THE PARADIGM OF CONSERVATION AGRICULTURE

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ABSTRACT

The concept of Conservation Agriculture (CA) is outlined in a series of principles and practices that are promoted. CA is an application of modern agricultural technologies to improve production while concurrently protecting and enhancing the land resources on which production depends. Application of CA promotes the concept of optimizing yields and profits while ensuring provision of local and global environmental benefits and services. Zero tillage, along with other soil conservation practices, is the cornerstone of CA. About 47% of the 95 million ha of zero tillage is practiced in South America, 39% in North America, 9% in Australia, and 3.9% in Europe, Asia and Africa.

INTRODUCTION

Conservation Agriculture is gaining acceptance in many parts of the world as an alternative to both conventional agriculture and to organic agriculture. Although the practice of conservation agriculture on a large scale emerged out of Brazil and Argentina, similar developments were occurring in many other areas of the world, notably North America in zero tillage, and Africa and Asia with technologies such as agroforestry. Conservation agriculture is based on the principles of rebuilding the soil, optimizing crop production inputs, including labor, and optimizing profits.

Zero tillage is now applied on more than 95 million ha worldwide, primarily in North and South America (Derpsch, 2005). Approximately 47% of the zero tillage technology is practiced in South America, 39% is practiced in the United States and Canada, 9% in Australia and about 3.9% in the rest of the world, including Europe, Africa and Asia.

In deference to other approaches, conservation agriculture promotes a series of principles to achieve conservation objectives, rather than a particular technology. This is in recognition of the fact that global agriculture is practiced in many different ecosystems, and technologies have to be carefully tailored to be successful. This article was prepared to outline these principles and to bring focus to the emerging paradigm of conservation agriculture.

DEFINITION OF CONSERVATION AGRICULTURE

Conservation agriculture (CA) is not 'business as usual', based on maximizing yields while exploiting the soil and agro-ecosystem resources. Rather, CA is based on optimizing yields and profits, to achieve a balance of agricultural, economic and environmental benefits. It advocates that the combined social and economic benefits gained from combining production and protecting the environment, including reduced input and labor costs, are greater than those from production alone. With CA, farming communities become providers of more healthy living environments for the wider community through reduced use of fossil fuels, pesticides, and other pollutants, and through conservation of environmental integrity and services.

Conservation agriculture is the integration of ecological management with modern, scientific, agricultural production. Conservation agriculture employs all modern technologies that enhance the quality and ecological integrity of the soil, but the application of these is tempered with traditional knowledge of soil husbandry gained from generations of successful farmers. This holistic embrace of knowledge, as well as the capacity of farmers to apply this knowledge and innovate and adjust to evolving conditions, ensures the sustainability of those who practice CA. A major strength of CA is the step-like implementation by farmers of complementary, synergetic soil husbandry practices that build to a robust, cheaper, more productive and environmentally friendly farming system. These systems are more sustainable than conventional agriculture because of the focus of producing with healthy soils.

Conservation agriculture promotes minimal disturbance of the soil by tillage (zero tillage), balanced application of chemical inputs (only as required for improved soil quality and healthy crop and animal production), and careful management of residues and wastes. This reduces land and water pollution and soil erosion, reduces long-term dependency on external inputs, enhances environmental management, improves water quality and water use efficiency, and reduces emissions of greenhouse gases through lessened use of fossil fuels. Conservation agriculture, including agroforestry (Figs. 1 and 2), specialty crops, and permanent cropping systems, promotes food sufficiency, poverty reduction, and value added production through improved crop and animal production, and production in relation to market opportunities. Reduced tillage leads to lessened human inputs, in both time and effort – this is generally attractive overall, but it is critical in HIV-affected regions.

Conservation agriculture is best achieved through community driven development processes whereby local communities and farmer associations identify and implement the best options for CA in their location. Local, regional and national farmer associations, working through community workshops, farmer-to-farmer training, etc., but with technical backstopping from conservation professionals, are the main players in the promotion of CA.

Conservation agriculture provides direct benefits to environmental issues of global importance. These include land degradation, air quality, climate change, biodiversity and water quality. Conservation agriculture relates directly to the United Nations Framework Convention on Climate Change, the International Convention on Biodiversity, the United Nations Convention to Combat Desertification (Fig. 3), and the various agreements on international waters.

Figure 1. Integrated paddy rice and agroforestry in Madagascar.

Figure 2. Integrated Agroforestry in Madagascar.


Figure 3. Mitigating the effects of desertification in Morocco.

THE PRINCIPLES OF CONSERVATION AGRICULTURE

Conservation agriculture emphasizes that the soil is a living body, essential to sustain quality of life on the planet. In particular, it recognizes the importance of the upper 0-20 cm of soil as the most active zone, but also the zone most vulnerable to erosion and degradation. Most environmental functions and services that are essential to support terrestrial life on the planet are concentrated in the micro, meso, and macro fauna and flora which live and interact in this zone. It is also the zone where human activities of land management have the most immediate, and potentially the greatest impact. By protecting this critical zone, we ensure the health, vitality, and sustainability of life on this planet.

The principles of CA and the activities to be supported are described as follows:

- *Maintaining permanent soil cover and promoting minimal mechanical disturbance of soil through zero tillage systems, to ensure sufficient living and/or residual biomass to enhance soil and water conservation and control soil erosion.* In turn, this improves soil aggregation, soil biological activity and soil biodiversity, water quality, and increases soil carbon sequestration. Also, it enhances water infiltration, improves soil water use efficiency, and provides increased insurance against drought. Permanent soil cover is maintained during crop growth phases as well as during fallow periods, using cover crops and maintaining residues on the surface;
- *Promoting a healthy, living soil through crop rotations, cover crops, and the use of integrated pest management technologies.* These practices reduce requirements for pesticides and herbicides, control off-site pollution, and enhance biodiversity. The objective is to complement natural soil biodiversity and to create a healthy soil microenvironment that is naturally aerated, better able to receive, hold and supply plant available water, provides enhanced nutrient cycling, and better able to decompose and mitigate pollutants. Crop rotations and associations can be in the form of crop sequences, relay cropping, and mixed crops;

- *Promoting application of fertilizers, pesticides, herbicides, and fungicides in balance with crop requirements.* Feed the soil rather than fertilize the crop. This will reduce chemical pollution, improve water quality, and maintain the natural ecological integrity of the soil, while optimizing crop productivity and economic returns;
- *Promoting precision placement of inputs to reduce costs, optimize efficiency of operations, and prevent environmental damage.* Treat problems at the field location where they occur, rather than blanket treatment of the field, as with conventional systems. Benefits are increased economic and field operation efficiencies, improved environmental protection, and reduced (optimized) input costs. Precision is exercised at many levels: seed, fertilizer and spray placement; permanent wheel placement to stop random compaction; individual weed killing with spot-spraying rather than field spraying, etc. Global positioning systems are sometimes used to enhance precision, but farmer sensibility in problem diagnosis and precise placement of treatments is the principal basis. In small-scale farming systems and horticultural systems, it also includes differential plantings on hills and ridges to optimize soil moisture and sunshine conditions;
- *Promoting legume fallows (including herbaceous and tree fallows where suitable), composting and the use of manures and other organic soil amendments.* This improves soil structure and biodiversity, and reduces the need for inorganic fertilizers;
- *Promoting agroforestry for fiber, fruit and medicinal purposes.* Agroforestry (trees on farms) provides many opportunities for value added production, particularly in tropical regions, but these technologies are also used as living contour hedges for erosion control, to conserve and enhance biodiversity, and to promote soil carbon sequestration.

Conservation agriculture strives to develop a balanced coexistence between rural and urban societies, based on increased urban awareness of the environmental benefits and services provided by the rural sector. It works with the international and national market place to develop financial mechanisms to ensure that environmental benefits provided by CA are recognized by society at large, and benefits accrued to CA practitioners. A recent example is the marketing of carbon credits under the Kyoto Accord, but this is only the beginning. Many other opportunities for environmental payments will develop in the future, including the potential for farm products produced under a new “conservation label”. The rapid adoption of conservation technologies by large as well as small farmers in many areas of the world, often without government support, is clear evidence of the economic, environmental and social benefits that accrue from these practices.

AGRICULTURAL AND ENVIRONMENTAL CO-BENEFITS OF ZERO TILLAGE

Zero tillage is a ‘cornerstone’ of CA, and can be practiced in both large and small farming systems (Fig. 4). With zero till (also termed no-tillage and direct drilling) the only tillage operations are low-disturbance seeding techniques for application of seeds and fertilizers directly into the stubble of the previous crop. Gradually, organic matter of the surface layers of zero tilled land increases, due to reduced erosion, increased yields resulting in more crop residue added to the soil surface, and differences in the assimilation and decomposition of soil organic matter. Gradually, an organic mulch is developed on the soil surface, and this is eventually converted to stable soil organic matter because of reduced biological oxidation compared to conventionally tilled soils. Zero tillage is effective in mitigating many of the negative on-farm and off-site effects of tillage,


Figure 4. Zero tillage in Argentina.

principally erosion, organic matter loss, reduced biodiversity and reduced runoff. These conditions are replaced with permanent soil cover, improvements in soil structure, improved organic matter status, improved water use efficiency, and improved soil biology and nutrient cycling.

Most of the agricultural benefits of zero tillage relate to increased organic matter in the soil. This results from the combination of eliminating soil disturbance in conventional tillage, increased biomass from improved crop yields, greater diversity of types of organic matter from increased rotation and cover crops, reduced erosion and differences in the assimilation and decomposition of soil organic matter from reduced surface soil temperatures and increased biodiversity. With time, the soil gradually becomes physically and chemically stratified with a mulch of accumulated plant litter at the soil surface, rich in organic carbon and nutrients. The mulch layer creates a stable microbial ecology and environment for biological activity, and insulates the soil from temperature extremes and rapid desiccation. The microbial and macro faunal (earthworms) populations become more like those of natural soils. Their activity greatly enhances the assimilation and transfer of surface organic mulches into deeper soil layers, and in the process creating physically robust channels to enhance water penetration and dispersion into the soil. In years of average or above average rainfall, the improved soil conditions ensure crop yields comparable to those with conventional tillage, but often with considerably less fertilizer and other inputs. In dry years, the improved soil moisture levels, aggregation and organic matter status of the zero till soils often ensure yield where conventionally tilled soils do not. Profit margins with zero tillage are normally better than under conventional tillage systems, and this enhances the sustainability and future continuity of the CA farming systems.

Zero tillage, including controlled traffic (where all in-field traffic traverses only specified wheel or foot tracks), is highly compatible to precision treatment of field conditions. Procedures include differential fertilizer applications according to nutrient requirements, spot spraying for weed control, controlled traffic in association with zero till, etc. As a consequence, wetlands, water bodies, habitats, and stream courses in agricultural areas can be better protected. In high input systems, precision treatment is becoming popular because of the improved efficiencies of operation and reduced input costs. At the same time, these principles have been used for many centuries in low input systems to optimize local nutrient, soil moisture, and sunshine conditions, as well as natural plant symbiosis.

Zero tillage is conducive to promotion of the environmental integrity of the soil systems, and to maintenance of environmental services. Stability of the soil organic matter under zero tillage, due to enhanced soil aggregation and reduced erosion, enhances sequestration of carbon and contributes to mitigation of climate change. Soil carbon sinks are increased by increased biomass due to increased yields, as well as by reducing organic carbon losses from soil erosion. Fuel use and tractor hours are reduced up to 75%, with further reductions in greenhouse gas emissions. Other environmental benefits include reduced siltation, eutrophication and pesticide contamination of rivers and dams. The system is also valuable to mitigate the environmental effects of droughts by ensuring some biological production, surface cover, and erosion control even under severe conditions, due to the greatly improved soil aggregation, biodiversity and organic matter status, and subsequent improved water infiltration and water storage in the soil.

SUMMARY

This article was prepared to clarify relationships between Conservation Agriculture and zero tillage. The principles of CA include maintaining permanent soil cover, promoting a healthy, living soil, promoting balanced application and precision placement of fertilizers, pesticides, and other crop inputs, promoting legume fallows, composting, and organic soil amendments, and promoting agroforestry to enhance on-farm biodiversity and alternate sources of income. CA provides direct benefits to environmental issues of global importance, including control and mitigation of land degradation, mitigation of climate change, improved air quality, enhanced biodiversity including agrobiodiversity, and improved water quality. Zero tillage, which is the main stay of CA, is now applied on more than 95 million ha worldwide, primarily in North and South America (Derpsch, 2005). Approximately 47% of the zero tillage technology is practiced in South America, 39% is practiced in the United States and Canada, 9% in Australia and about 3.9% in the rest of the world, including Europe, Africa and Asia.

REFERENCES

Derpsch, R. 2005. The extent of Conservation Agriculture adoption worldwide: Implications and impact. *Proceedings of the Third International Congress of Conservation Agriculture*. Nairobi, Kenya.