CONSERVATION AGRICULTURE

Promoting climate smart intensification of winter grain production while improving soil health in the Western Cape.
CONSERVATION AGRICULTURE IS AN IMPORTANT STEP TOWARDS THE OPTIMAL USE OF NATURAL RESOURCES AND TOWARDS A PROACTIVE RESPONSE TO CLIMATE CHANGE IN THE AGRICULTURAL SECTOR.
SUMMARY

Conventional winter grain production is heavily reliant on practices such as regular tillage, monoculture and the application of external inputs (e.g. agro-chemicals). These practices cause soil degradation through soil erosion as well as carbon and nutrient depletion. Studies have shown that this conventional system will in the near future become uneconomical and ecologically unviable. The reasons are quite clear: firstly, productive land will be unable to produce more food on a weakened natural resource base. Secondly, escalating input costs, particularly for diesel and agro-chemicals, place enormous pressure on the profit margins of farmers.

The situation is even more concerning when climatic risks, in particular future climate change, are taken into account. Climate change projections for the Western Cape suggest that we will experience continued warming (e.g. more hotter days). Projections also suggest changes in the quantity, intensity and distribution patterns of rainfall – for example, failure of sufficient autumn rain, higher frequency of heavy rainfall and flooding, a higher frequency of heavy, or late spring rainfall. The resulting heat and water stress will have a negative impact on yield and on the quality of grain. Due to increased temperatures and changing rainfall patterns, it is also expected that the prevalence and damage caused by pests and diseases will increase. Hence, the combination of conventional agriculture and climate change create a real threat to the productivity and profitability of the Western Cape winter grain sector and to national food security.

Conservation agriculture (CA) offers an alternative system which allows for agricultural intensification while improving soil health. CA builds on three cornerstones:
1. Minimal mechanical disturbance of the soil (no-till and zero-till);
2. Maximum diversity in crops grown, including cover crops and rotations;
3. Year-round organic cover on the soil, either with living plants or with plant residues.

CA has been identified as an important climate change adaptation response that may decrease the impacts of changes in temperature and rainfall on yields by improving soil water retention and soil fertility. CA practices also emit less carbon dioxide and sequestrate more carbon in the soil. The former is achieved through the reduced use of fossil fuels (needed for fertilising and ploughing), the latter through increasing organic soil cover and organic carbon content. CA therefore can be seen as a climate change response strategy with significant adaptation and mitigation potential.

CA has been adopted in the Western Cape for the sustainable production of rainfed grain and other field crops, but the underlying principles of sound integrated management of natural resources for the long-term sustainability of production apply equally to orchards and potato farming, with context-specific adjustments. The Rooibos sector has also shown great interest in integrating CA into their farming practices. In response to the rising interest from other commodities, the WCDoA has started to carry out CA research for potatoes and rooibos.
THE KEY OBJECTIVE OF CONSERVATION AGRICULTURE IS TO MAINTAIN A HEALTHY SOIL THROUGH MINIMUM MECHANICAL SOIL DISTURBANCE, PERMANENT ORGANIC SOIL COVER AND DIVERSIFICATION OF COVER CROP SPECIES.
TYPE OF CLIMATE CHANGE RESPONSE
Adaptation: Land use practice
Mitigation: Reduction in greenhouse gas emissions, soil carbon sequestration

COMMODITIES
Winter produced field crops

REGION
All field crop production areas in particular Swartland and Overberg, but also Sandveld, Southern Cape and Little Karoo

CLIMATE RISKS
Variability in rainfall, heavier rainfall, dry spells

TYPES OF FARMING SYSTEMS
Commercial farmer | Small-holder must be promoted

LEAD ORGANIZATION
Western Cape Department of Agriculture

PARTNERS / SERVICE PROVIDERS
• Grain SA
• Winter Cereal Trust
• CA Association Western Cape (CAWC)

COST
Annual cost: Trials R 500 000 | Research staff R700 000 and equipment R2 000 000
Cost for Farmers: High upfront investment e.g. R 800 000 (minimum) for a CA planter
Projected Payback time: Approximately 5 years

FUNDED BY
• Western Cape Department of Agriculture
• Winter Cereal Trust
CA is a farming approach that is based on agro-ecological principles directed at improving crop management in a sustainable manner. It originated from the practice of no-till and now incorporates crop rotation and the importance of residue cover. The key objective of CA is to maintain a healthy soil through minimum mechanical soil disturbance, permanent organic soil cover and through diversification of cover crop species grown in sequence and/or associations.

It is important to note that CA practices are used in diverse agro-ecological and socio-economic environments, and are highly variable. The simultaneous application of the three CA principles outlined above is not easily achieved. To successfully implement the principles requires CA equipment and farming practices that are developed to be most suitable for the specific locality or region and its biophysical characteristics. Hence, there is a strong need for long term, locally specific research and practical application that builds on learning by doing. For example, in the Western Cape residue cover can sometimes create problems as it can become so thick that tine planters cannot effectively penetrate the soil. CA also demands an understanding, sensitive management of the potentially disruptive nature of systemic changes and unintended consequences for certain elements of the system during the transition towards CA. Farmers that are shifting towards CA will, for example, have to adapt to a new approach for weed and pest management.

To make CA more applicable to the farming conditions of the Western Cape, the Western Cape Department of Agriculture has set up two long term trials that allow for collaborative research efforts on no-till, crop rotation, residue management and an integrated animal factor on the sustainability of a production system.

The first long term trial was started in 1996 and a second trial in 2002. To accommodate the regional differences in soil and climate, three research sites were set up in the Overberg and one in the Swartland.

**Overberg sites:**
- Swellendam: long rotation systems consisting of 5 years of lucerne pasture followed by a 5 year cash crop sequence;
- Riviersonderend: short rotation systems consisting of 3 and 4 year annual pasture and cash crop sequences, and two pure cash crop systems; and
- Riversdale: continuous cropping systems including cover crops and the use of zero-till;

**Swartland site:**
- Langgewens: cash crop systems and cash crop/pasture systems.
More recently, the Western Cape CA Association (CAWC) has been launched. CAWC is a forum where researchers and farmers can share knowledge and discuss context specific issues. The main aim is to get producers, industry, researchers and government working collaboratively to strengthen the adaptation and further advancement of CA practices in the Western Cape. The CAWC has currently 185 paying members. CAWC annually conducts three green tours (focusing on growing crops) and three brown tours (focusing on stubble retention and soil profiles) in different grain producing regions of the Western Cape. Monthly newsletters are sent out to inform readers on upcoming events or to highlight recent research outputs and success stories. CAWC has held three conservation symposia with international CA experts. Field days, which are part of the symposia, provide the opportunity to see CA at work and to interact with leading researchers in the CA field.

THE SCIENCE BEHIND CONSERVATION AGRICULTURE

Figure 1 shows the continuum of CA practices and illustrates that CA allows for a gradual, step-wise implementation. This makes the transition to a new farming system less disruptive.

![Figure 1: Overview of transition stages from conventional agriculture (Stage 1) to low-input organic CA (stage 7) Adapted from Blignaut et al. (2015).](image-url)

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<tr>
<th>STAGE</th>
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<tbody>
<tr>
<td>Conv. tillage</td>
<td>Min/ reduced tillage</td>
<td>Conv. no tillage (NT)</td>
<td>Conv. zero tillage (ZT)</td>
<td>CA_{HEI}</td>
<td>CA_{LEI}</td>
<td>Organic CA</td>
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<tr>
<td>Type of farming system</td>
<td>(Direct seeding equipment using tines) Production system lacks adequate soil cover and sound crop rotations. High use of external inputs</td>
<td>(Direct seeding equipment using discs) Production system lacks adequate soil cover and sound crop rotations. High use of external inputs</td>
<td>(NT or ZT using high quantities of external artificial inputs (i.e. fertilizer, herbicides, pesticides). Production system has adequate soil cover and sound crop rotations. High use of external inputs</td>
<td>(NT or ZT using low quantities of external artificial inputs (i.e. fertilizer, herbicides, pesticides). Production system has adequate soil cover and sound crop rotations. High use of external inputs</td>
<td>(NT or ZT using no quantities of external artificial inputs (i.e. fertilizer, herbicides, pesticides). Production system has adequate soil cover and sound crop rotations.</td>
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**SUSTAINABILITY GRADIENT**
1. **Minimal disturbance of the soil (no-till);**
Minimum disturbance of the soil can be achieved by using planters that apply techniques such as direct-seeding, and disc-drilling. No-till refers to the sowing of seeds into soil that has not been previously tilled in any way to form a seedbed. No-till practices help to retain moisture and carbon in the soil. They also ensure that the habitat of micro-organisms in the soil remains intact.

2. **Maximum diversity in crops grown, including cover crops;**
Maximum diversity in crops and the rotation of crops enhances the biodiversity on top of the soil and below. Furthermore, by promoting plant diversity CA increases biological regulation functions. The use of multi-species cover crops can improve the biodiversity within current systems, resulting in improved soil health. Healthy soils in turn have improved water holding capacity and water infiltration, and a richer microbial life, all leading to improved plant health. Increasing the diversity in crops allows also for the spreading of financial risk.

3. **Maximum cover on the soil, either with living plants or with plant residues.**
Maximum organic cover on top of the soil protects the soil against sun and rain. It keeps the soil cooler in summer and warmer in winter, provides nutrients for soil organisms that help sequestrate carbon, and builds soil structure leading to better soil fertility. For every 1% of added carbon to the soil, the water-holding capacity of that soil doubles. In addition to enhancing water infiltration, residual cover of the soil can also reduce soil erosion.
75 to 80% of grain farmers in the Western Cape are undertaking CA practices. However, the extent to which these farmers embrace the CA principles varies. Many farmers have converted to reduced or no-till (Stage 2 to 4 in Figure 1). According to Dr Johann Strauss, senior researcher and CA expert at Western Cape Department of Agriculture, 90% of the grain farmers in the Province practice no-till, 90% do crop rotation and about 65% maintain soil cover. This can be seen as a first step in a phased approach towards lower external input CA. Farmers in the Southern Cape have a slightly higher adoption rate than farmers from the Swartland.

The strong research base driven by the Western Cape Department of Agriculture has been instrumental in encouraging farmers to adopt the CA approach. The long term no-till crop rotation trials conducted by Western Cape Department of Agriculture have shown not only lower inputs, but also higher and more stable production in, for instance, wheat. Productivity is primarily improved through the improvement of soil health. Increased soil moisture retention, decreased soil temperature, increased micro-organisms and decreased compaction all contribute to better soil health.

Studies conducted by the Western Cape Department of Agriculture and the Agricultural Research Council (ARC) on a range of wheat farms have also shown that it is significantly cheaper to produce wheat under CA than under conventional farming techniques. Other benefits that became evident through the long term trials and other studies are, for example, the reduced erosion and environmental degradation as well as improved carbon content (organic material) in the soil.

Despite this positive evidence of the benefits provided by CA, there are several reasons why some farmers do not make the shift towards CA and why some farmers will revert back to conventional grain farming. CA is very knowledge intensive and requires patience, as the benefits will only start surfacing in the longer-term. This is particularly true for the Western Cape, where soil conditions are poor as a consequence of past management practices and natural conditions. Hence, the soil first needs to gain better organic matter and the mulch needs to build up. Farmers should therefore not expect soil fertility to re-establish very quickly. Another reason for the reluctance to switch to CA is the high upfront investment for purchasing CA equipment such as a new planter. In addition, it is important to note that CA needs to be complemented by other known good practices, such as integrated pest, nutrient, weed and water management.
From a climate change perspective, CA has the potential to reduce the impacts of existing and projected climate risks. Reduction in soil erosion, increased soil water retention and reduced soil surface temperature makes the CA system more resilient to variability of rainfall, heat stress and extreme climatic events. The beneficial effects of CA practices on improved soil moisture retention and reductions in runoff are especially striking during years of lower than average rainfall and drought. Previous experiences in the Western Cape have shown that while in a good year yields differences between conventional and CA are very similar, in a bad year (i.e. with unfavourable climate conditions) farmers practicing CA have a much better yield. The impacts of heavier rainfall such as erosion are also minimized due to better water infiltration into the soil. For example, 2015’s exceptionally late start to the rainfall season in the Swartland, as well as almost negligible rainfall in August and September, would normally (i.e. under conventional practices and low residue cover) have meant very low or even no yield at all. No-till planters can be used to dry seed crops before the first rains, which can contribute to a quicker take off of the crops, but in the 2015 season the residue cover played a significant role in conserving the available moisture over a longer period. This led to producers still being able to harvest. While CA is not a silver bullet (i.e. no system can produce a crop without water), CA helps to improve the chances of a harvest in dryer seasons.

More information is needed to understand the effect of CA on soil carbon sequestration, as a long-term climate change mitigation opportunity. But local and international studies are starting to provide a more accurate picture of the sequestration potential of particular CA practices in specific regions. A recent analysis of field cropping systems in the Eastern Free State, for example, provides evidence that CA practices are leading to the sequestration of organic carbon in the soil in the study area.

A recent modeling study for four maize production regions of South Africa over a 20-year period shows a significant potential for total net CO\textsubscript{2} equivalent (CO\textsubscript{2}e) emission reductions. The study showed reductions of between 1.3 and 13.6 tons CO\textsubscript{2}e/ha/year under a CA-friendly production system. The long term mitigation strategy for the Western Cape, developed by the Western Cape Department of Environmental Affairs and Development Planning, lists CA as a core mitigation strategy for the agricultural sector.

Furthermore, greenhouse gas emissions are reduced through the significant decrease in diesel use by farmers that have adopted no- or zero-till practices. A recent analysis by the ARC (2014) of the impact of CA on wheat production in the Western Cape, noted that no- or zero-till practices used at least 60 % less diesel compared to conventional tillage practices.
In South Africa, the total area under CA is still small compared to areas that use conventional practices. The Western Cape is a province with a high adoption rate with nearly 90% of winter grain farmers having a no-till machine. CA was introduced to the Western Cape by a group of forward thinking farmers led by the late Jack Human and further advanced through the research efforts of the Western Cape Department of Agriculture as well as strong sectoral cooperation, and has become a true success story in the Western Cape. Critical to the high uptake of CA in the winter grain sector has been the provision of empirical evidence by the Western Cape Department of Agriculture through its long term trials, as well as by the CA Association of the Western Cape (CAWC) which has been instrumental in outreach and in fostering strong collaboration between farmers, researchers and government.

Based on the experience of the past two decades and findings from recent studies, the following factors seem to have either enabled or hindered the adoption of CA in the Western Cape:

**ENABLING FACTORS**

- Reduced input cost was a big motivation for farmers to adopt CA
- Availability and affordability of no-till machinery suitable for the rocky and shallow soils in the WC
- Leadership and research by the WCDoA
- The outreach by the CAWC
- Cooperation between farmers, industry, government and researchers

**CHALLENGES**

- Cost of machinery- CA equipment is very capital intensive
- Farmers focus on short term benefits rather than long term benefits
- Farmers are of the opinion that they do not make any money from cover crops.
- Changing the mind-set of farmers to apply and trust a concept that stands in sharp contrast to conventional practices and experiences of previous generations
- The requirement to adopt a new approach to weed management
- CA is a knowledge intensive practice
THE WAY FORWARD

The Western Cape Department of Agriculture will start a new long term research trial in 2016. The new trial will have a strong focus on cover crops and on varied rotation systems. The other two long-term trials will be continued and improved upon. The Western Cape Department of Agriculture is also considering exploring how the establishment of small strips of natural corridors in the research sites will affect soil fertility, crop production and the return of natural predators.

To strengthen its effectiveness and outreach in the future, CAWC plans to identify and work with champions within each production area. It is envisioned that champions become regional contact points and use their farms as a base to show how CA can be used for productivity and environmental sustainability.

RESEARCH NEEDS:

The biggest research needs relate to the tailoring of CA practices to local conditions. The soil in the Western Cape is often shallow and of lower quality (because of previous farming practices and because of natural conditions). This warrants a better understanding of which CA practices are most beneficial in improving the health of the various soil types that make up the Western Cape’s grain producing areas.

Research needs that were expressed by farmers relate to the use of cover crops and which species can be used; the development of alternative inputs such as organic fertilisers; as well as the conditions of the Swartland region. Significant challenges exist in getting funding for PhD and Masters students within the existing trials and in encouraging and financially rewarding farmers to do their own on-farm trials.
RECOMMENDATIONS

The switch to CA should be gradual and based on a learning-by-doing approach (i.e. experimentation with local conditions).

Farmers who want to get involved or learn more should contact the CAWC, speak to other farmers who are using CA and/or look at results from long term trials and additional studies (some reports are listed below).

Appropriate incentives are required for farmers who want to change their crop management to CA. This should be complemented by incentives for farmers who already have made major investments (technological and financial) into CA.

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<th>Incentives for farmers to shift towards CA</th>
<th>Incentives for farmers who have already adopted CA</th>
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<td>• Assistance schemes for the purchase of specialised CA implements, e.g. through: o reducing or lifting import duties o support of the development of local manufacturing capabilities • Development of machinery that is better able to deal with local soil specific challenges (this also has job creation potential) • Providing low or no interest asset finance • Bank guarantees for CA farmers • On-farm support (extension, herbicides)</td>
<td>• Make the proposed carbon tax favorable for CA • A favorable water pricing scheme • Rewards for best practices • Continuous on-farm support • Rewards for on-farm trials and support of CA study groups • Priority consideration for disaster relief • On-farm knowledge support</td>
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On-farm support in the form of training, extension services, access to state-of-the-art knowledge derived from research and practical applications, and the supply of necessary inputs (such as acceptable herbicides) are critical for a successful shift to CA. The shift to CA is followed by a further transition to Low External Input (LEI) CA and ultimately to organic CA (no external inputs). It is furthermore critical that implementation programs, such as LandCare and Farmer Extension & Advisory Services, integrate CA into their programs wherever possible. A great deal of research is still needed to continue to build locally adapted CA systems over the short-, medium- and long-term, and to scale out effectively. The excellent research undertaken by the Western Cape Department of Agriculture needs to be further supported and complemented by investment to establish farmer-led applied research for various scales of farming.
FURTHER INFORMATION:

WESTERN CAPE DEPARTMENT OF AGRICULTURE WEBSITE: www.elsenburg.com
CONSERVATION AGRICULTURE WESTERN CAPE (CAWC): www.blwk.co.za/konta

Western Cape Department of Agriculture:
Dr Johann Strauss
Senior Scientist: Sustainable cropping systems, Directorate Plant Sciences
Phone: 021) 808-5479
Email: JohannSt@elsenburg.com

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Dr Johann Strauss