The role of biological activity

Crop roots and soil organisms are responsible for the creation of a network of interconnected **biopores** that cannot be created by mechanical tillage. In addition, biological activity ensures crop residues are incorporated into the soil, maximizing the soil-binding impact of organic matter.

G. BROWN

The farmer who adopts conservation agriculture is enhancing the activity of different beneficial organisms that undertake **biological tillage** and improve soil structure.

Controlling in-field traffic:

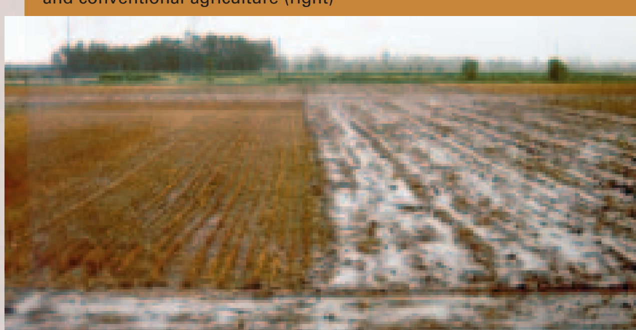
Whether human, animal or machinery traffic, it is vital to ensure that all types of traffic follow permanent tracks. In this way, all soil compaction is restricted to these known areas. The land between tracks is totally free of compaction, where combined with zero tillage.

Crop rotations:

The rotation of different crops, with their different root systems, optimizes the network of root channels in the soil to deeper soil depths. This leads to increased water penetration, water-holding capacity and available water for crop use.

The power of the absorptive soil system comes from the **synergy** of the four principles of conservation agriculture. The system is not prescriptive and there is no one recipe to suit all conditions.

Different infiltration patterns with zero tillage (left) and conventional agriculture (right)



B. RADFORD

5 MONITORING SOIL MOISTURE

How much rain will fall during the growing season cannot be predicted, but measuring the amount of plant-available water in soils will help to make adequate crop decisions.

Measurements of soil water content can be taken using a variety of techniques:

- **Feel and appearance** of the soil: vary with soil texture and moisture content. With experience, soil moisture can be estimated to an accuracy of about 5 percent.
- **Soil moisture probe:** the amount of water that is available for plants is estimated from the depth of insertion of the probe, interpreted with knowledge of the soil texture.
- **Capacitance probe:** measures the dielectric permittivity of the soil. This can be correlated with soil moisture content. Particularly useful for irrigation timing.
- **Tensiometer:** measures how strongly the water is held by the soil, and this can be related to crop stress and potential yield losses.

J. BENITES

J. BENITES

V.H. FREITAS

In conclusion, in improving soil moisture management and utilization, the challenge is to maximize the capture, infiltration and storage of rainfall water in the soil for enhanced crop production. This is achieved by promoting conditions that reproduce an absorptive, organic-matter-rich and biologically diverse soil.

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CONSERVATION
of natural resources
for sustainable
AGRICULTURE

Soil moisture

Improving soil moisture management for enhanced crop production

J. BENITES

1 SOIL MOISTURE MANAGEMENT: A VITAL KEY TO ENHANCED PRODUCTIVITY

A significant cause of low crop production and crop failure in rainfed agriculture is the combination of:

LOW AND ERRATIC RAINFALL

POOR UTILIZATION OF RAINFALL

Little can be done to increase rainfall or the number of rainfall events; thus efforts should concentrate on improving the capture of rainfall, soil water availability and water-use efficiency in rainfed agricultural lands.

This can be achieved by increasing the proportion of water that enters the soil (infiltration) while minimizing moisture loss through runoff and evaporation through increased soil cover and better soil management.

Increasing the water stored in soil should result in:

- improved yields through maximized rainfall utilization;
- reduced risk of yield losses due to drought;
- recharge of groundwater, securing the water level in wells and the continuity of river and stream flows.

IMPROVED SOIL MOISTURE MANAGEMENT will help farmers achieve **FOOD SECURITY** through enhanced productivity, reduced risk and greater reliability of available crop water.

2 SOIL-MOISTURE 'TREASURE HUNT' IN DRYLANDS

When rainfall lands on the soil surface, a fraction will infiltrate into the soil to replenish the soil water or flow through to recharge the groundwater. Another fraction will run off as overland flow and the last fraction will evaporate back into the atmosphere directly from unprotected soil surfaces and also from plant leaves.

Soil moisture is not only determined by the amount of rainfall but also by soil chemical properties and the soil architecture or physical structure, including pores. Soils differ in their architecture and capacity to hold water at plant-available tensions, depending on:

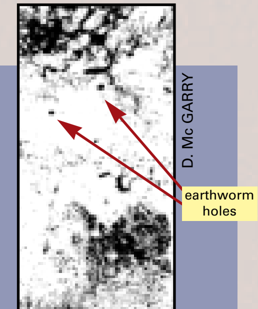
- soil texture,
- soil depth,
- organic matter content,
- biological activity.

Most people consider soil in terms of its solid components. This misses the essential component of **the pore spaces**.

The number, size and connectivity of pore spaces have crucial roles in determining the amount of water that a soil can absorb, hold and supply. Many interconnected pores of a wide range of sizes, particularly at the soil surface, will maximize infiltration and reduce runoff, increasing available soil water.

D. Mc GARRY

Comparison of soils with different porosity



D. Mc GARRY

Binary image (computer generated) of the soil structure

The network of soil pores varies according to the type of soil and how it has been managed. Appropriate land management has a great impact on restoring, improving and protecting soil porosity.

3 CAUSES OF CROP WATER STRESS

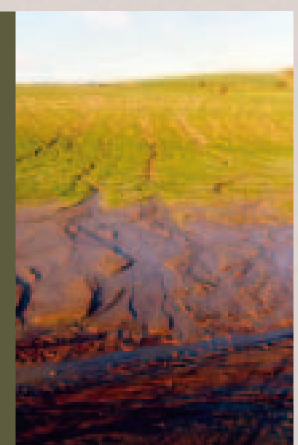
In order to prevent poor utilization of rainfall by crops, it is necessary to understand the processes that lead to deterioration in soil architecture. Two different areas in the soil need to be considered:

At the soil surface

The impact of raindrops on the bare surface can cause decreased porosity as a result of the formation of surface seals and crusts.

Runoff: loss of water that otherwise could have been used by crops.

- Consequence of soil degradation, not a primary cause.
- Responsible for soil erosion and peak river flows of great concern.
- Physical structures (e.g. contour banks) do not resolve the problem of soil degradation because they do not increase the porosity of soils.



T.F. SHAXSON

Beneath the soil surface

Tillage and traffic by machinery, humans and animals can destroy pore spaces and consequently result in **soil compaction**, especially in wet soils. This leads to increased runoff and to restricted root development (therefore, reduced soil depth).

Example of soil compaction

D. Mc GARRY

Tillage, in particular soil inversion by ploughing, also causes a decline in soil nutrient fertility through losses in organic matter and decreases in soil biological activity.

4 CONSERVATION AGRICULTURE: BUILDING UP THE SOIL ARCHITECTURE

In agriculture, an absorptive and biologically rich soil is achieved via the four key principles of conservation agriculture:

- Maintaining soil cover with plant residues or growing crops
- Minimal mechanical soil disturbance through reduced or zero tillage
- Restricting in-field traffic to permanent tracks
- Encouraging the use of rotation and cover crops

Permanent soil cover:

- protects the soil surface from the negative effect of raindrop impacts – enhances porosity on the soil surface;
- reduces the rate of evaporation from the upper layers of the soil;
- establishes better conditions and maintains a continuous food supply for soil organisms – from microbes to earthworms.

Minimal soil disturbance:

- reduces soil moisture loss following tillage;
- reduces or eliminates soil compaction, improving water infiltration into the soil and facilitating root development and crop growth;
- improves the living conditions of soil biota;
- reduces decomposition of organic matter and subsequent loss to the atmosphere.