Briefing Notes
Production Systems Management

Conservation Agriculture for Soil Moisture


FAO/T. Friedrich

Residue covered fields under Conservation Agriculture. Santa Catarina, Brazil

SYNOPSIS

FAO is very active in Conservation Agriculture. FAO is especially interested in the potential of conservation agriculture to retain soil moisture, through rainwater harvesting and optimizing soil moisture.

RECOMMENDATIONS ON RAINWATER HARVESTING IN AFRICA

Until recently, public investment related to water has been biased toward expansion of irrigation schemes and the intensification of irrigated agriculture in high-potential areas. In comparison, only limited investment has focused on making the best use of available rainfall in dry lands. FAO commissioned case studies and made recommendation on rainwater harvesting technologies in differing climate zones and farming systems.

The term "rainwater harvesting" means to capture rainwater and make it available to crops. In Africa, rainwater harvesting is useful in arid, semi-arid, and dry sub-humid agro-ecological zones. For many African countries, rainwater harvesting can reduce poverty and hunger while helping with sustainable economic growth. The goals of FAO work with rainwater harvesting are to: increase crop water availability; maximize water infiltration into the soil and its weather-holding capacity and reduce evaporation losses; and increase crop access to water and improve plant water-uptake capacity.

Low productivity in rain-fed agriculture is due to inadequate rainwater management strategies. The benefits of improved management strategies include increased productivity of arable and grazing land that suffers from inadequate rainfall and eased pressure on existing water resources.

Resulting from the commissioned case studies, FAO recommended that farmers need support for efficient implementation and expansion of rainwater harvesting techniques. Farmers should be provided with knowledge about implementation, maintenance, and tools. These support elements could help farmers in deciding to apply rainwater harvesting.

DROUGHT RESISTANT SOILS: OPTIMIZATION OF SOIL MOISTURE FOR SUSTAINABLE PLANT PRODUCTION

Under low and variable rainfall conditions, efficient soil moisture management is a good way to improve water use. In recognizing the importance of soil moisture, FAO's Land and Water Development Division (AGLL) organized an electronic conference, "Drought Resistant Soils: Optimization of soil moisture for sustainable plant production." The objective was to identify, describe, discuss, and promote actions that will assist farmers to improve water-use efficiency in rain fed agriculture and drought-proof their system. About 590 people subscribed to this electronic forum.

Soil moisture monitoring is usually a better decision-making tool for farmers than rainfall predictions and weather forecasts. The amount of rainfall is not a good measure for predictions on crop production. Particularly in conventional farming, there is only a loose relationship between rainfall quantity and subsequent soil moisture. Rainfall-water efficiency is reduced by unproductive losses through surface run off, unproductive soil evaporation through bare soil surfaces and unproductive evaporation due to the aeration of soil during tillage operation.

Conventional farming accelerates loss of soil moisture by reducing the ability of the soil to capture, drain, and store rainwater. Rainwater is often lost as run-off due to surface sealing because of clay fractions in the surface soil. The addition of organic matter gives stability to sandy soil aggregates, as the sand particles do not have any surface forces to bind them. However, intensive tillage reduces

Demonstration of the impact of rain drops on bare and on mulch covered soil. Santa Catarina, Brazil

"We need a blue revolution where more food is produced per unit water – i.e., more crop per drop"

Kofi Annan
UN Secretary General
Millennium Declaration, 2000

the soil's organic matter. Oxidation is accelerated by improved oxygen supply, resulting in further oxidation of the residual carbon in the system.

Under a no-tillage system, the soil's organic matter can be increased by: retaining crop stubble and residues; applying compost; and cultivating green manure cover crops. By not tilling, the vertical pore system created by roots, earthworms, and other soil animals is left undamaged, soil structure and aggregate stability are improved, and continuous but slow organic matter mineralization offers a permanent nutrient flow to the crops.

One problem associated with poor farmers is their aversion to risk as their livelihoods, and those of their families, depend on the decisions they make. Bad decisions could lead to hunger, farm loss, or worse. Farmers need some support during the early stages of changing farming practices.

In addition to increasing water infiltration and controlling erosion, soil cover has a major impact in reducing soil temperature, reducing evaporation, increasing available water for plants, enhancing biological activity, contributing to reduced soil compaction and soil crusting as well has having positive effects on soil chemical, physical, and biological properties. Soil cover is thus advantageous for the farmer and leads to increased productivity. Cropping systems which have permanent soil cover are essential in achieving long-term agricultural sustainability.

There are four requirements for the adoption of good land management practices.

1) For any new technology to be successfully adopted by farmers, it must bring the farmer a visible and immediate benefit, economic or otherwise.
2) This benefit must be substantial enough to convince the farmer to change his/her ongoing practices.
3) For the technology to be disseminated, the costs incurred must be able to be covered by the farmer.
4) The introduction of the new technology should be followed up by an extension service for a long period of time.

Tools to support soil moisture monitoring are usually not accessible to poor farmers. It is important to develop low technology field-useful approaches that give farmers and land users simple field-applied techniques and models for determining the onset the severity of drought, preferable methods based on the proper experience of the farmers themselves to estimate the needs of watering should be developed. These methods should be based on the observation of plants and on empirical evaluation of the humidity by touching soil samples.

PRINCIPLES OF CONSERVATION AGRICULTURE

One way to introduce the principles of rainwater harvesting and drought resistant soils into an agricultural cropping system is Conservation Agriculture. The system facilitates the infiltration of rainwater and the storage of water in the soil for crop growth.

Conservation agriculture requires implementing three principles, or pillars. These pillars are: 1) minimum soil disturbance; 2) diverse crop rotations and cover crops; 3) continuous plant residue cover. The main direct benefit of conservation agriculture and direct seeding is increased soil organic matter and its impact on soil quality. The foundation underlying the three principles is their contribution and interactions with soil carbon, the primary determinant to long term sustainable soil quality and crop production.

Conservation Agriculture includes no tillage or minimum tillage and direct seeding. No tillage helps to maintain the continuous macro-pore structure in the soil, which is important for water infiltration. No tillage increases the soil's organic matter, which is important for water retention. Furthermore, no tillage helps to retain soil cover, which is important in reducing evaporation losses. Under certain circumstances limited tillage can be acceptable. For example, limited tillage may be useful in reshaping irrigation furrows and bedstructures or in strip tillage for transplanting.

True soil conservation is largely related to organic matter, or carbon, management. By properly managing the carbon in our agricultural ecosystems, we can have less erosion, less pollution, clean water, fresh air, healthy soil, natural fertility, higher productivity, carbon credits, beautiful landscapes, and sustainability.

FAO/T. Friedrich

Direct planting by tractor in China.

▶ Currently only about 3% of the world's land is farmed with Conservation Agriculture principles according to FAO. If farmers perceived Conservation Agriculture as more profitable, more of them would adopt Conservation Agriculture. FAO will continue to support farmers with Conservation Agriculture.

Chemicals

During the past decade, it had been recognized that for no-tillage to be viable, weeds had to be controlled by some other method than tillage. But the range of agricultural chemicals then available was limited because of their residual effects in the soil. A delay of several weeks was necessary after spraying before the new crop could be safely sown, which partly negated saving of time, one of the more noteworthy advantages of no-tillage compared with tillage.

The application of any chemicals within agricultural food production raises the question of human and biological safety. Indeed, many chemicals must be very carefully applied under specific conditions. A large variety of herbicides has been developed which facilitate weed management under no tillage farming systems. Furthermore, crop rotations and cover crops, which can be managed either chemically or mechanically, facilitate weed management under conservation agriculture.

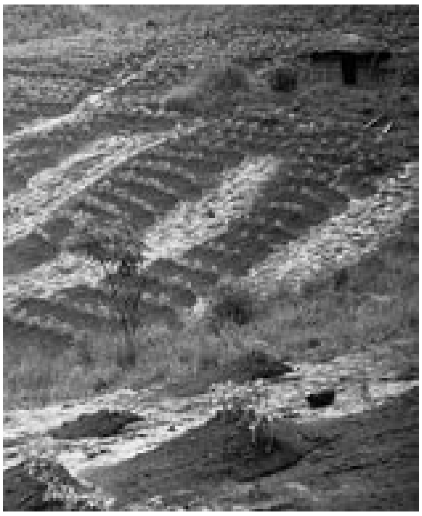
No-Tillage Farming

The notion of sowing seeds into untilled soils is very old. The ancient Egyptians practiced it by creating a hole in untilled soil with a stick, dropping seeds into the hole and then closing it again by pressing the sides together with their feet. But it was not until the 1960s, when the herbicides paraquat and diquat were released by the Imperial Chemical Industries Ltd (now Syngenta) in England, that the modern concept of no-tillage was born because now weeds could be effectively controlled without tillage.

Under no-tillage there is no soil movement required for growing crops. The seeds are introduced into the soil directly with minimum of soil disturbance. As much as possible of the surface residue from the previous crop is left intact on the surface of the ground, whether this is the flattened or standing stubble of an arable crop which has been harvested, or a desiccated flattened green manure cover crop.

Carbon Sequestration Using No-Tillage

Conservation agriculture is receiving global focus as an alternative to the use of conventional-tillage systems and as a means to sequester soil organic carbon. Conservation agriculture is cost-effective from a labor standpoint. More importantly, the practices that sequester soil organic carbon contribute to environmental quality and the development of a sustainable agricultural system. Tillage or other practices that destroy soil organic matter or causes loss and result in a net decrease in soil organic carbon do not result in a sustainable agriculture. Sustainable agricultural systems involve those cultural practices that increase productivity while enhancing carbon sequestration. Increased soil carbon means increased soil organic matter and hence better



FAO/ T.F. Shaxson

Runoff and erosion on steep land.
Zomba, Malawi

▶ **One method for farmer to estimate soil moisture is through measuring the evaporation. Based on the measured evaporation, farmers can more accurately determine the quantity of water and time at which to irrigate the crops.**

soil water holding capacity. Crop residue management, no-tillage, efficient management of nutrients, precision farming, efficient management of water, and restoration of degraded soils all contribute to a sustainable agriculture.

Soil tillage practices are significant to the carbon status of soils because they affect carbon dynamics. Tillage practices disturb the surface soil reduce soil organic carbon by increasing decomposition and mineralization of biomass due to increased aeration and mixing a plant residues into the soil, exposing previously protected soil organic carbon in soil aggregates to soil fauna, and by increasing losses due to soil erosion. Conversely, long-term no-tillage or reduced tillage systems increase soil organic carbon content of the soil surface layer as a result of various interacting factors, such as increased residue return, less mixing and soil disturbance, higher soil moisture content, reduced surface soil temperature, proliferation of root growth and biological activity, and decreased risks of soil erosion.

Water availability

Eighty percent of the world's cultivated land depends on "green water" for production. Green water is defined as water located in the soil. Agriculture which depends on only green water is called "rainfed agriculture." Green water resources will, in the foreseeable future, be the dominant source for human food production. However, only 15% of actual rainfall is productively used for crop growth.

There is increased pressure on "blue water resources." Blue water is defined as ground water or surface water bodies. Since blue water is limitied, it will be difficult to increase the size of areas under irrigation. Therefore, it is necessary to increase the efficiency of green water resources, or to increase the amount of food which is produced with each drop of rainwater. Experiments have shown that improved soil and water management through conservation agriculture can increase crop yield by 10–100% while halving the water requirements for crop production from 2,500 m3/ton to 1,250 m3/ton.

RESOURCES

FAO-CA homepage at http://www.fao.org/ag/ags/AGSe/Main.htm

In the internet FAO AG21 and the FAO homepage
http://www.fao.org/ag/magazine/0110sp.htm
http://www.fao.org/News/2000/000501-e.htm
http://www.fao.org/News/2001/011103-e.htm
http://www.fao.org/ag/magazine/0105sp.htm
http://www.fao.org/ag/magazine/0101sp1.htm

FAO Press Release
http://www.fao.org/WAICENT/OIS/PRESS_NE/PRESSENG/2001/pren0159.htm
http://www.fao.org/News/2001/010507-e.htm

Photo Library on CA at http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/consagri/photofile/file/Index.htm

Video
Four-minute Video Conservation Agriculture in Southern Brazil produced for the World Congress on CA in Madrid, October 2001 in English, Spanish and French.

FURTHER READING

García Torres, L., Benites, J., Martinez Vilela, A. and Holgado Cabrera, A. 2003. Conservation Agriculture: Environment, Farmers Experiences, Innovations. Kluver Academic Publishers. Netherlands.

CREDITS

Jan Poulisse, Jose Benites and Theodor Friedrich are contributing to FAO's work on conservation agriculture. A database was developed in support of technology transfer for conservation agriculture in Africa. This was carried out by FAO in collaboration with the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and the German Association for Conservation Tillage (GKB). The Production Systems Management Briefing Notes are produced by the Integrated Production Systems (PROD) Priority-Area of Inter-Disciplinary Action (PAIA).