CONSERVATION AGRICULTURE BENEFITS ON WATER HOLDING, CARBON MITIGATION AND REDUCING SOIL LOSSES

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There is an ever-present challenge in agriculture to maximise crop productivity in a sustainable basis with special concern for the tropical and sub-tropical regions where mis-management can result in rapid decline in soil conditions and loss of water and of productivity. This is particularly true in developing countries in Latin America, Africa and Asia, where already many rural people live in poverty; a problem that will only worsen with growth in World population.

Conventional agricultural practices, like ploughing, mixing crop residue and other biomass into the soil surface and burning of residues, have contributed to the deterioration of the physical quality of the soil, the structure and strength and water retention properties that relate most strongly to root growth and plant available water, and is also often related to the process of carbon sequestration. It causes the soil to become more dense and compacted, the organic matter content to be reduced and water runoff and soil erosion to increase. It also leads to droughts becoming more severe and the soil becoming less fertile and less responsive to fertiliser.

During the last 50 years there has been a profusion of agricultural development programmes throughout the world trying to arrest erosion, which is perceived as one of the main causes of land degradation. Sadly, though not surprisingly, the physical erosion control methods have failed to remedy the situation. What has often been judged initially as a success during the lifetime of a development programme, has frequently failed to be effective a few years later and after the departure of programme personnel, sustainability has failed to be achieved.

The challenge to reduces or stop soil erosion and water runoff is to maximise the capture, infiltration and storage of rainfall water into the soil for enhanced crop production. This is achieved by promoting conditions that reproduce an absorptive, organic matter rich and biologically diverse soil. In agriculture, this type of absorptive soil is achieved *via* the four key principles of Conservation Agriculture (CA): maintaining soil cover with plant residues, reducing mechanical soil disturbance by tillage, restricting in-field traffic to permanent wheel tracks, and encouraging the use of rotation and cover crops to increase organic matter and carbon sequestration, lessen erosion and bring biological diversity back to the soil, particularly earthworms. These principles have been thoroughly researched and implemented in large farming areas of many cropping systems, worldwide, e.g. Brazil, Argentina, Paraguay, USA, Canada and the dry lands of Australia. Improvements are many and at several levels: increased yields and farm productivity, reduced fuel use and labour requirements, as well as reduced requirement of external inputs due to significant increases in organic matter, reduced erosion and the return of biological diversity to the soil, particularly earthworms. There is no one recipe that fits all conditions, rather the power of the system comes from dynamic mixes of the four principles, and particularly synergy between the components.

Although still a controversial issue, the main contributors to the global climate change both in terms of substances (greenhouse gases - GHG's) and emitters have been clearly identified. Agriculture is accused to contribute with up to 20% to the total emission of GHG's with methane playing the major role amongst them (Cole, 1996). Fuel burning through agricultural machinery is often regarded as the main source of CO_2 emission of the primary sector, neglecting the CO_2 fluxes deriving from agricultural land caused by the “burning” of organic litter left after harvest and soil organic carbon (SOC) through the more or less intensive soil tillage, which is still considered the normal and “good agricultural practice”.

According estimations and measurements over decades soil organic matter (SOM) decreased considerably due to agricultural land use (Reicosky, 2001). Regarding a 1% reduction of SOC in the 30 cm topsoil layer an amount of around 45 tons of carbon or 166 tons of CO_2 per one hectare of land is lost to the atmosphere. This calculation clearly illustrates the impact that agriculture had and may have on the release of CO_2 to the atmosphere, where land use led and leads to a depletion of SOC.

On the other hand, it also reveals the potential of CO_2 sequestration, which a change of the agricultural practice into conservation agriculture could have, if it succeeded in restoring at least some of the SOC lost over decades of traditional land use, thus increasing not only the levels of SOM but also soil fertility and long-term sustainability of agriculture and food production.

In this context, conservation agriculture could play a decisive role, once this practice reduces biological oxidation and thus the mineralization rate of organic matter and soil carbon. A great number of studies shows that conservation agriculture are able to increase the levels of SOC, turning the soil into a sink for atmospheric carbon and a pool for the storage of tremendous amounts of carbon.

Although estimates of the total emissions vary widely, the contribution of agricultural activities and forestry products extraction to the emission of especially carbon dioxide, is estimated at only five percent of the global total (Benites, et al., 1999). Conversely, the potential of agriculture and forestry for sequestering carbon (the absorption of carbon in biomass) is significant.

Assuming an average accumulation of 1.0 t C ha^{-1} $year^{-1}$, an area like southern Brazil (Rio Grande do Sul, Santa Catarina and Paraná) under cultivation, applying the four key principles of conservation agriculture would have the potential to sequester 8 million tonnes of C annually, which corresponds with 29 million tonnes atmospheric carbon dioxide.

Estimates based on the assumptions that 30% and 40% of the arable land in Europe (EU-15) could be cultivated using no-tillage (NT) and reduced tillage (RT), respectively, and NT would increase SOC in 0.77 t ha^{-1} $year^{-1}$ and RT in 0.5 t ha^{-1} $year^{-1}$, a total yearly CO_2 sequestration of 130 Mt could be achieved. Compared to this amount, the saving of around 5.3 Mt CO_2 $year^{-1}$ through less fuel consumption due to the reduction of tillage operations is rather small. Together, this emission reduction would account for almost 40% of the 346 Mt CO_2 $year^{-1}$, which the EU-15 member states agreed to reduce until 2012 (Tebrügge, 2001).

Similar figures are provided for the USA, reporting a potential carbon sequestration of 0.45 to 1.0 t ha^{-1} a^{-1} summing up to an average annual agricultural soil sink of 180 Mt C $year^{-1}$. Thus, soils sinks could offset about 30% of the CO_2 emission reduction target of the USA (Lal et al., 1988).

To achieve change from conventional to conservation effective practices requires the implementation of several aspects: (a) exposure of farmers to alternate CA practices, particularly through participatory field schools and on-farm demonstrations to show the benefits and practicalities of the new techniques, equipments and crop types; (b) initiate training in the practical use of the new technologies; support provision, particularly in the period of transition, through flexible funding mechanisms and incentives; (c) foster dynamic and interactive cooperation and dialogue between scientists, suppliers and farmers, and between government and educational institutes; (d) develop and use farmer friendly tools to measure soil physical health and water use efficiency; and (e) to achieve and record improvements in land productivity, farming costs and environmental benefits (e.g. carbon sequestration) resulting from the new CA practices.

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