Introduction to Conservation Agriculture: principles and benefits

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Summary

This practice describes how conservation tillage, and especially zero-tillage helps reverse soil erosion caused by soil tillage.

Description

Conventional “arable” agriculture is normally based on soil tillage as the main operation. The most widely known tool for this operation is the plough (= a tool used in farming for initial cultivation of soil in preparation for sowing seed or planting), which has become a symbol of agriculture.

Soil tillage has in the past been associated with increased fertility, which originated from the mineralization of soil nutrients as a consequence of soil tillage. This process leads in the long term to a reduction of soil organic matter. Soil organic matter not only provides nutrients for the crop, but it is also, above all else, a crucial element for the stabilization of soil structure.

Therefore, most soils degrade under prolonged intensive arable agriculture. This structural degradation of the soils results in the formation of crusts and compaction and leads in the end to soil erosion. The process is dramatic under tropical climatic situations but can be noticed all over the world. Mechanization of soil tillage, allowing higher working depths and speeds the use of certain implements like ploughs, disk harrows (= iron or steel discs which have slight concavity and are arranged into two or four sections) and rotary cultivators have particularly detrimental effects on soil structure.

The excessive tillage of agricultural soils may result in short term increases in fertility, but will degrade soils in the medium term. Structural degradation, loss of organic matter, erosion and falling biodiversity are all to be expected.

Soil erosion resulting from soil tillage has forced us to look for alternatives and to reverse the process of soil degradation. The logical approach to this has been to reduce tillage. This led finally to movements promoting conservation tillage, and especially zero-tillage, particularly in southern Brazil, North America, New Zealand and Australia.

Over the last two decades the technologies have been improved and adapted for nearly all farm sizes; soils; crop types; and climatic zones. Experience is still being gained with this new approach to agriculture and FAO has supported the process for many years.

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1. The concept of conservation agriculture

Experience has shown that these techniques, summarized as conservation agriculture (CA) methods, are much more than just reducing the mechanical tillage. In a soil that is not tilled for many years, the crop residues remain on the soil surface and produce a layer of mulch. This layer protects the soil from the physical impact of rain and wind but it also stabilizes the soil moisture and temperature in the surface layers.

Thus, this zone becomes a habitat for a number of organisms, from larger insects down to soil borne fungi and bacteria. These organisms macerate the mulch, incorporate and mix it with the soil and decompose it so that it becomes humus and contributes to the physical stabilization of the soil structure.

At the same time this soil organic matter provides a buffer function for water and nutrients. Larger components of the soil fauna, such as earthworms, provide a soil structuring effect producing very stable soil aggregates as well as uninterrupted macropores leading from the soil surface straight to the subsoil and allowing fast water infiltration in case of heavy rainfall events.

This process carried out by the edaphon, the living component of a soil, can be called "biological tillage". However, biological tillage is not compatible with mechanical tillage and with increased mechanical tillage the biological soil structuring processes will disappear.

Certain operations such as mouldboard (=wedge formed by the curved part of a steel plow blade that turns the furrow) or disc ploughing have a stronger impact on soil life than others as for example chisel ploughs. Most tillage operations are, however, targeted at loosening the soil which inevitably increases its oxygen content leading in turn to the mineralization of the soil organic matter. This inevitably leads to a reduction of soil organic matter which is the substrate for soil life.

Thus, agriculture with reduced, or zero, mechanical tillage is only possible when soil organisms are taking over the task of tilling the soil. This, however, leads to other implications regarding the use of chemical farm inputs. Synthetic pesticides and mineral fertilizer have to be used in a way that does not harm soil life.

As the main objective of agriculture is the production of crops, changes in the pest and weed management become necessary with CA. Burning plant residues and ploughing the soil is mainly considered necessary for phytosanitary (sanitary with regard to pests and pathogens) reasons, to control pests, diseases and weeds. In a system with reduced mechanical tillage based on mulch cover and biological tillage, alternatives have to be developed to control pests and weeds. Integrated Pest Management becomes mandatory.

One important element to achieve this is crop rotation (see Crop rotation in conservation agriculture), interrupting the infection chain between subsequent crops and making full use of the physical and chemical interactions between different plant species. Synthetic chemical pesticides, particularly herbicides are, in the first years, inevitable but have to be used with great care to reduce the negative impacts on soil life.

To the extent that a new balance between the organisms of the farm-ecosystem, pests and beneficial organisms, crops and weeds, becomes established and the farmer learns to manage the cropping system, the use of synthetic pesticides and mineral fertilizer tends to decline to a level below that of the original “conventional” farming system.

1.1. Advantages of conservative agriculture

Conservation Agriculture, understood in this way, provides a number of advantages on global, regional, local and farm level:

- It provides a truly sustainable production system, not only conserving but also enhancing the natural resources and increasing the variety of soil biota (= the biologically active powerhouse of soil, including micro-organisms and soil “animals”), fauna and flora (including wild life) in agricultural production systems without sacrificing yields on high production levels. As CA depends on biological processes to work, it enhances the biodiversity in an agricultural production system on a micro- as well as macro level.
- No till fields act as a sink for CO_2 and conservation farming applied on a global scale could provide a major contribution to control air pollution in general and global warming in particular. Farmers applying this practice could eventually be rewarded with carbon credits.
- Soil tillage is among all farming operations the single most energy consuming and thus, in mechanized agriculture, air-polluting, operation. By not tilling the soil, farmers can save between 30 and 40 percent of time, labour and, in mechanized agriculture, fossil fuels as compared to conventional cropping.
- Soils under CA have very high water infiltration capacities reducing surface runoff and thus soil erosion significantly. This improves the quality of surface water reducing pollution from soil erosion, and enhances groundwater resources. In many areas it has been observed after some years of conservation farming that natural springs that had dried up many years ago, started to flow again. The potential effect of a massive adoption of conservation farming on global water balances is not yet fully recognized.
- Conservation agriculture is by no means a low output agriculture and allows yields comparable with modern intensive agriculture but in a sustainable way. Yields tend to increase over the years with yield variations decreasing.
- For the farmer, conservation farming is mostly attractive because it allows a reduction of the production costs, reduction of time and labour, particularly at times of peak demand such as land preparation and planting and in mechanized systems it reduces the costs of investment and maintenance of machinery in the long term.
- The conjunction of all the advantages mentioned before, provides an improvement in the resilience of the agro-system against severe weather events. Together with this, the potential improvement of crop yield due to better soil conditions, will help farmers´ livelihoods to be less vulnerable to these extreme risks.

1.2. Disadvantages of conservation agriculture

Disadvantages in the short term might be the high initial costs of specialized planting equipment and the completely new dynamics of a conservation farming system, requiring high management skills and a learning process by the farmer. Long term experience with conservation farming all over the world has shown that conservation farming does not present more or less but different problems to a farmer, all of them capable of being resolved. Particularly in Brazil the area under conservation farming is now growing exponentially having already reached the 10 million hectare mark. Also in North America the concept is widely adopted.

2. The principles of conservative agriculture

2.1 Direct planting

The direct planting of crop seeds involves growing crops without mechanical seedbed preparation and with minimal soil disturbance since the harvest of the previous crop. Direct seeding is understood in CA systems as synonymous with no-till farming, zero tillage, no-tillage, direct drilling, etc.

Planting refers to the precise placing of large seeds (maize and beans for example); whereas seeding usually refers to a continuous flow of seed as in the case of small cereals (wheat and barley for example). The equipment penetrates the soil cover, opens a seeding slot and places the seed into that slot. The size of the seed slot and the associated movement of soil are to be kept at the absolute minimum possible.

Ideally, the seed slot is completely covered by mulch again after seeding and no loose soil should be visible on the surface. Land preparation for seeding or planting under no-tillage involves slashing or rolling the weeds, previous crop residues or cover crops; or spraying herbicides for weed control, and seeding directly through the mulch. Crop residues are retained either completely or to a suitable amount to guarantee the complete soil cover, and fertilizer and amendments are either broadcast on the soil surface or applied during seeding.

2.2 Permanent soil cover

The permanent soil cover, especially by crop residues and cover crops, is important to protect the soil against the deleterious effects of exposure to rain and sun; to provide the micro and macro organisms in the soil with a constant supply of "food"; and alter the microclimate in the soil for optimal growth and development of soil organisms, including plant roots.

3. Validation of the practice

Conservation tillage, and especially zero-tillage, was successfully implemented in southern Brazil, North America, New Zealand and Australia. Over the last two decades the technologies have been improved and adapted for nearly all farm sizes; soils; crop types; and climatic zones. Experience is still being gained with this new approach to agriculture and FAO has supported the process for many years.

4. Minimum requirements for the successful implementation of the practice

Applying CA in farms imply high initial costs of specialized planting equipment and the completely new dynamics of a conservation farming system, requiring high management skills and a learning process by the farmer.

5. Agro-ecological zones

- Tropics, warm; and
- Subtropics, warm/mod cool.

6. Objectives fulfilled by the project

6.1 Resource use efficiency

This practice helps maintaining the soil from degradation due to conventional tilling practices.