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CONSERVATION AGRICULTURE BETWEEN CONCEPT AND APPLICATION

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ABSTRACT

The challenges of agricultural sustainability have become more intense in recent years with the sharp rise in the cost of food, energy and production inputs, climate change and water scarcity. The question is how to meet such challenges? How should be agriculture in the 21st century? The worldwide scientific and empirical evidences highlighted the important role could be achieved through rapid adoption and spread of conservation agriculture (CA). Experience worldwide over the past four decades has demonstrated how CA through the simultaneous application of a set of practices of minimal mechanical soil disturbance, organic soil cover and diversified cropping can lead to greater and stable yields, better use of production costs, enhanced crops, soil and ecosystem health, and improved climate change adaptability and mitigation. However, despite of the beneficial effects of the CA on the environment sustainability and in improving productivity and economics, yet the question arise: why CA is not spreading faster and why then do the majority of farmers are still using other tillage implements? This could be mainly attributed to the fact that much of the current production system science and education as well as the policy and institutional support systems for the modern tillage-based agricultural practices are not suitable to transformation towards enhance conservation agriculture. Furthermore for a greater number of countries there is lack of knowledge about CA systems and their management and absence of funded research and extension services. The needed enabling policies, and practical actions to promote the transformation of current production systems towards CA ones will be fully discussed in this paper.

Keywords: *conservation agriculture, soil management, environmental sustainability, Mediterranean.*

INTRODUCTION

The expected increase in population and the associated demands for food will bring additional pressures on the natural resources land and water. Consequently, the development community strongly highlighted the need for the development of sustainable agriculture production systems that are compatible with the

management of all ecosystem services and also permit the restoration of degraded agricultural lands. Indeed, nowadays, business –as-usual with regards to agriculture development is increasingly considered inadequate to deliver sustainable production intensification to meet future needs in terms of food security, poverty alleviation and economic growth and ecosystem services (Friedrich et al., 2009a, Kassam et al., 2009). Modern agriculture paradigm based on genetics, agrochemicals and intensive tillage, is beginning to run out of steam and is being increasingly challenged.

Indeed under the conventional tillage agriculture, globally we currently have most of our agricultural lands performing under sub optional and degrading conditions (Huggins and Reynolds, 2008). The sever degradation of the resource base on one hand and the environment deterioration on the other one beside other negative extremities are the major driving forces to shift from the tillage system (TA) to the conservation agriculture one (CA) which offers optional resource use with high productivity and enhanced ecosystem services. CA now spearheads an alternative biological and ecosystem paradigm that can make a significant contribution to sustainable production intensification and in meeting agricultural and food needs of future human population (Uphoff et al., 2006; FAO, 2008 Pretty 2008; Friedrich et al., 2009, Kassam et al., 2009, and FAO, 2010).

Empirical and scientific evidence from different parts of the world have shown that CA concepts and principles are of universal validity and their practices locally can successfully provide a range of productivity, socio economic and environmental benefits to the producers and the socity at large (Goddard et al., 2008; Reicosky, 2008; Pepresch and Friedrich, 2009a, 2009b).

This paper will cover some issues related to CA including (A) concepts and principals of CA; (B) world wide experience of benefits that can and are being harnessed through CA systems; (C) current status of adaption and spread of CA globally and its relevance to farming in the Mediterranean semi-arid environment.

Why CA?

Now a days many countries around the world are facing several difficult issues among them the number of unnourished and hungry people are increasing, the land available per person is decreasing and demand for food is increasing. The big question is how to produce the additional food to meet the increasing demand? And in the main time maintain a small farm profit? In spite of difficulty in answering the raised question yet, the solution could be found in CA systems as it a seems to be an appropriate solution tackling the several problems mentioned above.

There are several reasons which are strongly pushing towards the transformation of the agricultural systems from the tillage practices to the conventional ones, some of these crucial reasons could be outlined in:

- Global agricultural production will need to increase by 70 percent (and by practically 100 percent in developing countries) to meet needs of an estimated world population of approximately 9.2 billion in (2050) FAO, 2006.

- Crisis and emerging situations, which seem to be more frequent under climate change scenarios, and the political pressure for more sustainable use of natural resources and protection of environment on the one hand, and for improving and eventually reaching food security on the other provide opportunities to harness these pressure for supporting the adoption and spread of CA and for helping to overcome the existing hardness to adoption.
- With tillage agriculture and soil degradation, it is not possible to adequately harness the necessary ecosystem services for the society such as clean water, erosion control, carbon sequestration, nutrient cycling, etc.
- CA is an approach to managing agro-ecosystems for improved and sustained productivity while preserving and enhancing the resource base and the environment.
- As stated by FAO (2007) CA is a concept for resources saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production level while concurrently conserving the environment.
- CA can be described as one of the best options available to farmers that improves food security, farm profitability, and farmer livelihoods.
- Furthermore through the adaption of CA practices, large productivity, economic, social and environmental benefits can be harnessed. (Lahmar and Triomphe, 2007).
- Widespread adaptation of CA has been demonstrated to be capable of producing large and demonstrable savings in machinery and energy use, and carbon emissions, arise in soil organic matter content and biotic activity, less erosion, increases crop water availability and thus resilience to drought, improve recharge of aquifers and reduced impact of the apparently increased volatility in weather associated with climate change. It will cut production costs, lead to more reliable harvests and reduce risks especially for small land holders (FAO, 2008).
- CA systems have a higher adaptability to climate change as well as a high potentiality to slow/reserve the rate of emission of CO2 and other greenhouses gases (GHG). (Baig and Gamache, 2009, CTIC/FAO, 2008).
- Society gains from CA on both large and small farms is quite felt by the increase stability of food supplies due to greater resilience of crops in the face of climate drought, and male nutrition, and health of rural population, with less call on curative health services (World Bank, 2000).

- Uncertainty about the price and availability of energy in the future suggests the need for measures to reduce overall requirements for farm power and energy while maximizing energy use efficiency. This can be achieved through CA practices hence energy requirement can be lowered by up to 60 percent or more compared to conventional farming.

CA Principles:

Conservation agriculture (CA) involves the simultaneous application of three interlinked principals (Figure 1) based on locally formulated practiced mainly: (Friedrich et al., 2009; Kassam et al., 2009, 2011a)

The first: is practicing minimum mechanical soil disturbance which is essential to maintaining minerals within soil, stopping erosion, and preventing water loss from occurring within the soil.

The second: Permanente organic cover which is much like the first in dealing with protecting the soil. The principle of managing the top soil to create a permanent organic soil cover can allow for growth of organisms with the soil structure, which will break down the mulch left on the soil surface and thereby produces a high organic matter level which will act as a fertilizer for soil surface.

The third: diversification of crop species grown in sequences and/or associations. Rotation/associations should involve 3 different crops. It aims at enhancing natural biological processes above and below the ground. Crop rotation can be used best as disease control against other preferred crops (Hobbs et al., 2007). Indeed, rotational crops will act as a natural insecticide and herbicide against specific crops. Establishing crops in rotation allows for an extensive build up of rooting zones which will allow for better water infiltration (Hobb et al., 2007).

The principles of CA and the locally formulated adaptation practices have the capacity to slow and reserve productivity losses and environmental damage, thus offering an innovative sustainable approach to farming in all agro ecologies.

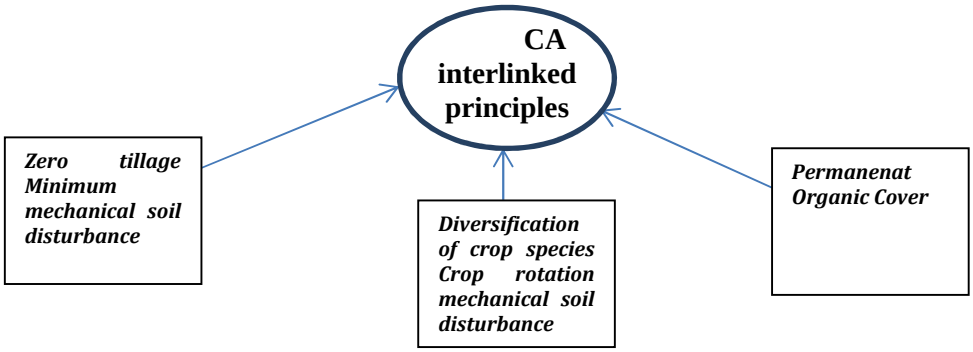

Figure 1: CA Principles

CA Restrictions:

The primary restriction to CA adoption is the assumption that soil tillage is essential for agricultural production. Other restrictions include those of intellectual, social, technical, environmental and political characteristics. Key restrictions with mainstreaming CA systems relate to problems with up scaling which is largely due to the lack of knowledge, expertise, inputs especially equipment and machinery, adequate financial resources and infrastructure, and poor policy support (Friedrich and Kassam 2009; Friedrich et al., (2009b). Other restrictions in the weakness in generating the knowledge needed for the transformation of farming sector towards (CA). This is the case in many countries including those of the Mediterranean region.

To fulfill this gap those countries should rely on: (a) the evidence and successful experiences already exist in several countries around the world; (b) establish a network of publically funded on farm operational research in which farmers can be provided with an opportunity and financial support to experiment with CA practices and adopt them to suit their socio-economic and agro-ecological conditions; (c) the management of the machinery sector to develop a new set of mechanical technologies for CA farming and (d) governments must make a firm and sustained commitments to encourage and support CA and above all providing the farmers with the needed financing and logistic support to adopt CA practices (Friedrich and Kassam 2009; Freidrich et al., 2009).

CA Challenges

- Like with any farming system, adoption of CA has constraints, CA is more technologies normally have to be tailored to specific production environment. Establishing CA can be difficult in the initial years, particularly in some semiarid areas, more clayey soils, compact soils, and on poorly drained soils, under those conditions special innovation are often required.
- Other challenge under CA practicing is pest and disease control where specific residue attract specific pests and this will require the use of pesticides and herbicides at least in the initial years.
- Under the CA systems one of the main principles is maintenance of soil cover with crop residues and this to some extent eliminates an important source of animal fodder particularly in the areas where livestock are important in farm economies.
- However, the globally experiences gained and learned lessons on the adoption and spread of CA show that the above mentioned challenges can be and are being overcome through locally-formulated solutions involving a range of public and private sector stakeholders working together with

farmers along different pathways of adoption and transformation tillage agriculture system to the conservation one.

- Under CA systems weed controls often highlighted as special challenge. To face this challenge still more research is needed to provide local solutions on integrated weed management in CA systems that can keep the use of herbicides to a minimum or avoided where necessary possible.

Potential benefits from Conservation Agriculture.

In the field of CA there are many benefits that both the producer and conservationist can obtain: on the side of conservationist CA can change the way humans produce food and energy. With conservation come environmental benefits of CA. These benefits include less erosion possibilities, better water conservation, improvement in air quality due to lower emissions being produced and a chance for larger biodiversity in a given area.

On the side of producers and/or farmers: CA gives farmers a means of conserving, improving, and making more efficient use of their natural resources FAO (2006). CA is shown to have even higher yields and higher outputs than conventional agriculture once it has been established over long periods.

The FAO believes that there are three major benefits from CA:

- Within fields that are controlled by CA the producer will see an increase in organic matter.
- Increase in water conservation due to the layer of organic matter and ground cover to help eliminate transportation and access runoff.
- Improvement of soil structure and rooting zoon.

However, as much as conservation agriculture can benefit the world, there are some problems that come with it. There are many reasons why conservation agriculture cannot always be a win-win situation:

- There are not enough people who can financially turn from conventional farming to conservation,
- The process of CA takes time, when the producers starts the CA process, the results can be of financial loss to them.
- Another financial undertaking in purchasing of new equipment in order to produce effectively.

Box 1:. Conservation farming offers many benefits to TOP and agriculture including:

- *Reduced erosion and improved soil structure.*
- *Improve infiltration and moisture efficiency.*
- *Improved soil health and nutrient retention.*
- *Lower soil temperature and better establishment.*
- *Increased planting opportunities and flexibility.*
- *Lower machinery labour and maintenance cost, and*
- *More reliable yields. (reference ?)*

Spread of conservation agriculture

CA comprising minimum mechanical soil disturbance and direct seeding, organic mulch cover from residues and cover crops, and crop species diversification through rotations and associations, is now practiced globally on about 117 million ha in all continents and all agricultural ecologies**. (Table 1)**

Table 1. Extent of Adoption of Conservation Agriculture Worldwide (countries with > 100,000 ha)

Country	Area under No-tillage (ha) (2008/2009)
USA	26,500,000
Argentina	25,785,000
Brazil	25,502,000
Australia	17,000,000
Canada	13,481,000
Paraguay	2,400,000
China	1,330,000
Kazakhstan	1,300,000
Bolivia	706,000
Uruguay	655,000
Spain	650,000
South Africa	368,000
Venezuela	300,000
France	200,000
Finland	200,000
Chile	180,000
New Zealand	162,000
Colombia	102,000
Ukraine	100,000
Total	116,921,000

**Source: Derpsch and Friedrich., 2010*

During the last decade, CA has been increasing at the rate of 6 million hectares per annum mainly in north and South America and Australia, and more recently in Asia, Africa, and Europe, where large increase in the adoption of CA are expected.

Nowadays CA is actually applied on about 10 percent of the world's crop land and adoption is growing fast. However, it is not growing fast enough to face the challenges ahead, such as the need to eradicate hunger and food insecurity for a growing population and address the threats of climate change, land and environmental degradation, resource scarcity and increasing cost of food productions inputs and energy.

However, for the rapid adoption and spread of CA we are in need to:

- A change in commitment and behavior of all concerned stakeholders.
- For farmers, it is needed a mechanism to experiment, learn and adopt
- For the policy makers and institutional leaders, transformation of tillage system to CA requires that they fully understand the large and long term economic, social and environmental benefits
- Sustained policy and institutional support role that can provide incentives and required services to farmers to adopt CA practices and improve them over time.

CA in the Mediterranean

Several researchers Lahmar and Triomphe (2007), and Plata et al., 2007, in their work concerning CA and its implementation in the Mediterranean region, all endorsed the benefits that can be harnessed by farmers in the semiarid Mediterranean environment, in the Mediterranean countries and particularly the developing one. However, they reported that CA is perceived as a powerful tool as it allows farmers to improve their productivity and profitability as well as conserving and even improving the natural resources base and environment. It should be understood that without farmer engagement and appropriate enabling policy and institutional support, rapid uptake of CA is not likely to occur.

Unfortunately deep analysis of CA practices and its adaptation, indicate that national administration in many developed and developing countries of the Mediterranean are still not full convinced that the concept of conservation agriculture is the most promising one to meet the requirements of an environmentally friendly farming, capable to meet the needs of the farmers to lower production costs and increase farm income due to increases and greater stability in yield production, soil protection against wind and water erosion, greater nutrient efficiency and better water economy in dry land areas.

CA practices in dry Mediterranean areas: challenges and constraints

CA adoption in dry lands faces critical challenges linked to water scarcity and drought hazard, low biomass production and acute competition between conflicting uses including soil cover, animal fodder, cooking, heating fuel, raw material for habitat etc. Other key factor is attributed to poverty and vulnerability of many small holders those relying more on livestock than on grain production. However, in dry climate areas it has been shown that biophysical, economic and knowledge constraints.

Can be surmounted if the stakeholders are working together and if policy and institutional support and relevant knowledge can be provided to farmers. Equally, for small holder farming there is critical need for a comprehensive assessment of the ecological and socio-economic conditions under which CA would be practiced.

Enhancement of CA practices: supporting measures. (Box 2)

- Formation of producers associations. This is one of the measures of vital importance particularly in developing countries where small farms are dominant. Such associations can provide the farmers with the required machinery tools needed for CA practices. In addition, it facilitates the exchange of experience, the dissemination of information on the CA practices amongst smaller farmers.
- Support of agricultural service providers. This measure plays an important role in facilitating the wide spread adoption of CA practices as it disposes of direct drills beside providing the seeds that can grow successfully under the prevailing local conditions and thereby easing the constraints related to adoption of CA practices.
- Support of adaptive research on CA systems lags behind what farmers are discovering and adapting own initiatives. Indeed, the many synergistic interactions between components of CA practices are not fully understood. There are still some research is needed concerning crop rotation, weed control, increase crop water productivity and on farm water use efficiency. In order to find sustainable solutions to the most urgent questions behind the low application rate of CA, the national research institutions should install multi-stations trials accompanied by on farm trials.
- Facilitation of exchange of information and experiences among farmers. This is the primary task of the extension surface officers. This implies that extension service stuff should be under continuous training to update their know how and knowledge of CA systems. Strengthening the extension service body is a win-win game not only in facilitating exchange amongst farmers but also providing research institutions with the actual problems the farmers are facing to decide on the actions to be implemented.
- Education. Students at agricultural schools and universities have to become acquainted with CA during their studies. Furthermore students should be provided with well-organized training programmes in CA during their studies. The production of training manuals beside scientific videos and technical information handbooks are the most appropriate tools for this task.

- National and regional networking. Experiences with national and regional networks showed to be very efficient in enhancing the disseminative of CA practices. The running networking activities exchange is easing of information and experiences between practitioners and researchers and other experts, enhancing institutional support and improving cross sectorial co-ordination in terms of making the best use of existing but dispersed experience and information. According to Hamdy (2010), to gain major benefits from networking and networks it is needed to dedicate capable key members acting as focal points, consistent flow of adequate trusted information, a shared scene of professional development, political and decision making and above all a good and reliable communication system.

Box 2:. CA Practices supporting measures*::*

- *Formation of procedures associations*
- *Support agricultural services providers*
- *Support of adaptive research on CA*
- *Facilitation of exchange of information and experiences among farmers*
- *Education*
- *National and regional networks (reference ?) retention.*
- *Lower soil temperature and better establishment.*
- *Increased planting opportunities and flexibility.*
- *Lower machinery labour and maintenance cost, and*
- *More reliable yields*

Spreading CA systems: major governmental tasks

Globally, courtiers involved in introducing and implementation CA systems to replace the conventional TA in order to tackle the notable deterioration in soil health and its productivity, environment degradation and shortage in food production, governments are requested to do the followings:

- Harmonize their policies to support the adoption of CA
- Introduce mechanisms which provide incentives for farmers to CA
- Pursue the case of conservation agriculture as a central mechanism for agriculture sector climate change mitigation in the international negotiations for a post Kyoto climate change agreement
- Include conservation agriculture as base concept for the adaptation of agriculture to the challenges of climate change in the national action plans for adaptation
- Support the UN food and agriculture organization in the endeavor to establish a special programme on conservation agriculture to facilitate this process in its member countries.

CONCLUDING REMARKS AND RECOMMENDATIONS

- CA is knowledge intensive and a complex system to learn and implement, it cannot be reduced to a simple standard technology. It is now considered to be a practical agro-ecological approach achieving sustainable agriculture intensification. It offers environmental. Economic and social advantages that are not fully possible with tillage-based production systems, as well as improved productivity and resilience and improved ecosystem service while minimizing the excessive use of agrochemicals, energy and heavy machinery. (FAO, 2011)in addition in order to put chandler practicing.
- The scaling up of CA practices to achieve national impact requires a dynamic complement of enabling policies and institutional support to producers and supply chain service providers only then it will become possible for CA practices.
- Conservation agriculture, like many agricultural methodology, must be adapted to local environmental and socio economic conditions. It is not a silver bullet solution to the problems facing modern agriculture, but it is one of the better alternatives available.
- Every country in the world must begin to set target for change towards CA, and use all available means and processes to set the transformation in motion thereby securing significant economic, socioeconomic and environmental benefits for the farmers and for the population at large in the world.
- If CA practices are to take off in many countries particularly those suffering serious food shortage a behavioral change in all stakeholders must be encouraged and facilitated. This includes the role and competences of the key national extension, research and education institutions, the government departments, development agencies and donors that support them as well as the private sectors that has an important role to play in innovation processes and in input supply including equipments and machinery
- A full benefits of CA take several years to fully manifest themselves, fostering dynamic CA sector requires an array of enabling policy and institutional support over a long-term time horizon. This will allow farmers to take advantage of the future carbon and water markets and support for environmental services currently under discussion internationally.

- Yield is the primary output commodity from CA systems. However we need to consider the long-term positive economic, environment, social, cultural and policy dimensions of CA systems as opposed to the corresponding negative attributes of conventional tillage agriculture. Thus it becomes quite important that we understand all of the benefits of CA, not just the yield impacts.
- In addition, now it is being increasingly recognized as important for longer-term sustainability and resilience of food production and agriculture systems, in the face of increased climatic variability and climate change.
- A more structural response to the opportunities presented by CA calls for a realignment of agricultural institutions, including research, extension and education, as well as agriculture development policies to enable CA to choice around which to strengthen national and international food and agriculture system.

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