003, 2004*);

2) Optimise crop and livestock relationships as related to crop residues and fertilizer use;

3) For tree crops, use of cover crops between rows and use of supplementary or deficit irrigation (*Pelegrín et al., 2001; Zaragoza and Delgado, 1996; Zaragoza et al., 2002*);

4) Use of improved plant material adapted to more crop residue production;

5) Use of improved plant material with better transpiration efficiency (TE) and water use efficiency (WUE);

6) Optimise technologies (soil calibration, use of organic products, placement on time-space and machinery) to increase fertilize use efficiency (*Angás et al., 1999; López-Bellido and López-Bellido, 2001; López-Bellido et al., 1997, 1998, 2000, 2003; Mrabet, 2001a; Murillo et al., 2000; Santiveri et al., 2004; Tab, 2003*);

7) Use of crop rotations to increase crop diversification and improve weed control (*Alvaro-Fuentes et al., 2003; López-Bellido et al., 1998; López-Bellido and López-Bellido, 2001; López-Fando and Pardo, 2001; Moreno et al., 2000; Sombrero et al., 1998*).

Technologies described in points 2, 4 and 5 are potentially appropriate for CA under dryland farming systems, but there is a lack of references in the reviewed literature for these topics in the Mediterranean region.

b) Irrigated farming systems

Main strategy: **Improving water management** (saving and distribution) (*Cantero-Martínez et al. 2004; Fernández et al., 2001a, 2002; Palomo et al., 2002*) **and soil quality** (*Fernández et al., 1991; Moreno et al., 1996*).

Technologies:

1) Use of CA optimizing the best crop residue management (excess) in terms of quantity and distribution;

2) For fruit tree crops, use of cover crops between rows and use of deficit irrigation (*Fernández and Moreno, 1999; Fernández et al., 2001b; Pelegrín et al., 2001*);

3) Optimise irrigation systems adapted to CA for saving water and energy (*Pelegrín et al., 2001*);

4) Optimise irrigation systems adapted to CA that avoid loss of soil quality (*Coelho et al., 2000; Pelegrín et al., 2001*);

5) Optimize technologies (soil calibration, use of organic products, placement on time-space and machinery) to increase fertilizer use efficiency (*Berenguer et al., 2004; Pelegrín et al., 2003; Santiveri et al., 2002*);

6) Use of crop rotations to increase crop diversification and improve weed, pest and diseases control.

Technologies described in points 1 and 6 are potentially appropriate for CA under irrigated farming systems, but there is a lack of references in the reviewed literature for these topics in the Mediterranean region.

3.1.2. Organic Farming (OF)

Main strategy: Optimising soil fertility and management of natural resources and pest and diseases control and establishing the most appropriate crops and livestock farming systems to improve the economical balance at a farm level especially in multicropping systems.

Technologies:

1) Optimise irrigation systems for improving product quality (*Ismail et al., 1999*);

2) Use of raw materials, residues of crops and agriculture industries for the production of high quality composts (*Manios and Dialynas, 1995; Manios and Siminis, 1988, Vrilakis et al., 1999; Manios et al., 2001; Manios, 2004*);

3) Improvement of soil physico-chemical characteristics by compost amendments (*Aggelides and Londra, 2000; Paschalidis et al., 2002*);

4) Weed control by covering soil with crop residues (*Bilalis et al., 2003*);

3.2. Suitable geographical situations and biophysical conditions

3.2.1. Conservation Agriculture (CA)

Although, in general, most of the geographical and biophysical conditions could be suitable for CA in the Mediterranean basin, **site-specific experimentation is needed to assess the suitability of specific CA practices.**

The practice of CA in *semiarid conditions* reduces water loss from soil surface and enhances organic mater accumulation. Conservation tillage systems offer special advantages for farming soils with a content of organic matter less than 2.5 % or soils with a high silt content (*Moreno et al., 1997, 2005; Bescansa et al., 1998; Mrabet, 2002b; González et al., 2003; Imaz et al., 2004*).

The development of CA is particularly necessary in erosion and desertification-prone areas. Tillage systems such as no-tillage, reduced tillage and ridge tillage are used by farmers to control erosion and to comply with soil conservation measures (*De la Rosa et al., 2005*). Long fallowing (16 to 17 months), in the cereal/fallow rotation, may favour soil losses by wind erosion on agricultural soils of semiarid lands (*López et al., 2001; López and Arrúe, 2005*). These authors also showed that reduced tillage, with chiselling as primary tillage, could be a viable alternative to conventional tillage (mouldboard ploughing) for wind erosion control (*López et al., 1998, 2000*).

Soils with impeded drainage and susceptible to compaction are not always suitable for CA. On the contrary, well-drained soils usually give good yields when crops are grown in high residue content systems, in particular under no-tillage. These soils include coarse textured soils with good internal drainage, soils with good surface drainage and soils without layers restricting water movement (*Sombrero et al., 1996, 1998; de Benito et al., 1998, 1999; Mrabet, 2000; Coelho et al., 2000; Catalán et al., 2001; Moreno et al., 2003; Murillo et al., 2004; Alvarez, et al., 2004*). Locations with low crop residue production are not fully suitable for no-tillage technologies.

Reclaimed soils in marsh areas (i.e. Marismas del Guadalquivir) are not suitable for CA due to the high clay content, high salinity and an extremely saline shallow water table, so the crop production is sustained by both irrigation and field drainage systems, and subsoiling at a depth of 55 cm once a year crossing the field (*Moreno et al., 1995*).

3.2.2. Organic Farming (OF)

In principle, the biophysical and geographical conditions in the European Mediterranean areas are not a limiting factor for the development of OF. In Italy, a large number of OF farms are present in many regions substantially different in terms of climate, physical and agro-ecological conditions (Source: http://www.politicheagricole.it/PRODUZIONE/AGRIBIO/italia_2004.pdf). OF decisions are then taken by farmers more in reference to social and economical conditions. In Greece, most organic farms are situated in Southern and Central Greece due to the main organic products, olive oil and olives followed by vineyards (*Van der Smissen, 2000*). There is enough know-how for these crops, the costs for organic cultivation practices are not much higher than the conventional costs, and the subsidy per hectare is high.

3.3. Socio-economic, cultural and policy conditions necessary for technology adoption by farmers

3.3.1. Conservation Agriculture (CA)

In the developing countries of the Mediterranean area, old-aged farmers, illiteracy, income level, farm structure, skills, and cultural traditions are important constraints for the development of new technologies and particularly for CA systems.

The development of any technology should be accompanied with training programs for adviser and farmers. It should be remarked the importance of the extension services to spread information, maintaining experiments and feedback information from farmer needs to researchers and policy makers. Private industries and enterprises should have a role in the development of technologies. Handicaps to development of many technologies come from the lack of materials and spare parts to support the equipment and technology *(Cantero-Martínez, et al., 2004).*

Current policies promoting CA in developing countries should change towards natural resources (soil and water) conservation. Encourage CA through subsidies and incentives to farmers should be promoted and carefully implemented to demonstrate the benefits of CA and not by the subsidy itself *(Cantero-Martínez and Gabiña, 2004)*.

In developed countries, it should be clarified and recognised by public opinion the benefits of CA in a long-term. The interest of the EU, national and local administrations and policy makers in CA are very variable and do not often respond to long-term requirements for CA systems to be developed and adopted. **Current policies promoting CA in European Mediterranean countries should change towards natural resources - soil and water- conservation, yield stability, and sustainability of agricultural systems more than to increase the productivity**. **Encourage CA through subsidies and incentives to farmers should be promoted specifically for natural resources and biodiversity conservation.**

3.3.2. Organic Farming (OF)

Future adoption of OF by farmers will depend on a series of general social and economical aspects. The first one is consumer education. Secondly, the land tenure system should be rearrange and facilitate the access to land. The land-tenure system is important in assuring farmers that the future benefits of current farm improvements can be achieved. If this is not so, long-term investments which improve sustainability will not be made (*FAO, 1998*). Rearranging the OF market (e.g. the distribution system, prioritising the short market cycle), proposing specific paradigms for OF research, defining clear food standards for trazability and labelling and recognising the gap between OF production and conventional production are other conditions necessary for OF dissemination.

Regarding policy conditions, these should be specific for OF (e.g. certification) and aimed to protect agro-biodiversity, to facilitate seed regulation permitting local seeds market and local seeds production, and to introduce OF products in the public food system.

3.4 Socio-economic and environmental impacts expected

3.4.1. <u>Conservation agriculture (CA)</u>

With regard to the ***agronomic impacts*** of CA, in general crop yields increase under CA systems in the Mediterranean Platform and in the other platforms as well and, this is very positive under dry conditions (*Mrabet, 2000; 2002a*; *González et al., 2003; Cantero-Martínez et al., 2003*). In particular, crop yields depend on climate, soil properties, cropping systems and farmers. Crop emergence may be affected by agricultural systems (*Mrabet, 1997; Santiveri et al., 2004*).

Conservation agriculture increases water infiltration into the soil and improves water use efficiency, especially in rainfed farming areas (*Gómez et al., 2002; Moreno et al., 2001; López and Arrúe, 1996; Kacemi, 1992*). Likewise, CA increases soil nutrient retention, improves nutrient use efficiency and reduces the use of fertilisers. In general, soil fertility increases in CA and, particularly under no-tillage. Soil organic mater and some macronutrient contents are higher under conservation tillage than under conventional tillage (*Mrabet et al., 2001a, b*). Most farmers in Mediterranean drylands rely on an integration of crop and livestock. **The major challenge facing CA development is how to achieve sustainable improvement in livestock and crop production with limited reliance on fertilizers and feed supplementation** (*Mrabet, 2001a*). Crop residue management is the basis of CA and improves soil protection, fertility and humidity (*López et al., 2004; 2005; Mrabet, 1997*).

A change in weed population and weed inversion can be a problem under conservation tillage (*ElBrahli and Mrabet, 2000*). In some cases, however, CA may be a tool for weed control. A permanent vegetal cover in CA systems favours, in general, a higher incidence of pests compared to conventional agriculture.

Tillage systems and timing of fertilizer application (either as nitrogen or phosphorus) are important decisions for Mediterranean farmers practicing dryland farming. Crop response to nitrogen fertilisation is higher under CA than under conventional agriculture (*Santiveri et al., 2004*). A positive impact of crop rotation under CA is mentioned. It improves and stabilises yields and is beneficial for weeds, pest and disease control. Fallow management with CA systems increases soil water storage and has a positive effect on weed control (*Moret et al., 2005; Lampurlanés et al., 2002; Bouzza, 1990; Mrabet et al., 2003*).

Regarding the ***environmental impacts***, in general, CA improves soil physical properties and fertility through an improvement of soil structure, an increase in soil water-holding capacity and a reduction of direct water evaporation from soil (*Kacemi, 1992; Mrabet, 1997*). As mentioned above, CA increases soil organic mater (*Ibno Namr and Mrabet, 2004; López-Fando and Almendros, 1995; López-Fando and Pardo, 2001*). Likewise, CA improves enzymatic activity and increases biological activity and microbial biomass. The persistence and mobility of herbicides and pesticides are lower in CA systems. The practice of CA decreases the emission of CO_2 to the atmosphere and reduces soil erosion (*Álvaro-Fuentes et al., 2004; Gómez et al., 2002; Mrabet, 2003b*).

From a ***socio-economic impac****t* point of view, CA implies a reduction in the cost of direct inputs (*Pérez de Ciriza, 2004; Sombrero et al., 2001; Mrabet, 2001b; Hernánz et al., 1995*). The cost of labour, energy and time in farming operations is lower under CA than under conventional agriculture (*Bourarach, 1989; Dycker and Bourarach, 1992*). However, CA needs a higher investment in new machinery. Depending on the agricultural system and the local conditions, in general, farm profitability is higher under CA than under conventional agriculture.

3.4.2. Organic farming (OF)

From the ***agronomic impact*** point of view, the influence of OF on crop growth and yield is variable while that on soil nutrient content can be positive (*Stamatiadis et al., 1996; Paulou et al., 2003*). Water is the main determining factor with respect to crops and yields. Fruit quality and yield can be substantially improved by the water regime (*Ismail et al., 1999*). Although there is little evidence that organic and conventional foods differ in respect to the concentrations of the various micronutrients there seems to be a slight trend towards higher ascorbic acid content in organically grown leafy vegetables and potatoes (*Magkos et al., 2003*). There is also a trend towards lower protein concentration but of higher quality in some organic vegetables and cereal crops.

The weed control system in organic wheat farms can only be carried out mechanically and is more time consuming and has a higher cost. The soil tillage system affects weed flora. Changes in tillage can have a significant effect on weed control and weed population (*Bilalis et al., 2001*).

The correct use of crop residues helps conserve soil moisture and deal with weeds, while also improving soil structure. The crop system implemented on organic farms requires that crop residues are incorporated into the soil following the end of wheat cultivation. This system leads to a reduction in soil moisture and the creation of favourable conditions for the emergence of weeds. The use of crop residues to cover soil can maintain soil moisture and lead to a reduction in dry weed mass, population density and population frequency as well as a reduction in weed population diversity, regardless of the initial weed flora before the implementation of different soil tillage systems. Finally, an increase in the prevalence of broad-leafed weeds was observed as the level of soil cover increased (*Bilalis et al., 2003*).

With regard to the ***environmental impacts,*** recycling of organic residues by composting and land application would contribute to sustainable development. The raw materials that can be used to produce high quality composts are mainly the residues of cultivations and agricultural industries and the organic fraction of municipal solid waste and sewage sludge (*Manios and Dialynas, 1995; Manios et al., 2003; Vrilakis et al., 1999*). *Aggelides and Londra (2000)* reported that in most of the cases the soil improvements were proportional to the application rates of the compost and they were greater in loamy soils than in clay soils. Moreover, increasing the organic matter content of soil has the additional benefit of reducing the problems associated with the use of brackish water for crop irrigation, which is frequently the case in some areas of Greece, e.g. Crete (*Tsikalas and Manios, 1986*).

The application of organic wastes could be a way of solving two problems, the waste disposal and the correction of the low organic matter content of many agricultural soils (*Kapetanios et al., 1993*). However, it could lead to phytotoxic levels in soils (*Matsi and Keramidas, 1999*) and crops (*Manios et al., 2004*). No differences were found in the total concentrations of Fe, Cu, Mn, and Zn in organic farming soils compared to conventional and fallow soils (*Vavoulidou et al., 2004*).

Regarding the ***socio-economic impacts***, and considering organic olive oil as a major organic product in the Mediterranean (e.g. in Greece), it appears that it is much easier for olive farmers to convert their plantations to organic. *Baourakis and Stamataki (1997)* stated that the potential organic farmer is most likely the one motivated by financial factors. *Tzouvelekas et al. (2001)* suggested that the organic olive-growing farms exhibited a higher degree of technical efficiency than did conventional olive-growing farms. As a result, organic olive growing has recently become the dominant type of organic farming in Greece. A market survey on the quality of organic wine showed that this type of wine is an investment for Greek agribusiness (*Tsintarakis, 2001*).

Tzouvelekas et al. (2002) suggested that the organic wheat farms examined were relatively more efficient than conventional wheat farms. Reasons may include lower profit margins and restrictions on inputs permitted, which may force organic farmers to be more cautious with input use.

3.5. Proposals for appropriate local and regional policies

Taking into account that CA contributes to reducing poverty, induces food and environmental security, enhances natural resources conservation, and improves livelihood and development of rural communities in the Mediterranean area, it is recommended that future local and/or regional policies (i.e. forthcoming CAP agri-environmental measures in Northern European Mediterranean countries) should be aimed at:

- Promotion of education, demonstration and dissemination of CA;
- Promotion of Extension Services for CA technology transfer;
- Involvement of farmers and farmer association in CA development and dissemination;
- Support of integrated studies for national, regional or local adoption of CA;
- Promotion and support the access of farmers to CA technology;
- Support networking on CA for knowledge development and sharing;
- Promotion of participatory CA projects involving all the stakeholders;
- Legal measures for a good development of CA;

With regard to ***Organic Farming*** (OF) appropriate local and regional policies should consider the following aspects:

- Dissemination of information about the importance of OF products;
- Official training on OF systems;
- Specialised extension services for continuous education of organic farmers;
- Seminars on OF sponsored by the EU;
- Identification of potential markets (strategic marketing);
- Suitable distribution network for OF products;
- Support of integrated studies for national, regional or local adoption of OF;
- Pilot projects that explore and promote feasible organic agricultural techniques looking to the small economic and land dimension.

4. Research proposals for the Mediterranean Platform

4.1. Knowledge gaps to be filled

4.1.1. <u>Knowledge gaps in Conservation Agriculture (CA)</u>

The adoption of ***CA*** leads to the necessity to revise the whole management process. Yet, it appears that gaps in knowledge in crop and soil management under CA are still permanent in most countries. Most data are gathered from experimental plots and hence extrapolation or out-scaling stay difficult in countries where no-tillage is still at experimental or R&D stage.

There is little research conducted to date solely on sociological and economic factors concerning the evolution and the social impact of CA systems and various authors state the need for more research into the social and economical implications of these 'new' agricultural systems. In fact, from existing results, the socio-economic impact of CA may appear to be contradictory. Global environmental impacts of CA have to be considered: climate change, resource management, and fuel consumption.

For the **Mediterranean platform**, it is important to **develop a network of benchmark sites for long term research on CA among Mediterranean countries to generate knowledge**. The research gaps concern the following topics:

- Crop production and quality under no-tillage systems;
- Crop and livestock integration;
- Combined water and nitrogen use efficiency under CA;
- Integrated weed control practices in CA;
- Integrated pest and disease management in CA;
- Nutrient cycling and fertilization under CA;
- Long term experiment in crop rotations for weed, pest and diseases control;
- Crop breeding for CA;
- Irrigation systems vs CA;
- Crop diversification in CA;
- Intercropping and cover crops performances in CA;
- Soil quality indicators under CA;
- Soil erosion control;
- Soil biodiversity;
- Crop residue management;
- Carbon sequestration in agricultural soils;
- Contamination and pollution of soil, air and water;
- Greenhouse gas emissions and global warming;
- Social and economic studies;
- CA adoption studies.

4.1.2. Knowledge gaps in Organic Farming (OF)

Regarding information gaps in OF it is proposed to fill gaps in research on the following issues:

- Site-specific and long term research;
- Crop production and quality under OF systems;
- Combined water and nitrogen use efficiency under OF;
- Integrated weed control practices in OF;
- Pest and disease management;
- Nutrient cycling and fertilisation under OF;
- Adapted genetic resources;

- Crop rotations under OF;
- Intercropping and cover crops performances in OF;
- Soil quality indicators under OF;
- Contamination and pollution of soil and water;
- Soil biodiversity;
- Social and economical studies.

As stated in the inventory and assessment report (R1.2), it has to be taken into account that the above knowledge gaps represent a consensus agreed by a limited number of CA/OF expert teams who represent a small number of Mediterranean region countries. According to this limitation, they are priorities for Mediterranean-level research and policy, not for national or local research and policy.

4.2. Refined research topics and priorities

4.2.1. __Conservation Agriculture (CA)__

There had been some excellent research into CA in the Mediterranean region. We now wish to see it extended and better applied. Research Priorities in *Conservation Agriculture* (CA) for the Mediterranean Platform region should be focused to fill gaps of knowledge in the following general subject matters:

- Site-specific and well-designed long-term experiments are needed in benchmark areas of the Mediterranean Region (rainfed and irrigated conditions; research on-farm level);
- Perennial crops management for CA (olive, almond, vineyard);
- Crop residue management under CA;
- Weed management and control under CA;
- Crop and soil response of CA under irrigation conditions (different irrigation methods);
- Crop breeding and biotechnology for CA;
- Soil conservation and erosion control studies under CA;
- Soil and water contamination under CA;
- Water economy, quality and management under CA;
- Machinery and equipment for CA development adapted to some selected areas (e.g. Southern Mediterranean countries);
- Crop nutrition and fertilisation (research has to be focused on soil test calibration and plant analysis for recommendations under CA and on banding fertilisers and type of fertiliser application in some areas);
- Studies on integrated crop and animal production systems under CA;
- Research is needed on short and long-term dynamics and balance of C and N in soils;
- Soil organic matter (quantity and quality) and C sequestration under CA;
- Soil biology and biochemistry (ecology) evolution under CA (drylands and irrigated lands);
- Socio-economic impact of CA (studies on farmer perception of CA systems; no-tillage sociology; economic analysis and modelling);
- Integrated pest and/or disease management under CA.

4.2.2. __Organic Farming (OF)__

Although OF is practised on large areas in Mediterranean countries (e.g. Italy, Greece, Spain), it has not been detected a substantial body of research and knowledge on this alternative to conventional agriculture (*Isart and Llerena, 1999; Zanoli and Micheloni, 1999)*. More research on OF is hence urgently needed.

Research priorities in *Organic Farming* (OF) for the Mediterranean Platform, should take into account the following topics:

- Crop nutrition and fertilisation in OF (soil test calibration and plant analysis for agronomic recommendations);
- Indicators of environmental impact of OF;
- Water economy, quality and management under OF;
- Improvement of quality of organic fertilizers;
- Soil and soil microbial activity;
- Fate of heavy metals and organic pollutants from organic materials used as fertilisers;
- Fate of mobile nutrient elements under different OF systems;
- Nutrient balance sheet at farm level;
- Rhizosphere and plant-microbial interactions;
- Effects of tillage under OF systems;
- Long term effects on crop yield and quality;
- On-farm research on quality improvement of farmer seeds, plants and animal multiplication under different OF systems;
- Development of weed management practices under OF systems;
- Studies on integrated crop and animal production systems under OF;
- Identification of varieties resistant to pests and diseases under OF (development of biological control practices);
- Better disease management;
- Botanical insecticides;
- Improvement of local, regional and national markets. Market studies to better understand the need of consumers and orient the supply;
- Development of machinery and equipment adapted to OF;
- Comparative studies between OF and conventional farming practices.

We should emphasise the need of implementing site-specific and well-designed long-term experiments research in selected areas of the Mediterranean Region. Special attention should be paid to research on perennial crops (olive, almond and vineyard). Further development of scientific co-operation among Mediterranean countries and promotion of scientific knowledge on OF adapted to Mediterranean conditions (networking) is also needed.

5. References

Aggelides, S..M., Londra, P.A. 2000. Effects of compost produced from town wastes and sewage sludge on the physical properties of a loamy and a clay soil. Bioresource Technology 71: 253-259.

Agrela, F., Gil, J.A., Giráldez, J.V., Ordóñez, R., González, P. 2003. Obtention of reference value in the measurement of the cover fraction in conservation agriculture systems. p. 44-47. Proc. II World Congress on Conservation Agriculture, Vol. II, Iguassu Falls, August 2003, Brasil.

Álvarez, M. A., González-Barragán, M. I., De Benito, A. and Sombrero, A. 2004. Tillage systems and crop rotation effect on soil properties in a semi-arid region of the Duero basin. Actas VI Congreso SEAE. II Congreso Iberoamericano Agroecología,. Almería. Spain.

Álvaro-Fuentes, J., Santiveri F, Lloveras J., Cantero-Martínez C. 2003. Producción de veza forrajera en siembra directa dentro de una rotación con cereales de invierno en secano semiárido. p. 187-192. En: Robles AB., Ramos ME., Morales MC., Simon E., González JL., Boza J. (Eds.). Pastos, desarrollo y conservación. Consejería de Agricultura y Pesca. Junta de Andalucía.

Álvaro-Fuentes, J., López, M.V., Gracia, R., Arrúe, J.L. 2004. Effect of tillage on short-term CO2 emissions from a loam soil in semi-arid Aragon (NE Spain). *Options Méditerranéennes*, Serie A, 60: 51-54.

Angás P., Gabrielle B., Cantero-Martínez C. 1999. Crop growth and soil water and nitrogen dynamics, as affected by tillage and fertilizer nitrogen under semi-arid conditions. Simulation by Ceres-Barley. International Symposium of Modelling Cropping Systems. European Society for Agronomy, Lleida.

Baourakis G., Stamataki E., 1997. Searching for endogenous development practices: the production of organic olive oil. Medit. 8: 4-8.

Berenguer P., Borras G., Santiveri F., Cantero-Martínez C., Lloveras J. 2004. Yield response of maize to nitrogen fertilisation in irrigated areas of the Ebro valley (Spain). VII ESA Congress “European Agriculture in a Global Context”. July 2004. Copenhagen. Denmark.

Bescansa, P., Otazu, N., Enrique, A., Irañeta, J., Del Castillo J. 1998. Influencia de distintos sistemas de laboreo de conservación en propiedades del suelo y en la producción de cereal de secano en condiciones semiáridas (Olite, Navarra). Edafología 4: 147-154.

Bescansa, P., Imaz, M.J., Virto, I., Enrique, A., Hoogmoed, W.B. 2005. Soil water retention as affected by tillage and residue management in semiarid Spain. Soil & Tillage Research (*in press*).

Bilalis, D., Efthimiadis, P., Sidiras, N. 2001. Influence of three tillage systems on weed flora in a 3-year rotation with four crops. J. Agron. Crop Sci. 186: 135-141.

Bilalis, D., Sidiras, N., Economou, G., Vakali, C. 2003. Effect of different levels of wheat straw soil surface coverage on weed flora in Vicia faba crops. J. Agron. Crop Sci. 189: 233-241.

Bourarach, H.E. 1989. Mécanisation du travail du sol en céréaliculture pluviale : performances techniques et aspects économiques dans une région semi-aride au Maroc. Thèse de Doctorat en Sciences Agronomiques, IAV Hassan II, Rabat, Morocco.

Bouzza, A. 1990. Water conservation in wheat rotations under several fallow management and tillage systems in semiarid areas. PhD Diss. University of Nebraska, Lincoln, USA.

Bradbury, D.E. 1981. The physical geography of the Mediterranean lands. p. 53-62. *In*: di Castri, F., Goodall, D.W., Specht. R.L. (Eds.). Mediterranean-type shrublands. Ecosystems of the world XI,. Elsevier, Amsterdam, The Netherlands.

Calderón, M.J., Hermosín, M.C., Moreno, F., Cornejo, J. 2000. Mobility of trifluralin under traditional tillage and conservation tillage in SW Spain. pp. 1-9. *In*: A. Mermoud, A. Musy, L.S. Pereira, R. Ragab (eds.) Proc. Intern. Workshop “Control of Adverse Impact of Fertilizers and Agrochemicals”, 51st International Executive Council (IEC) of the International Commission on Irrigation and Drainage (ICID), 22-27 October 2000, Cape Town, South Africa.

Cantero-Martínez, C. 2003. Evaluation of water management and crop production technologies in Mediterranean arid and semi-arid systems. Seminar on Optimization of water use by plants in the Mediterranean. Association of Applied Biologists, March 2003, Palma de Mallorca.

Cantero-Martínez C., Gabiña, D. (Eds.) 2004. Mediterranean Rainfed Agriculture: Strategies for Sustainability. *Options Méditerranéennes*. Serie A. No. 60, 335 p. (ISBN 2-85352-294-6).

Cantero-Martínez C., Angás P., Ameziane T., Pisante M. 2004. Land and Water Management Technologies in the Mediterranean Region. *Options Méditerranéennes Serie A* 60: 35-50.

Cantero-Martínez, C., P. Angás, Lampurlanés, J.. 2003. Growth, yield and water productivity of barley (Hordeum vulgare L.) affected by tillage and N fertilization in Mediterranean semiarid, rainfed conditions of Spain. Field Crops Research 84: 341-357.

Catalán, G. De Andrés, E.F.. Sánchez, J, Ayerbe L., Tenorio J.L. 2001. Effects of crop residue management on efficiency and water evolution in a barley monoculture system. p. 581-585. *In*: Proc. I World Congress on Conservation Agriculture: A Worldwide Challenge, Volume II, Madrid, Spain

Coelho, M.B., Mateos, L., Villalobos, F.J. 2000. Influence of a compacted loam subsoil layer on growth and yield of irrigated cotton in Southern Spain. Soil & Tillage Research 57: 129-142.

COMMISSION OF THE EUROPEAN COMMUNITIES. 2004. COM(2004)415 final. COMMUNICATION FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT. *European Action Plan for Organic Food and Farming*, Brussels, 10.06.2004.
Available at: http://europa.eu.int/comm/agriculture/qual/organic/plan/index_en.htm

Cooper, P.J.M., Gregory. P.J., Tully, D., Harris, H.C. 1987. Improving water use efficiency of annual crops in the rainfed farming systems of West Asia and North Africa. Exp. Agric. 23:113-158.

Cuevas, M.V., Calderón, M.J., Fernández, J.E., Hermosín, M.C., Moreno, F., Cornejo, J. 2001. Assessing herbicide leaching from field measurements and laboratory experiments. Acta Agrophysica 57: 15-25.

de Alba, S., C. Lacasta, G. Benito, and A. Pérez-González. 2001. Influence of soil management on water erosion in a Mediterranean semi-arid enviroment in Central Spain. I World Congress on Conservation Agriculture: A worldwide challenge. p. 173-177.

de Benito, A. Sombrero, A., Escribano, C. 1998. Soil moisture evolution and its relation with cereal yield in different tillage systems in the Duero Basin. p. 49-50. *In*: M.Zima, M.L. Bartosova (Eds.), IV Congress European Society of Agronomy, Nitra ,Slovakia.

de Benito, A. Sombrero, A. and Escribano, C. 1999. Influence of conservation tillage on soil properties. Agricultura. LXVIII.: 538-541.

de la Rosa, D., Díaz-Pereira, E., Mayol, F., Czyz, E.A., Dexter, A.R., Dumitru, E., Enache, R., Fleige, H., Horn, R., Rajkay, K., Simota, C., 2005. SIDASS project Part 2. Soil erosion as a function of soil type and agricultural management in a Sevilla olive area, southern Spain. Soil & Tillage Research 82: 19-28.

Díaz-Pereira, E., Prange, N., Fernández, M., de la Rosa, D., Moreno, F. 2002. Predicting soil water erosion using the ImpelERO model and a mapped reference area in the Sevilla province (Spain). Advances in GeoEcology 35: 533-542.

Dorado,J., López-Fando, C., Del Monte, J.P. 1998. Barley yield and weed development as affected by crop sequence and tillage systems in a semi-arid environment. Commun. Soil Sci. Plant Anal. 29:1115-1131.

Dorado, J., Zancada, F.J., Almendros, G., López-Fando C. 2003a. Changes in soil propeties and humic substances after long-term amendments with manure and crop residues in dryland farming systems. J. Plant Nutr. Soil Sci. 166:.31-38.

Dorado, J., F.J. González Vila, M. C. Zancada, G. Almendros, López-Fando C. 2003b. Pyrolytic descriptors responsive to changes in humic acid characteristics alter long term sustainable management of dryland farming systems in Central Spain. Journal of Analytical and Applied Pyrolysis 68-69: 299-314.

Duchateau, K. 2003. Organic Farming in Europe. Statistics in Focus, Theme 8-2/2003, Eurostat, 8 p.

Dycker, J., Bourarach, E.H. 1992. Energy requirements and performances of different soil tillage systems in the Gharb and Zaër regions. p. 373-390. *In*: Bourarach, E.H., Oussible, M., Bouaziz, A., El Himdy, B. (Eds.). Proc. Intern. Seminar on Tillage in Arid and Semiarid Areas, April 1992. Rabat, Morocco.

El-Brahli, A., Mrabet, R. 2000. La jachère chimique: pour relancer la céréaliculture non-irriguée en milieu semi-aride Marocain.. p. 133-145. *In*: Proc. Journée Nationale sur le Désherbage des Céréales. Centre Aridoculture, 23 Novembre 2000, Association Marocaine de Malherbologie, Settat, Morocco.

Emberger, C., Gaussen, H., Kassas M., de Philippis, A. 1963. Bioclimatic map of the Mediterranean Zone: explanatory notes. UNESCO-FAO. Paris. 58 pp.

Elías, F. 1984. Criterios climatológicos para la definición de la Región Mediterránea. p. 5-12. *En*: Actas III Jornadas de Cultura Árabe e Islámica. Instituto Hispano-Árabe de Cultura. Madrid. España.

European Commission. 2005. Agri-environment Measures. Overview on General Principles, Types of Measures, and Application. Directorate General for Agriculture and Rural Development Unit G-4 - Evaluation of Measures applied to Agriculture, Studies, 24 p.
(Available at: http://europa.eu.int/comm/agriculture/publi/reports/agrienv/index_en.htm).

European Union. 1991. Council Regulation (EEC) No 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. Office for Official Publications of the European Communities.

European Union. 2005a. COMMISSION REGULATION (EC) No 1294/2005 of 5 August 2005 amending Annex I to Council Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs Official Journal of the European Union.

European Union. 2005b. COMMISSION REGULATION (EC) No 1318/2005 of 11 August 2005 amending Annex II of Council Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. Official Journal of the European Union.

European Union. 2005c. COMMISSION REGULATION (EC) No 1336/2005 of 12 August 2005 amending Annex III to Council Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. Official Journal of the European Union.

FAO. 1998. Evaluating the potential contribution of organic agriculture to sustainability goals. FAO's technical contribution to IFOAM's Scientific Conference, Mar del Plata, Argentina, Nov. 1998. Available at: http://www.fao.org/documents/show_cdr.asp?url_file=/////docrep/003/ac116e/ac116e00.htm.

Fernández, J.E., Moreno, F. 1999. Water use by olive trees. Journal of Crop Production 2: 101-162.

Fernández, J.E., Moreno, F., Cabrera, F., Arrúe, J.L., Martin-Aranda, J. 1991. Drip irrigation, soil characteristics and the root distribution and root activity of olive trees. Plant and Soil 133: 239-251.

Fernández, J.E., Moreno, F., Murillo, J.M., Cuevas, M.V., Kohler, F. 2001a. Evaluating the effectiveness of a hydrophobic polymer for conserving water and reducing weed infection in a sandy loam soil. Agric. Water Manage. 51: 29-51.

Fernández, J.E., Palomo, M.J., Díaz-Espejo, A., Clothier, B.E., Green, S.R. Girón, I.F., Moreno, F. 2001b. Heat-pulse measurements of sap flow in olives for automating irrigation: tests, root flow and diagnostics of water stress. Agric. Water Manage. 51: 99-123.

Fernández, J.E., Slawinski, C., Moreno, F., Walczak, R.T., Vanclooster, M. 2002. Simulating the fate of water in a soil-crop system of a semi-arid Mediterranean area with the WAVE 2.1 and EURO-ACCESS-II models. Agric. Water Manage. 56: 113-129.

Gómez, J.A., Giráldez, J.V., Pastor, M., Fereres, E. 1999. Effects of tillage method on soil physical properties, infiltration and yield in an olive orchard. Soil & Tillage Research 52: 167-175.

Gómez, J.A., Orgaz, F., Villalobos, F.J., Fereres, E. 2002. Analysis of the effects of soil management on runoff generation in olive orchards using a physically based model. Soil Use and Management 18: 191-198.

González, P., Fereres, E., Giráldez, J.V., Martín, I.., García, M., Gil, J., Agüera, J. 1988. Non tillage dry farming in heavy clay soils under mediterranean climate. p. 661-666. *In*: Proc. of the 11th ISTRO, Conference, Vol. 2, Edimburgh, Scotland.

González, P., Giráldez, J.V., Ordóñez, R., Perea, F. 2003. Yields in a 20-year soil management experiment in a vertisol of southern Spain. p. 359-362. *In*: Proc. of the II World Congress on Conservation Agriculture, Vol. II, August 2003, Iguassu Falls, Parana, Brasil.

Hernanz, J.L., Sánchez-Girón, V. 1988. Experiments on the growing of cereals with different tillage systems in Central Spain. p. 691-696. *In*: Proc. of the 11th ISTRO Conference, Vol. 2, Edimburgh, Scotland..

Hernanz, J.L., Arrúe, J.L., Cantero, C. (Eds.). 1998. Creación de una red temática sobre laboreo de conservación. Informe Final, Acción Especial CICYT, AGF96-1613-E, ETSIA, UPM, Madrid, 180 p.

Hernanz, J.L., Sánchez-Girón, V., Cerisola, C. 1995. Long term energy use and economic evaluation of three tillage systems for cereal and legume production in Central Spain. Soil & Tillage Research 35: 183-198.

Ibno Namr, K., Mrabet, R. 2004. Influence of agricultural management on chemical quality of a clay soil of semi-arid Morocco. Journal of African Earth Sciences 39: 485-489.

ICARDA. 1979. Introduction to Agriculture in West Asia and North Africa. Technical Manual No. 6, International Centre for Agricultural Research in Dry Areas. Aleppo, Syria, 88 pp.

Imaz, M.J., Virto, I., Bescansa, P., Enrique, A., Hoogmoed, W.B. 2004. Soil quality related to soil erosion in conservation agriculture on low organic matter soils. P. 423-425. In: Invited Lectures and Abstracts, Fourth International Conference on Land Degradation, September 2004, Cartagena (Spain).

Isart, J., Llerena, J.J. (Eds.) 1999. Organic Farming Research in the EU: Towards 21st Century. ENOF White Book, The European Network for Scientific Research Coordination on Organic Farming, Barcelona, 108 p. (ISBN: 84-921533-3-4)

(Available on-line at: http://www.cid.csic.es/enof/index.html)

Ismail, A.S., Stavroulakis. G., Metzidakis, J., Metzidakis, I.T., Voyiatzis, D.G. 1999. Effect of irrigation on the quality characteristics of organic olive oil. *In*: Proc. Third International Symposium on Olive Growing, Chania, Vol. 2, September 1997, Crete, Greece. (Acta-Horticulturae. No. 474, 687-690).

Kacemi, M. 1992. Water conservation, crop rotations and tillage systems in semi-arid Morocco. PhD Diss. Colorado State University.

Kapetanios E. G., Loizidou, M., Valkanas, G. 1993. Compost production from Greek domestic refuse Bioresource Technology 44: 113-116

Lampurlanés, J., Angás, P, Cantero-Martínez, C. 2001. Root growth, soil water content and yield of barley under different tillage systems on two soils in semiarid conditions. Field Crops Research 69:27-40.

Lampurlanés, J., Angás, P, Cantero-Martínez, C. 2002. Tillage effects on water storage during fallow, and on barley root growth an yield in two contrasting soils of the semi-arid Segarra region in Spain. Soil & Tillage Research 65: 207-220.

Le Houérou, H.N. 1993. Changements climatiques et désertisation. Sécheresse 4: 95-111.

López, M.V., Arrúe, J.L. 1996. Effect of conservation tillage on the macroporosity of a dryland soil in the Huesca province (NE Spain). p. 125-129. *In*: L. García Torres, A. Varela, P. González (Eds.), Actas del Congreso Nacional de Agricultura de Conservación: Rentabilidad y Medio Ambiente, October 1996, Córdoba, Spain.

López, M.V., Arrúe, J.L. 1997. Growth, yield and water use efficiency of winter barley in response to conservation tillage in a semi-arid region of Spain. Soil & Tillage Research 44: 35-54.

López, M.V. and. Arrúe, J. L. 2005. Soil tillage and wind erosion in fallow lands of central Aragon: An overview. Sustainable use and management of soils. Arid and Semiarid Regions. A. Faz Cano, R. Ortiz and A.R. Mermut (Eds.). Advances in GeoEcology 36. Catena Verlag (*in press*).

López, M.V., J.L. Arrúe and V. Sánchez-Girón. 1996. A comparison between seasonal changes in soil water storage and penetration resistance under conventional and conservation tillage systems in Aragón. Soil & Tillage Research 37: 251-271.

López M.V., Gracia R, Arrúe JL. 1999. Reduced tillage for soil conservation in semi-arid fallow lands of Central Aragón. p. 651-652. *In*: J. Bech (Ed.) Extended Abstracts *6th International Meeting on Soils with Mediterranean Type of Climate*, Barcelona, 4-9 July 1999, Universidad de Barcelona, Barcelona, Spain.

López, M.V., Gracia, R., Arrúe, J.L. 2000. Effects of reduced tillage on soil surface properties affecting wind erosion in semi-arid fallow lands of Central Aragon. European Journal of Agronomy 12:191-199.

López, M.V, Gracia R, Arrúe JL. 2001. An evaluation of wind erosion hazard in fallow lands of semi-arid Aragón (NE Spain). Journal of Soil and Water Conservation 56:212-219.

López, M.V., Arrúe, J.L., Álvaro-Fuentes, J., Moret, D. 2004. Cereal residue management through conservation tillage in semi-arid Aragon (NE Spain). p. 625-626. *In*: Jacobsen SE, Jensen CR, Porter JR (Eds.), Book of Proceedings, *VIII Congress of the European Society for Agronomy, 'European Agriculture in a Global Context'*, 11-15 July, 2004, Copenhagen, Denmark.

López, M.V., Arrúe, J.L., Álvaro-Fuentes, J., Moret, D. 2005. Dynamics of surface barley residues during fallow as affected by tillage and decomposition in semi-arid Aragon (NE Spain). European Journal of Agronomy 23: 26-36.

López, M.V., Moret, D., Gracia, R., Arrúe JL. 2003. Tillage effects on barley residue cover during fallow in semi-arid Aragon. Soil & Tillage Research 72: 53-64.

López, M.V, Sabre, M, Gracia, R, Arrúe JL, Gomes L. 1998. Tillage effects on soil surface conditions and dust emission by wind erosion in semi-arid Aragon (NE Spain). Soil & Tillage Research 45: 91-105.

López-Bellido, L. 1992. Mediterranean cropping systems. p. 311-357. *In*: Pearson, C.J. (Ed.), Ecosystems of the World: Field Crops Ecosystems 18A. Elsevier, Amsterdam, The Netherlands.

López-Bellido,R.J., López-Bellido, L. 2001. Efficiency of nitrogen in wheat under Mediterranean conditions: effect of tillage, crop rotation and N fertilization. Field Crops Research 71: 31-46.

López-Bellido, R.J., López-Bellido, L., Castillo,J.E., López-Bellido, F.J. 2003. Nitrogen uptake by sunflower as affected by tillage and soil residual nitrogen in a wheat-sunflower rotation under rainfed Mediterranean conditions. Soil & Tillage Research 72: 43-51.

López-Bellido, L., Fuentes, M., Castillo, J.E., López-Garrido, F.J. 1998. Effects of tillage, crop rotation and nitrogen fertilization on wheat-grain quality grown under rainfed Mediterranean conditions. Field Crops Research 57: 265-276.

López-Bellido L., López-Bellido R.J., Castillo J.E., López-Bellido, F.J. 2000. Effects of tillage, crop rotation, and nitrogen fertilization on wheat under rainfed Mediterranean conditions. Agronomy Journal 92: 1054 1063.

López-Bellido, L., López-Bellido, R.J. Castillo,J.E., López-Bellido, F.J. 2001. Effects of long-term tillage, crop rotation and nitrogen fertilization on bread-making quality of hard red spring wheat. Field Crops Research 72: 197-210.

López-Bellido, L., López-Garrido, F.J., Fuentes, M., Castillo, J.E., Fernández, E.J. 1997. Influence of tillage, crop rotation and nitrogen fertilization on soil organic matter and nitrogen under rain-fed Mediterranean conditions. Soil & Tillage Research 43: 277-293.

López-Fando, C., Almendros, G. 1995. Interactive effects of tillage and crop rotations on yield and chemical properties of soils in semi-arid Central Spain. Soil & Tillage Research 36: 45-57.

López–Fando, C., Pardo, M.T. 2001. The impact of tillage systems and crop rotation on carbon sequestration in a Calcic Luvisol of Central Spain. I World Congress on Conservation Agriculture: A worldwide challenge. p. 135-139.

López-Piñeiro, A., Muñoz, A., Rato, J.M., Albarrán, A., Barreto, C., García, A. 2004. Eight year-old effects of direct sowing in the physical-chemical properties of a cromic luvisol of south-western Spain. p. 158. I*n*: Abstracts I Congreso Ibérico de Ciencia del Suelo, Vol 1, June 2004, Bragança, Portugal.

Magkos F., Arvaniti, F., Zampelas, A. 2003. Organic food: nutritious food or food for thought? A review of the evidence. International Journal of Food Sciences and Nutrition 54:357-371.

Manios, T. 2004. The composting potential of different organic solid wastes: experience from the island of Crete. Environment International 29: 1079-1089.

Manios, V.I., Dialynas, G.. 1995. Introduction of biowaste composting in Heraklion Crete. *In*: Bidlingmaier, W, Stegman, R. (Eds). *In*: International symposium on Biological waste management—a wasted chance?, Bochum, Germany.

Manios, V.I.., Siminis, H.I.. 1988. Town refuse compost of Heraklio. Biocycle 29: 44-47.

Manios, T., Kanakopoulos, D., Petousis, D., Manios, V. 2001. Organic waste management in Greece. International Conference on the Organic Waste Management in the Mediterranean Area, 22–24 February, Spain.

Manios T, Maniadakis K, Frantzeskaki N, 2003. Sewage sludge composting on the Island of Crete. Biocycle 44: 53-55.

Manios, T., K., Maniadakis, M. Kalogeraki, E., Mari, S., Terzakis, P., Magiatis, E., Mikros, A., Agalias, I., Spanos , Manios, V. 2004. Co-composting olive residuals and green waste on Crete. BioCycle 45: 67-70.

Matsi ,T., Keramidas, V.Z. 1999. Fly ash application on two acid soils and its effect on soil salinity, pH, B, P and on ryegrass growth and composition. Environmental Pollution 104: 107-112.

Moreno, F., Murillo, J.M., Pelegrín, F., Girón, I.F., 2005. Long-term impact of conservation tillage on stratification ratio of soil organic carbon and loss of total and active CaCO3. Soil & Tillage Research (*in press*).

Moreno, F., Pelegrín, F., Fernández, J.E., Murillo, J.M. 1997. Soil physical properties, water depletion and crop development under traditional and conservation tillage in southern Spain. Soil & Tillage Research 41: 25-42.

Moreno, F., Murer, E.J., Stenitzer, E., Fernández, J.E., Girón, I.F. 2003. Simulation of the impact of subsoil compaction on soil water balance and crop yield of irrigated maize on a loamy sand soil in SW Spain. Soil & Tillage Research 73: 31-41.

Moreno, F., Murillo, J.M., Girón, I.F., Fernández, J.E., Pelegrin, F. 2001. Conservation and traditional tillage in years with lower and higher precipitation than the average (south-west Spain). p.591.595. *In*: L. García-Torres, J. Benites & A. Martínez-Vilela (Eds.), Proc. I World Congress on Conservation Agriculture, Vol. II, October 1-5, 2001, Madrid, Spain.

Moreno, F., Pelegrín, F., Fernández, J.E., Murillo, J.M., Girón, I.F. 2000. Effects of traditional and conservation tillage on soil physical properties, water depletion and crop development in southern Spain. Proceedings of the 15th Conference of the International Soil Tillage Research Organization. In CD-ROM, 10 pp. 2-7 July 2000, Fort Worth, Texas, USA.

Moreno, F., Cabrera, F., Andreu, L., Vaz, R., Martín-Aranda, J., Vachaud, G. 1995. Water movement and salt leaching in drained and irrigated marsh soils of SW Spain. Agric. Water Manage. 27: 25-44.

Moreno, F., Cayuela, J.A., Fernández, J.E., Fernández-Boy, E., Murillo, J.M., Cabrera, F. 1996. Water balance and nitrate leaching in an irrigated maize crop in SW Spain. Agric. Water Manage., 32: 71-83**.**

Moret, D., Arrúe, J.L., López, M.V., Gracia, R. 2005. Influence of fallowing practices on soil water and precipitation storage efficiency in semi-arid Aragon (NE Spain). Agricultural Water Management (*in press*).

Mrabet, R. 1997. Crop residue management and tillage systems for water conservation in a semiarid area of Morocco. PhD Diss. Colorado State University.

Mrabet, R. 2000. Differential response of wheat to tillage management systems in a semiarid area of Morocco. Field Crops Research 66: 165-174.

Mrabet, R. 2001a. No-Tillage System: Research Findings, Needed Developments and Future Challenges for Moroccan Dryland Agriculture. p. 737-741. *In*: L. García-Torres, J. Benites & A. Martínez-Vilela (Eds.), Proc. I World Congress on Conservation Agriculture, Vol. II, October 1-5, 2001, Madrid, Spain.

Mrabet, R. 2001b. Le semis direct: potentiel et limites pour une agriculture durable en Afrique du Nord. CDSR-AN/CEA,.30p. http://www.uneca.org.

Mrabet, R. 2002a. Wheat yield and water use efficiency under contrasting residue and tillage management systems in a semiarid area of Morocco. Experimental Agriculture 38: 237-248.

Mrabet, R.. 2002b. Stratification of soil aggregation and organic matter under conservation tillage systems in Africa. Soil & Tillage Research 66: 119-128.

Mrabet, R. 2003a. Mediterranean Conservation Agriculture: A paradigm for cropping systems. 16th Triennial Conference of International Soil Tillage Research Organisation (ISTRO-2003). 13-19 July, 2003. Brisbane, Australia. 6p.

Mrabet, R. 2003b. No-tillage as a technology for preventing desertification. II World Congress on Conservation Agriculture, Iguassu Falls, Parana, Brazil, August 11-15, 2003.

Mrabet, R., Bouzza, A. 1994. Conservation de l'eau sous différentes rotations céréalières et systèmes de gestion des résidus de récolte en semi-aride. Ann. Report. Aridoculture Center. Mrabet, R., 1997. Crop residue management and tillage systems for water conservation in a semiarid area of Morocco. PhD Diss. Colorado State Univ. Fort Collins, CO. USA. 220p.

Mrabet, R., El-Brahli, A., Bessam, F., Anibat, I. 2003. No-Tillage Technology: Research review of impacts on soil quality and wheat production in semiarid Morocco. Options Méditerranéennes 60:133-138.

Mrabet, R., Ibno-Namr, K., Bessam, F., Saber, N.. 2001a. Soil chemical quality changes and implications for fertilizer management after 11 years of no-tillage wheat production systems in semiarid Morocco. Land Degrad. & Develop. 21:1–13.

Mrabet, R., Saber, N., El-Brahli, A., Lahlou, S., Bessam, F. 2001b. Total, particulate organic matter and structural stability of a Calcixeroll soil under different wheat rotations and tillage systems in a semiarid area of Morocco. Soil & Tillage Research 57:225-235.

Murillo, J.M., Moreno, F., Pelegrín, F., Fernández, J.E. 2000. Nutritional response of sunflower and wheat crops to traditional and conservation tillage under rainfed conditions in southern Spain. 10 pp. *In*: Proceedings of the 15th Conference of the International Soil Tillage Research Organization,. July 2000, Fort Worth, Texas, USA (in CD-ROM).

Murillo, J. M. Moreno, F., Girón, I. F., Oblitas M. I. 2004. Conservation tillage: long term effect on soil and crops under rainfed conditions in south-west Spain (Western Andalusia). Spanish Journal of Agricultural Research 2: 35-43.

Navarrete, L., Fernández-Quintanilla,C. Hernanz J.L., Sánchez-Girón, V. 2002. El no cultivo reduce la población de malas hierbas frente al laboreo tradicional. Tierras 84: 48-59.

Ordóñez, R., González, P., Llanos, I., Giráldez, J.V., 2001. The protective role of stubble in dry-farming conservation-agriculture in Southwestern Spain. Proc. I World Congress on Conservation Agriculture, Vol. II, 435-439. Madrid, Spain, October 2001.

Pala, M., Harris, H.C., Ryan, J., Makboul, R., Dozom, S. 2000. Tillage systems and stubble management in a Mediterranean-type environment in relation to crop yield and soil moisture. *Exp. Agr.* 36:223-242.

Palomo, M.J., Moreno, F**.**, Fernández, J.E., Díaz-Espejo, A., Girón, I.F. 2002. Determining water consumption in olive orchards using the water balance approach. Agric. Water Manage. 55: 15-35**.** **¿?**

Paschalidis, Ch.., Kavvadias, V., Akribos, J. 2002. Liquid piggery waste application to cotton ecosystem.. Journal of Balkan Ecology 5: 41-47.

Paskoff, R.P. 1973. Geomorphological processes and characteristic land forms in the Mediterranean regions of the world. p. 53-60. *In*: di Castri F., Mooney HA (Eds.). Mediterranean Type Ecosystems: Origin and Structure. Springer. Berlin, Germany.

Paulou G., Oixaliotis K., Kavvadias V. 2003. The effect of organic and inorganic fertilization on the growth and nitrate accumulation in Lettuce in relation to the cultivation period. 21st Conference of Greek Society of Horticulture, Ioannina, 8-10 Octomber 2003, p.111-114

Pelegrín, F., Madueño, A., Moreno, F., Franco, A. 2003. Sembradora específica de cubiertas vegetales en los sistemas de no laboreo en olivar. Anales de Ingeniería Mecánica 14: 993-996.

Pelegrín, F., Moreno, F., Madueño, A., Franco, A., Girón, I.F., Fernández, J.E. 2001. The use of green covers to conserve soil and water in a water harvesting systems within an olive orchard. p. 401-407. In: L. García-Torres, Benites, J., Martínez-Vilela, A. (Eds.), Proc. I World Congress on Conservation Agriculture, Vol. II, October 1-5, 2001, Madrid.

Perea, F., Giráldez, J.V., González, P., Gil, J., Ordóñez, R., 2003. Influence of soil moisture on the compaction of clay soils under conservation agriculture in Mediterranean environments.p. 498-501. *In*: Proc. II World Congress on Conservation Agriculture, Vol**.** II, August 2003, Iguassu Falls, Parana, Brasil,.

Pérez de Ciriza, J.J., Delgado, J, Carro, P., Amezqueta, J. 2000. Demostración de alternativas de laboreo para secanos semiáridos de Navarra. Presentación y análisis de nueve sembradoras. Navarra Agraria Nº 121:18-28.

Pérez de Ciriza, J.J. 2003. Experiencia y resultados de 15 años de laboreos en Navarra. p. 2-5. En: Actas Jornada sobre Agricultura de Conservación, Universidad Pública de Navarra, Pamplona.

Pérez de Ciriza, J.J., 2004. Etudes économiques comparatives en Navarre: travail profond – superficiel – semis direct. p. 108. En: Actes II Rencontres Méditerranéennes sur le Semis Direct, 19-22 janvier 2004, Tabarka, Tunisie.

Roquero, C. 1979. The potential productivity of Mediterranean soils. p. 21-42. *In*: Proc. 14th Intern. Colloquium on Soils of Mediterranean Type Climate and their Yield Potential. Potash Institute, Seville, Spain.

Rohner-Thielen, E. 2005. Organic Farming in Europe. Eurostat.Statistics in Focus, Agriculture and Fisheries 31/2005. 8 p.

Sánchez-Girón, V., A. Serrano, J.L. Hernánz, Navarrete L. 2004. Economics assessment of three long-term tillage systems for rainfed cereal and legume production in semi-arid central Spain. Soil & Tillage Research.78: 35-44.

Santiveri, F., Lloveras, J., Marti, S., Cantero-Martínez, C. 2003. Crop residue trends on soil water accumulation affected by tillage system and N fertilization in semi-arid conditions of Northeast Spain. Seminar on Optimization of water use by plants in the Mediterranean. Association of Applied Biologist. March 2003, Mallorca.

Santiveri, F., Lloveras, J., Marti, S., Cantero-Martínez, C. 2004. Crop emergence and early crop growth of Barley affected by crop residue under different tillage systems and N fertilization rates in semi-arid conditions of Northeast Spain. Options Mediterranénnes 60: 63-72.

Santiveri F., Martin-Buila, B., Lloveras, J., Cantero-Martínez, C. 2002. Effect of tillage and nitrogen on yield in irrigated corn. VII Congress of the European Society for Agronomy. 15-18 July, Córdoba.

Simota, C., Horn, R., Fleige, H., Dexter, A., Czyz, E.A., Díaz-Pereira, E., Mayol, F., Rajkai, K., de la Rosa, D. 2005. SIDASS project Part 1: a spatial distributed simulation model predicting the dynamics of agro-physical soil state for selection of management practices to prevent soil erosion. Soil & Tillage Research 82: 15-18.

Sombrero, A., De Benito, A., Nieto M. 2004. Rotation effects on barren brome (Bromus sterilis L.) control in conservation tillage. p. 669-670. *In*: Proc.. VIII Congress European Society for Agronomy, Copenhagen, Dinamarca.

Sombrero, A.; Benito, A. Escribano, C., Tenorio,J.L., Catalán,G; Pérez de Ciriza,J.J., Irañeta,J. 2001. Rentabilidad de un cultivo de cereal en tres sistemas de laboreo en zonas semiáridas del Norte de España. I Congreso Mundial sobre Agricultura de Conservación. Madrid (España). Actas de Congreso. Páginas 795-799.

Sombrero, A.; De Benito, A.; Escribano, C.; and García, M.A. 1996. Water content and compaction soil evolution under three tillage systems. National Congress of Conservation Agriculture. Córdoba (Spain). pp. 183-187.

Sombrero, A., De Benito, A. and Escribano, C. 1998. Alternative tillage systems: Minimum and no tillage systems. Boletín Informativo. Servicio Agrario. Caja de Burgos. Volumen: 35: 12-16.

Stamatiadis, S, Lopa-Tsakalidi, A, Maniati, L.M., Karageorgou, P., Natioti, E., Doran, J.W., Jones, A.J. 1996. A comparative study of soil quality in two vineyards differing in soil management practices. Methods for assessing soil quality, p.381-392; SSSA Special Publication Number 49.

Tab, N. 2003. Contribution à l'étude de l'influence des systèmes de travaux du sol et de la fertilisation azotée sur le comportement du blé et la qualité chimique d'un sol argileux du semi-aride Marocain. Diplôme des Etudes Supérieures Approfondies en Amélioration de la Production Agricole. Faculté des Sciences et Techniques, Settat, Maroc. 103p.

Tenorio, J.L., De Andres, E.F., Sánchez, J., Esteban, E., Catalán, G. 2002. Effect of different tillage systems in cold semiarid Spain. p. 545-546. *In*: Proc. VII Congress of the European Society for Agronomy, Córdoba, Spain.

Tsikalas, P.E., Manios, V.I. 1986. Effect of irrigation with saline water on cucumbers grown in greenhouse. Agric Res;10:41 –48.

Tsintarakis, C. 2001. Customer satisfaction evaluation for Greek quality and organic wine. Chania (Greece). Thesis (M.Sc.). 92 p.

Tzouvelekas, V., Pantzios, C.J., Fotopoulos, C., 2002. Measuring multiple and single factor technical efficiency in organic farming: the case of Greek wheat farms. Food Journal 104: 591-609.

Tzouvelekas, V., Pantzios, C.J. Fotopoulos, C. 2001. Technical efficiency of alternative farming systems: the case of Greek organic and conventional olive-growing farms. Food-Policy 26: 549-569.

Van der Smissen, N. 2000. Organic Farming in Greece. Organic Europe.Country reports: Greece. (Available at: *www.organic-europe.net/country%5Freports/greece*).

Vavoulidou, E., Avramides, E.J., Papadopoulos, P., Dimirkou, A. 2004. Trace metals in different crop/cultivation systems in Greece. Water, Air, and Soil Pollution: Focus 4: 631–640.

Vrilakis, E., Syminis, C., Kefaki, M., Manios, T, Stentiford, E.I.. 1999. Pilot scale composting at the city of Rethymnon, on the island of Crete. p. 471–475. *In*: Proc. Conference on Disposal and Utilisation of Sewage Sludge: Treatment Methods and Application Modalities, October 1999, IWQA, Athens, Greece.

White, K.D. 1970. Fallowing crop rotation and crop yield in Roman times. Agricultural History 44: 281-290.

Zanoli, R., Micheloni, C. 1999. State-of-the-art of research on organic farming in Mediterranean EU countries. Chapter 4. *In*: R. Zanoli and R. Krell (Eds.), Proc. "Research Methodologies in Organic Farming", 30 September-3 October 1998, Frick, Switzerland, FAO, Rome.

Zaragoza, C., Delgado, I.. 1996. Un ensayo de coberturas vegetales en viña. ITEA. Vol. extra 17: 404-405.

Zaragoza, C., Crespo, J., San Nicolás, M.A., Fernández-Cavada, Sopeña, J.M., Gómez-Aparisi, J. 2002. Ensayo de sistemas de mantenimiento del suelo en almendro. ITEA Vol. extra 23: 89-92.