

CONSERVATION AGRICULTURE

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Summary

The basic principle of conservation agriculture is to minimize soil-disturbance in order to stabilize soil structure, increase fertility and balance the ecosystem. Applied together, conservation agriculture practices - no tillage, permanent soil cover, use of cover crops and crop rotations - have complementary positive outcomes: no tillage maintains stable soil structure and biological activity; a permanent organic soil cover protects the soil surface from erosion and creates a stable and favorable micro-climate; cover crops provide organic matter, reduce erosion and improve soil fertility; and crop rotation enhances the biodiversity of the system and therefore contributes to weed, pest and disease control.

Conservation agriculture is a model of sustainable agriculture as it leads to profitable food production while protecting and even restoring natural resources. Conservation agriculture benefits farmers because it reduces production costs and increases yields, but it also has positive impacts on the whole society: enhancement of food security thanks to a better soil fertility, improvement of water quality, reduction of erosion and mitigation of climate change by increasing carbon sequestration, etc. Conservation agriculture systems are also less sensitive to extreme climatic events and therefore contribute to the adaptation to climate change and the resilience of agricultural systems. Hence, conservation agriculture becomes a fundamental element of sustainable production intensification, combining high production with the provision of environmental services.

Conservation agriculture has shown its full potential in Latin America, where it has been very successful at the economic and environmental level for the last twenty years. It is now expanding to other continents. While developing, conservation agriculture is facing new challenges to adapt to new geographic areas and socio-economic situations. Particularly for resource-poor farmers, these labor- and resources- saving practices could be very relevant, if they could be tailored to their specific systems.

1. Definition of Conservation Agriculture

The Food and Agriculture Organization of the United Nations (FAO) defines conservation agriculture (CA) as follows:

“CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes. CA is characterized by three principles which are linked to each other, namely: (1) continuous minimum mechanical soil disturbance;(2) permanent organic

soil cover; and (3) diversified crop rotations in the case of annual crops or plant associations in case of perennial crops.”

FAO also defines CA with the following quantifying parameters:

1. Minimal soil disturbance: the disturbed area must be less than 15 cm wide or 25% of the cropped area (whichever is lower); no periodic tillage disturbs a greater area than the aforementioned limits.
2. Soil cover: three categories are distinguished: between 30-60%, 61-90% and 91%+ ground cover, measured immediately after the planting operation; ground cover less than 30 % will not be considered conservation agriculture.
3. Crop rotation: the rotation should involve at least three different crops.

2. Basic Principles

Conservation agriculture is based on healthy functioning of the whole agro-ecosystem with a maximum attention and focus on the soil. The soil is the entry point and it has to be considered not only as a simple physical support for roots and plants, but as a living entity with its physical, chemical and biological characteristics. The focus of CA embraces not only the nutrient contents of the soil but also its structural and biological status, which are determinants of sustained productivity.

The paradigm of CA is that an undisturbed soil has the opportunity to develop and produce healthier plants. Indeed, not disturbing the soil has a lot of positive outcomes: soil life can develop in a stable habitat in quantity and quality better than on tilled soils; the structural integrity of the soil is maintained, so continuous vertical macro-pores are not destroyed and remain as drainage channels for rainwater into the soil; the weed seed bank in the soil does not receive the stimulation for germination. Seeding under conditions of minimum soil disturbance is achieved by direct seeding through the mulch cover without tillage.

No-tillage is necessary, but it is not sufficient to achieve a sustainable CA system. It has to be combined with at least two complementary practices which are soil cover and diversified crop rotations.

A permanent organic soil cover (from a crop, a cover crop or a vegetative mulch) ensures the protection of the soil surface from wind, rain, sun and from drying out, and provides a regular supply of organic matter, which is a key feature for soil fertility. In addition, the mulch suppresses the germination of weeds, provides habitat for beneficial fauna, and feed for the soil organisms.

Finally a well designed crop rotation allows sustainable management of the system, because it aids in the suppression of weed and pest problems. Different crop species with different root systems explore different soil horizons and hence increase the efficiency of the use of soil nutrients.

Only the combination of these techniques with their synergistic effects can lead to a sustainable, resource-saving agriculture, and at the same time be productive and profitable. This type of agricultural system is referred to as conservation agriculture.



Figure 1. Maize planted into wheat straw (crop rotation) by direct planter (minimal soil disturbance), without removing the previous crop residue (permanent soil cover): Good conservation agriculture (Friedrich, 2007).

3. Purpose of Conservation Agriculture

At the beginning, CA was developed as a natural resource-saving practice. The development of conservation tillage began in the USA in 1935, as a result of the dust bowl which devastated large areas of the United States in the 1930s. The principal objective was to retain a cover by crop residues on at least 30% of the soil surface, and to protect the soil from wind erosion. Zero tillage was introduced in Brazil in the early 1970s, mainly as an answer to severe water erosion problems (Derpsch, 2001). There, in the hilly parts of southern Brazil, water erosion was leading to disastrous loss of soil and severe degradation of farmland. In response to these problems a new kind of agriculture has been developed without any mechanical soil movement (zero tillage and direct seeding) and with the use of cover crops and crop rotations. The initial zero-tillage technique came from the USA. It was converted to a more complete approach called CA in Brazil, and it is now coming back as such to the USA.

Today, CA is still promoted for its resource-saving capacity: to maintain or enhance soil fertility, to fight against erosion and desertification and/or to better use scarce rain water resources. But CA is also recognized for its economic benefits which mainly convinced farmers to adopt it: increased yields, reduced production costs, labor reduction, increased farm incomes, better production stability and therefore better food security. Thus, CA could be a way to achieve the UN Millennium Development Goals, of eradicating extreme poverty and hunger while ensuring environmental sustainability.

Conservation Agriculture is also showing a new, very interesting benefit in the fight against global warming. It has been shown that CA is able to increase carbon sequestration in the soil. On average, under humid temperate conditions, 0.5 t/ha/year of organic carbon can be captured (Baker *et al.*, 2007). CA could therefore be promoted as a practice that contributes to mitigating climate change.

4. Conservation Agriculture in the World

Nowadays, CA is practiced worldwide on more than 100 million ha with exponential growth rates. The area cultivated under conservation agriculture more than doubled between 1999 (45,5 Million ha) and 2005 (95 Million ha). The countries with the biggest area under no-tillage are the USA, followed by Brazil, Argentina, Canada, Australia and Paraguay. However, the highest rates of adoption and the best quality of CA systems (permanent no tillage) are concentrated in Latin America: in Argentina, Brazil and Paraguay CA exceeds 60% of the total agricultural land (Derpsch, 2005).

Country Area	Under No-tillage (ha) 2004/2005
USA	25 304 000
Brazil	23 600 000
Argentina	18 269 000
Canada	12 522 000
Australia	9 000 000
Indo-Gangetic-plains*	1 900 000
Paraguay	1 700 000
Bolivia	550 000
South Africa	300 000
Spain	300 000
Venezuela	300 000
Uruguay	263 000
France	150 000
Chili	120 000
Colombia	102 000
China	100 000
Other	1 000 000
Total	95 480 000

(*) Includes four countries in South Asia, India, Pakistan, Bangladesh and Nepal.

Table 1. Extent of no-tillage adoption worldwide (Derpsch, 2005).

4.1. Latin America

CA was designed in Brazil and Latin America. The good environmental and economic performances of CA systems and the implementation of supporting policies led to a rapid and widespread adoption of this system. In the southern states of Brazil, CA has been promoted by public bodies as research, rural extension and fisheries services (maintained by the state government with the support of municipalities). The implementation has always been done with a participative strategy, including farmers groups at the watershed level. Farmers contributed to finding agronomic solutions (adapted cover crops and rotations) suitable for their farming systems and to designing specific implements for direct seeding in collaboration with local machinery industries. Even private companies like cooperatives, agro-industries and small rural industries

have been involved in CA expansion from the very beginning. This multi-stakeholder strategy has been very efficient and successful, as CA is now utilized on 60% of the total agricultural land area in this region.

Moreover in terms of quality of no-tillage, Brazil and the neighboring countries have very high standards. Green manure cover crops and crop rotation are widely used. Permanent no-tillage is applied on more than 90% of the whole land area under this technology in Argentina, Brazil, Bolivia and Paraguay (Derpsch, 2005).

4.2. USA, Canada, Australia

No-tillage agriculture was born in the USA in the 1930s, and since then the USA has always been the largest area under no-tillage in the world. However, it is interesting to note that in this country no-tillage accounts for only 22.6% of all cropland hectares. Conventional agriculture with tillage remains the dominant system, even if CA is a valid option for farmers. In comparison, in Latin America no-tillage has become the main agricultural system on 60% of the cropland.

Moreover, only about 10-12% of the total area under no-tillage is permanently not tilled (CTIC, 2005). Occasional tillage prevents the system from reaching its optimum balance, as the soil is disturbed regularly. Research has shown that it takes more than 20 years of continuous no-tillage to reap the full benefits of the system. Farmers that practice rotational tillage, i.e., plow or till their soils occasionally, will never experience the full benefits of the system (Derpsch, 2005).

Canada shows the fourth largest area under no-till with 12.5 million ha.

In Australia, CA has been widely and quickly adopted by farmers. It has improved weed control, time of sowing, drought tolerance and has enabled more efficient water use in dry regions. But inappropriate seeding machines, which disturb the mulch too much, and sheep that graze crop residues are leading to insufficient soil cover. Efforts still need to be undertaken to improve the practices and the sustainability of the system.

4.3. Europe

CA exists in Europe but it is not widely spread, the area of cropland under no-tillage does not exceed 2% of the agricultural land. The European Conservation Agriculture Federation (ECAAF) is promoting CA since 1999. The adoption has been slow but noticeable in Spain, France, Germany, Switzerland and Finland. A greater acceptance of CA/No-till at political level is needed in the EU in order to increase farmer acceptance. Spain is the leading country in terms of no-till adoption in Europe. In total it is reported that CA is applied on about 650,000 ha, which represent 10% of arable land in Spain. Besides annual crops grown in the no-tillage system, many olive plantations and fruit orchards have turned to no-till systems.

France is also among the more advanced countries in Europe in terms of CA adoption. The French no-till farmers association estimates that no-tillage is practiced on about 200,000 ha in this country. Some farmers have developed superior no-till systems with green manure cover crops and crop rotations which are working very well.

The adoption of no-tillage technologies was very fast in Finland. According to FINCA (Finnish Conservation Agriculture Association) in less than ten years no-tillage grew from some hundred hectares to 200,000 ha in 2008. The reason for this rapid adoption was that those farmers that believed in the no-till system and made it work communicated their experiences to their peers.

Switzerland is another important country in Europe for CA, not so much for the area under CA, but for the importance of the official support to CA.

4.4. Asia

Fast development of CA has been observed in the last five years in Central Asia, especially in Kazakhstan. The total area of “reduced tillage” in Kazakhstan is about 3 to 5 million ha, but the area with permanent no-till and rotation, that is to say with full CA practices, covers 1.2 million ha.

China has been experiencing dynamic development of CA. Starting with a research phase in the 1990s, the system has now recently been adopted and its technology mainly extended to rice production. In 2008, it was estimated that about 1.3 million ha are under CA in China.

In South Asia (India, Pakistan, Nepal and Bangladesh) there is a significant interest in CA. No-till wheat is grown on more than 4 million ha, but for the moment tillage is still used for other crops in the rotation. The adoption of full CA, i.e., permanent no-till for all rotational crops, remains marginal. The Indian Professional Alliance for Conservation Agriculture (PACA) is promoting and developing CA practices. The expansion is likely to be fast and widespread as there is a general interest in resource saving technologies in this region.

4.5. Africa

CA is spreading in many areas of Africa and particularly in eastern and southern Africa, where it is promoted by FAO and the African Conservation Tillage Network (ACT). CA is already adapted over 370,000 ha in South Africa. For the last decade many African countries have been exposed to no-tillage systems and CA, and some of them have included this into their government policies (Kenya and Tanzania). CA has also been incorporated into the regional agricultural policies by NEPAD (New Partnership for Africa's Development) and more recently by AGRA (Alliance for a Green Revolution in Africa).

Building on indigenous and scientific knowledge and innovative equipment design from Latin America, farmers in at least 14 countries (Kenya, Uganda, Tanzania, Ghana, Zambia, Zimbabwe, Malawi, etc.) are now practicing CA. So far the area in ha is still small, since most of the promotion is among small farmers, but there is a steadily growing movement involving in the region already far more than 100,000 small scale farmers, with an adoption area in Kenya and Tanzania of about 20,000 ha.

The specific conditions found in Africa - the majority of farmers are resource-poor

farmers relying on less than 1 ha, food insecurity, degradation of soil fertility, drought and irregular rains, shortage of human power for agricultural labor, etc. - present new challenges for CA in Africa. CA could respond to growing food demand by increasing food production while reducing negative impacts on the environment. This requires the development of locally adapted technologies that are consistent with CA principles.

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Biographical Sketches

Amélie Berger is an agronomist, specialized in sustainable plant production. In 2002, she got a master's degree of agronomy from the National School of Agronomy of Montpellier (France). During her studies, she worked on sustainable plant production issues like organic agriculture, crops rotation, improving fallows, agro-forestry and soil fertility. From 2003 to 2007, she worked as a project manager for the development of organic agriculture in France, in two organic farmers' organizations. Actually she's working as a consultant for the Plant and Production Division of the FAO (Food and Agriculture Organization of the United Nations) in Rome.

Theodor Friedrich is an expert in conservation agriculture with more than ten years practical work experience in this area. Since 1994, he serves as the Senior Officer of FAO/Rome in the areas of agricultural mechanization and crop production systems, particularly promoting Conservation

Agriculture. Born in El Tigre, Venezuela, Friedrich has traveled the world and worked since 1982 for different organizations with an agricultural and development focus in more than 60 countries in the Americas, Africa, Asia, Europe and Oceania. He earned his Ph.D. in 1988 from Göttingen University in agricultural engineering, and he specializes in work with agriculture, agricultural engineering and mechanization, agricultural extension, technical co-operation with developing countries, conservation agriculture and integrated pest management.

Josef Kienzle is a skilled mechanic and agricultural engineer with a post graduate degree in advanced agricultural development. Since 1996 he serves in the Rural Infrastructure and Agro-industries Division of FAO with a focus on labor saving technologies vs. rural employment and equity aspects, private sector roles in equipment supply as well as farmer empowerment and small enterprise development for agricultural and rural services. He is leading an FAO field program in East Africa and Brazil entitled Conservation Agriculture for Sustainable Agriculture and Rural Development “CA for SARD”. This program promotes small farmers in learning and applying CA practices. The program enhances south-south knowledge transfer with regard to CA equipment manufacture and emphasizes on Africa wide networking to share lessons learnt and innovations (agricultural mechanization strategies, small enterprise development, increased productivity and input efficiency).