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The restorative effect of conservation agriculture on soil health

By Christal-Lize Muller

Soil health is at the heart of conservation agriculture. Without conservation it is impossible to implement sustainable eco-friendly systems that meet the needs of both humans and animals. The principles of conservation agriculture function in tandem to improve ecological service delivery, of which soil health forms the basis.

Stockfarm wanted to find out more about the role of soil health in conservation agriculture and spoke to Dr Gerhard du Preez, senior lecturer in agricultural sciences at North-West University (NWU), who focusses his research on agricultural soil health and restoration ecology, and Dr Hendrik Smith of Asset Research, a company that facilitates the implementation of the Maize Trust's conservation agriculture programme.

They both agree that conservation systems that include healthier soil may help many of the components of a farming enterprise to fall into place, which of course benefits the producer. These benefits, Dr Smith explains, include more stable, increased production, the reduced use of inputs, climate resilience, less soil erosion, greater biodiversity and increased profitability.

The important role of livestock

Animals play an indispensable role in nature and should form part of conservation agriculture systems, and even crop production. "Herbivores such as wild game species are no longer as abundant and must therefore be replaced with livestock. Livestock have a significant impact on soil health and the ecology," he explains.

"The correct integration and use of livestock in a conservation agriculture system means that key ecological functions and services are restored. This has major benefits for nature and the producer."

A dark picture

South Africa, says Dr Du Preez, is facing a dire situation with vast hectares of arable land having deteriorated due to conventional agricultural practices. According to him, between 70 and 80% of the country's arable land has already been degraded due to traditional agricultural practices over many decades.

Standard agricultural practices that physically disturb the soil, such as ploughing and hoeing, have a major impact on soil ecosystems and health, while the indiscriminate use of inorganic fertilisers and herbicides contributes to global warming and the pollution of soil and water systems. Inorganic fertiliser also affects the health and functioning of the soil's ecosystem.

Dr Du Preez says complex ecosystems, with their diverse range of plants and animals, are consequently degraded and reduced to monoculture systems. These systems are entirely dependent on external, anthropogenic inputs (e.g. the use of fertilisers and herbicides, which are unnatural).

The impact of conventional agricultural practices, he says, has weakened the structure of agricultural soil because it contains no aggregates that can bind it together. Fertile topsoil washes away due to water erosion, which is clearly visible in overcultivated fields and overgrazed veld.

These practices remove excessive amounts of carbon, which contributes to the soil's structure, and mainly carbon-containing organic matter from the soil. Without a healthy structure, the soil loses its water-holding capacity and erosion increases. Important organisms that feed on carbon and organic matter also disappear from the soil.

Mixed farming improves soil

Dr Smith believes the correct application of conservation agriculture principles, including the integration of livestock, can maximise the positive impact on soil health. Crop and livestock components should not be operated separately, but must rather be integrated into mixed farming systems.

"It is possible to do this successfully and sustainably through crop rotation. In this instance, diverse cover crops and cash crops on which ultra-high-density (UHD) livestock grazing is applied.

With regard to improved soil health, Dr Du Preez agrees that cover crops play a key role in conservation and regenerative systems. It supports a robust root system, builds up carbon in the soil and suppresses weed growth. An added advantage of practicing UHD grazing on

A conservation system at Vrede. (Photograph: Ané Loggenberg)

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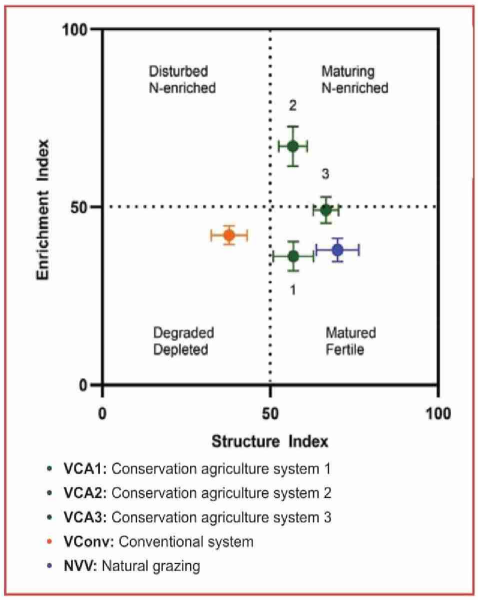
Figure 1: Measurement results of the three different systems near Vrede. (Source: Ané Loggenberg, North-West University)



cover crops, he says, is the manure and urine (natural organic fertiliser) deposited by the animals, as it provides nutrients that nourish the soil's ecosystem.

Dr Smith explains that it is necessary to apply high or UHD grazing to obtain the desired effect on soil health and biodiversity. Changes in infrastructure (water and fences) and good herd management are aspects that should be in place to make these systems possible.

Applying conservation agriculture practices in a livestock farming enterprise, he says, has many benefits. Soil fertility is increased by making use of cover crops and livestock in annual crop rotations, or a resting field system. This method also increases the quality of grain in follow-up crops. A legume-containing cover crop mix also releases more nitrogen for the follow-up crops.

In addition, it increases the soil's organic matter content and improves the structure of the soil. Runoff, soil erosion and deep drainage will decrease, as the grazing of diverse cover crops usually offers better cover than in the case of aggressive conventional tillage. "Many of the annual cover crop species and perennial pastures have deep root systems that can utilise nutrients and water deep in the soil," he says.

Weed management is improved by allowing livestock to graze on them. It limits the establishment of weed seeds, and depletes the seed bank of some weeds. "Conservation agriculture can also reduce pest and disease pressure by 'pushing' and 'pulling' these pests out of a field. Livestock integration enhances the positive effect of biodiversity on these fields."

Conservation systems

In a study conducted on two farms near Vrede in the Eastern Free State, in which both Drs Du Preez and Smith were involved, the conservation plots contained soil that was healthy and not degraded. The opposite was true for the conventional plots.

The study confirmed that conservation systems offer several valuable advantages that translates into a real rand-and-cent value for the producer.

The study substantiates the beneficial effects of conservation agriculture, including improved pest control, circulation of nitrogen and other nutrients in the soil, build-up of carbon levels, improved water infiltration into the soil, and the elimination of soil erosion.

Three systems were measured: a negative reference (conventional system), a positive reference (natural veld grazing system), and three conservation systems that were switched from conventional to conservation systems more than seven years ago.

Different plots on the fields were set aside in order to obtain the necessary measurements. All systems (conventional, natural, conservation) had the same sized plots, making measurements comparable. Ecological nematode indices based on beneficial nematodes (such as bacterivores and predators) were calculated to determine how healthy the soil is and how well the ecosystems are functioning.

Nematodes and structure index

Dr Du Preez explains that, unlike root-knot and lesion nematodes which are pests, the majority of nematodes in a natural ecosystem are beneficial and provide a valuable service to the environment. Beneficial nematodes also suppress various pests and diseases.

Two ecological nematode indices were calculated, namely the enrichment index and the structure index. The enrichment index indicates the degree of enrichment (nutrients) present in the soil's ecosystem. This goes hand in hand with nitrogen enrichment.

The structure index refers to the health of the food web in which the natural flow of energy takes place. If disturbances such as the physical disturbance of soil were to break the chain in the food web, it is measured against this index.

A low soil structure (below 50) is indicative of a poorly functioning, unhealthy food web. A score above 50 is indicative of a healthy, functioning food web that facilitates the efficient flow of energy through the system.

The average value of each plot in terms of structure and enrichment was measured (*Figure 1*).

Results from the study

The conventional system had a structural and enrichment value of around 40. This indicates that the soil's ecosystem, due to low nutrient levels, was degraded (unhealthy) and relatively depleted. Dr Du Preez says they expected this outcome, as conventional systems typically show signs of soil disturbance, which can be attributed to physical disturbance and the indiscriminate use of inorganic chemicals.

The natural veld grazing system proved to be a healthy, functional and fertile system. Sufficient nutrients were available to the plants as the impact of humans and animals was minimal.

All three conservation systems' structural indices exhibited values above 50. One system had a mature ecosystem with rich, fertile soil, while the other two conservation systems showed that they were maturing and had good, fertile soil. SF

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