CONSERVATION AGRICULTURE IN SOUTH AFRICA

PROGRESS, CHALLENGES AND OPPORTUNITIES

Hendrik Smith, CA Facilitator, Grain SA
WHAT ARE THE ‘SIGNALS’ FROM MOTHER EARTH?

WHY DO WE NEED CONSERVATION AGRICULTURE?
Average soil loss under cultivated, annual crops: 13 ton/ha/yr

(Le Roux et al., 2008)
Wind erosion
The State of South Africa’s Biodiversity (SANBI, 2013)

Map legend:
- Critically endangered
- Endangered
- Vulnerable
- Least threatened
Hazardous agricultural chemicals (WRC, 2016 – human health)

Climate Change

Additional Warming Depends on Current Emissions

2015 ESTIMATE

Our Current Path

Extreme Carbon Cuts

NET-NEGATIVE GLOBAL EMISSIONS

1980 2020 2060 2100

3.2-5.4°C >1000 PPM
2.0-3.7°C 720-1000 PPM
1.7-3.2°C 580-720 PPM
0.9-2.3°C 430-480 PPM

Emissions based on billions of tons of CO2 per year from fossil fuels and cement
“The predicted rate of CO₂ production from soil cultivation exceeded the CO₂ from fossil fuels until the 1960s.”

Bohn, 1978

Lal, 2010
46% SOC lost due to cultivation

In: Swanepoel et al. 2016
Carbon sequestration in the terrestrial biosphere is relatively cost-effective and has numerous co-benefits. Technological options have been widely proven, and are immediately available for wide-scale applications in diverse eco-regions. It is important to identify policies that promote the adoption of appropriate technologies by land managers in developed and developing countries. (Pg, billions metric tons C.)
Objective: to improve soil health (rehabilitate degraded soils)

To initiate No-tillage on a dead soil, which is low in organic matter as well as low in micro- and macrobiological activity, will lead to lower yields than in conventional tillage systems.
Carbon Footprint
Case study: Western Cape Grain Industry

**Boundary Start**

1. **Farm / Crop Details**
   - Hectares
   - Ton Grain
   - Etc.

2. **Electricity**
   - Eskom / Grid
   - Renewable

3. **Direct / Indirect Fuel**
   - Diesel
   - Petrol
   - Etc.

4. **Fertiliser & Agro-Chem**
   - Pure N, P & K
   - Compost
   - Lime
   - Pesticides
   - Etc.

5. **Land Use Change**
   - Virgin land clearing

**Boundary End**

1. **Crop Residues**
   - Residue carbon stocks

- CO2
- Other GHG’s
- CO2 N2O
Western Cape Results: Current scenario, hotspots

- Fertilisers 70.6%
- Lime 13.0%
- Agro-chemicals 1.1%
- Diesel 9.3%
- Crop residues 6.0%

Bar chart: Current scenario inputs per ha
- Crop residues
- Diesel
- Agro-chemicals
- Lime
- Fertilisers
Western Cape Results: Carbon Footprint, Future ideal CA scenario

- Significant decline in GHG emissions from current to future CA farming regimes in Wintergrain region.

36% decline
“Despite policies originating from the 1992 Rio Earth Summit, the state of the global environment has continued to deteriorate.” (Howes et al., 2017)
SOME KEY ISSUES AROUND THE PRINCIPLES
Principles

- Minimum soil disturbance
- Diversity, including plants/crops and animals
- Permanent organic soil cover — Mulching
- Maximise living roots

- Integrated soil fertility and acidity management
- Integrated weed management
- Integrated pest and disease management
- Integration of animals

It creates consciousness of how nature works and how to mimic it.
95 per cent of terrestrial diversity is within the soil itself.

Awareness and Recognition of soil as a vital living ecosystem that sustains plants, animals and humans.
Minimum mechanical soil disturbance:

The downward spiral of soil degradation (in cropland)

Every time you plough the soil is aerated and the microbial activity spikes with the resultant break down of SOM, releasing CO$_2$ and NH$_3$ into the atmosphere with the loss of SOC and organic N.

Every time you plough the soil critical amounts of soil water is lost through evaporation.
Direct planting in crop residues
Good germination on good crop residue cover
Permanent organic soil cover

Functions:
- *Protects and improves* soil
- *Food for* micro-organisms
- Control soil *temperature*
- Suppresses *weeds*
- Improves soil *water* balance
Soil erosion dramatically decreases with increasing surface cover. *Note:* FP = fall plough, FC = fall chisel, NT = no-till; circles = corn, no circles = soybeans.

Generation of adequate biomass (>6 t/ha/yr dry matter) is crucial.

This figure shows that:
- surface residue reduces erosion,
- reduced tillage (chisel and no-till) leaves more residue and results in less erosion than plowing, and
- corn (circled) returns more residue than soybeans.
North West Province, South Africa

Sunflower - Sunflower

Summer cover crops
Diversified cropping

Main functions of crop rotations and associations:
- Provide quantity and quality (diversity) of biomass (dry matter, shading or ground cover) for weed, pest and erosion control
- Produce a positive residual fertilizer effect on following cash crops
- Provide food and fodder
- Positive impact on biodiversity
- Diversity of food sources for microorganisms

Diversified cropping takes over the role of ploughing, fertilisers, pesticides & herbicides.
Crop rotation

- At least 3 crops!
Intercropping

- Achieving diversity in row-crops
- Planting alternating rows of maize and beans, or growing a cover crop in between the cereal rows.
- This means growing two or more crops in the same field at the same time.
Intercropping

- Mixed intercropping
- Row intercropping
- Strip cropping
- Delayed or relay cropping
Intercropping – examples in SA
## COVER CROP OPTIONS

<table>
<thead>
<tr>
<th></th>
<th>Seed Name</th>
<th>Variety</th>
<th>Planting Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Black oats; Hawer (swart); Avena strigosa</td>
<td>(70kg/ha)</td>
<td>Nov – Dec after rain</td>
</tr>
<tr>
<td>2</td>
<td>Oats; Hawer; Avena sativa</td>
<td>(70kg/ha)</td>
<td>Mid Feb after rain event</td>
</tr>
<tr>
<td>3</td>
<td>Rye; Rog; Secale cereal</td>
<td>(70kg/ha)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Radish; Radys; Raphanus sativus</td>
<td>(5-6kg/ha)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Korog; Triticale hexaploied</td>
<td>(70kg/ha)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Grazing vetches; Weiwieke; Vicia dasycarpa</td>
<td>(25kg/ha)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mixture (V. dasycarpa + A. strigosa + R. sativus)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Dolichos; Slingerboon; Lab-lab purpereus</td>
<td>(25kg/ha)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Mays; Mielies; Zea mays; high density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Cowpea; Akkerboon; Vicna unguiculata</td>
<td>(70kg/ha)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Velvetbean; Fluweelboon; Mucuna pruriens</td>
<td>(70kg/ha)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Sunflower Sonneblom; Helianthus annuus</td>
<td>(25kg/ha high density)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Sorghum; Sorghum bicolor</td>
<td>(25kg/ha high density)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Pearl millet; Babala; Pennisetum glaucum</td>
<td>(25kg/ha high density)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Soybean; Soyaboon; Glycine max</td>
<td>(25kg/ha high density)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Mixture (S. bicolor + L. purpereus + C. juncea)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Sunhennop; Sonhennop; Crotalaria juncea</td>
<td>(50kg/ha)</td>
<td></td>
</tr>
</tbody>
</table>
Multi-specie (9) Cover Crops – warm season
(Water table sandy soils, Kroonstad, Jan 2016)
Multi-specie (4) Cover Crops – cool season
(Clay soils, Vrede, Free State)
Smallholders - high density intercropping systems
Cover Crops – management and integration with local systems

**Large seeds:**
- Dolichos
- Cowpea
- Maize
- Soya

**Small seeds:**
- Sunhennop
- Millet
- Forage sorghum
- Canola
- Radish
- Grazing vetch
Cover Crops – management and integration with local systems
Integrating livestock into crop systems

The goal is to mimic natural grazing systems (in which wild grazers move in large herds) that will improve soil function.
Example: Diverse Crop-Livestock System

Quality application of ALL CA principles

High value fodder → highly productive livestock

Sustainable, regenerative, profitable crop-livestock systems

Profitability

Risk

C-sequestration & biodiversity

Maize + WCC

Maize + WCC

Soya + WCC

SCC + WCC

Soya + WCC

Maize + WCC

Maize + WCC

Soya + WCC

SCC + WCC

Soya + WCC

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Maize + WCC

Maize + WCC

Soya + WCC

SCC + WCC

Soya + WCC
Global Maize Input Costs (BFAP, 2017)

US$ per ton maize produced

- Seeds
- Nitrogen
- Phosphorus
- Pesticides
- Contractor
- Crop Insurance
- Diesel
- Total establishment cost

International sample average
Real agricultural prices declining (BFAP, 2017)
A modelling case study showed a very large monetary benefit of adopting commercial CA systems, illustrating improved viability of maize production, as a result of cost reduction owing to lower input use, increases in yields, less emission into the environment and carbon sequestration. From De Wit et al. (2015)
CA trial results in South Africa

...supporting international data
Commercial farming Treatments:

- Crop density (pop & row width)
- Rotations
- Tine vs Disc
- Cultivars
- Cover crops
- Livestock integration

Up to 16 on-farm trial sites per project
Crop diversity and livestock integration

Positive impact on soil health

Effective management of weeds, pests and diseases

Mitigate and adapt to climate change

Positive impact on biodiversity

High water use efficiency

Higher, stable yields and profitability

High net C-sequestration rate
Comparison between local and Argentinian row widths and plant population densities

Plant density effect on yields

Lower
- Less crop residues
- Less roots
- More weeds

Higher
- Quicker build-up of mulch
- More roots
- Less weeds

Cultivar choices
Smallholder Trials - Treatments (KwaZulu-Natal & Eastern Cape):

- Crops and Cultivars
- Rotations
- Cover crops
- Intercropping
- Implements
- Agro-chemicals
### Trial summaries over 4 seasons: Bergville and Matatiele

<table>
<thead>
<tr>
<th>Smallholder Trial summaries - 4 seasons</th>
<th>Bergville</th>
<th>EC, SKZN</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of villages</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>No of trial participants</td>
<td>28</td>
<td>83</td>
</tr>
<tr>
<td>Area planted (trials) - ha</td>
<td>2.8</td>
<td>7.2</td>
</tr>
<tr>
<td>Average yield maize (t/ha)</td>
<td>3.74</td>
<td>3.63</td>
</tr>
<tr>
<td>Min and max yield maize (t/ha)</td>
<td>2-4.3</td>
<td>1-6.7</td>
</tr>
<tr>
<td>Actual amount of maize pp</td>
<td>233kg</td>
<td>576kg</td>
</tr>
<tr>
<td>Rand replacement value (maizemeal)</td>
<td>R 1 600</td>
<td>R 4 500</td>
</tr>
<tr>
<td>Average yield beans (t/ha)</td>
<td>1.24</td>
<td>0.26</td>
</tr>
</tbody>
</table>
Bergville - Case study

- 3-4 years: Reduced need for herbicide - no spraying on trial plots this season
- Increased soil organic matter, reduced fertilizer requirements - No basal fertilizer applied - only top dressing
- Reduced runoff and erosion
- Increased yields and diversity
Scaling up of farming operation (smallholders)

Area of their land used: from > 0.1 ha to 1-2.5 ha

Commercial smallholders in loose value chains

Scaling up of farming operation through CA

Semi commercial smallholders

Non commercial smallholders

Area of their land used: from > 0.1 ha to 1-2.5 ha
Soil Structure
Soil porosity
Soil colour
Number and colour of soil mottles
Earthworm counts and other soil fauna
Soil cover at planting
Crop cover at 6-8 weeks
Soil depth
Run-off and erosion
Micro-organisms
Roots

Start to analyse your soil's BIOLOGY

Use appropriate indicators
Not only YIELD, but also Profitability, nutrition, biodiversity, etc.
A REVIEW OF CONSERVATION AGRICULTURE RESEARCH IN SOUTH AFRICA

Number of CA research outputs
(not popular publications)

Trends in the number of CA research outputs over time (not popular publications)

Distribution of research sites in South Africa


Bubble size indicates effort where the larger bubbles represent more outputs per site.
CA ADOPTION – ARE WE APPLYING ALL THE PRINCIPLES?
# Percentage Adoption by Province

<table>
<thead>
<tr>
<th>Province</th>
<th>No-Till Planter</th>
<th>CA (2 crops)</th>
<th>CA (3 crops)</th>
<th>CA - 2 crops &amp; No-till</th>
<th>CA - 3 crops &amp; No-till</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free State</td>
<td>23.4%</td>
<td>24.8%</td>
<td>11.7%</td>
<td>8.0%</td>
<td>6.6%</td>
</tr>
<tr>
<td>Western Cape</td>
<td>75.7%</td>
<td>41.7%</td>
<td>29.1%</td>
<td>35.9%</td>
<td>27.2%</td>
</tr>
<tr>
<td>North West</td>
<td>35.5%</td>
<td>24.2%</td>
<td>6.5%</td>
<td>16.1%</td>
<td>4.8%</td>
</tr>
<tr>
<td>Mpumalanga</td>
<td>57.1%</td>
<td>51.4%</td>
<td>2.9%</td>
<td>37.1%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Northern Cape</td>
<td>31.6%</td>
<td>15.8%</td>
<td>10.5%</td>
<td>10.5%</td>
<td>5.3%</td>
</tr>
<tr>
<td>KwaZulu-Natal</td>
<td>75.0%</td>
<td>66.7%</td>
<td>16.7%</td>
<td>50.0%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Limpopo</td>
<td>37.5%</td>
<td>37.5%</td>
<td>12.5%</td>
<td>25.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Gauteng</td>
<td>100.0%</td>
<td>66.7%</td>
<td>0.0%</td>
<td>66.7%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Eastern Cape</td>
<td>100.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

Findlater, 2015
## Grain Farming Systems Typology in SA
*(from Blignaut et al., 2015)*

<table>
<thead>
<tr>
<th>Type of farming system</th>
<th>Conv. tillage</th>
<th>Min. or reduced tillage</th>
<th>Conv. no tillage (NT)</th>
<th>Conv. zero tillage (ZT)</th>
<th>CA(_{HEI})</th>
<th>CA(_{LEI})</th>
<th>Organic CA</th>
</tr>
</thead>
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<tr>
<td><strong>Sustainability gradient</strong></td>
<td>Grain Farming Systems Typology in SA</td>
<td><strong>Reduction degradation &amp; CA</strong></td>
<td><strong>500% increase Ecosystem services; 120% yield effectiveness</strong></td>
<td><strong>&lt;10% risks; 300% + reliability</strong></td>
<td><strong>60% adoption</strong></td>
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- **Conv. tillage**: Conventional tillage
- **Min. or reduced tillage**: Minimum or reduced tillage
- **Conv. no tillage (NT)**: Conventional no tillage
- **Conv. zero tillage (ZT)**: Conventional zero tillage
- **CA\(_{HEI}\)**: Conservation Agriculture with High External Inputs
- **CA\(_{LEI}\)**: Conservation Agriculture with Low External Inputs
- **Organic CA**: Organic Conservation Agriculture

- **89% adoption**
- **Reduction degradation & CA**

- **Soil C-sequestration; 500% increase Ecosystem services; 120% yield effectiveness**
- **<10% risks; 300% + reliability**

- **Production system lacks adequate soil cover and sound crop rotations.**
- **High use of external inputs**
- **Production system has adequate soil cover and sound crop rotations.**
- **Low quantities of external artificial inputs (i.e. fertilizer, herbicides, pesticides).**
- **Production system has adequate soil cover and sound crop rotations.**
CA IMPLEMENTATION – FROM GOAL TO IMPACT
CA is driven by innovative farmers and groups

Gabe Brown, ND

Anth Muirhead, KZN

Hannes Otto, NWP

Mphumelele Hlongwane- Bergville

Izak Dreyer, Vrede

Jack Human, WC

Hlongwane & Madondo, KZN

Danie Slabbert, Reitz
Agricultural Innovation System
The overall goal is the **mainstreaming** of Conservation Agriculture to and through farmers to ensure, sustain and improve national and household food security and income. (to ALL grain producers)
New Farmer-centered CA
Innovation Systems Research areas

Maize and wheat production areas
- Minor
- Major
- Study sites
Facilitate continuous learning and adaptation

Use every opportunity to maximise interaction and learning WITH farmers and stakeholders

Innovation Platforms
CA Policy Development: FAO – DAFF – ARC
POLICY OPTIONS [MEASURES PROMOTING CA USE]

Creating awareness
Resource allocation
Providing incentives
Communication
Capacity building
Investing in Research
Partnerships
Monitoring and evaluation
CONCLUSIONS AND RECOMMENDATIONS
Limited research on:

- Soil cover
- Cover crops
- Soil biology
- Soil water
- Livestock integration
- Economics
- GHG emissions (C-footprint)
- Value adding with regenerative / CA certification
Research and Development needed ...

... to accelerate CA mainstreaming and adoption

- in various agro-ecological zones, which needs to
- focus on immediate impacts, but
- with a long-term view of
- continuous adaptation of CA principles
- in local farming conditions
- through systems research approaches
- either through farmer-led, or on-station trials
- Creating and enabling environment i.e. Policies (incentives)
Need to rigorously and continuously investigate & improve CA systems, e.g. more diversification

“Green Wall”

... to mitigate and adapt against land degradation, desertification and climate change
“I invite everyone here to swallow the alarm clock!”

Christiana Figueres, former executive secretary of the UN FCCC, under whom the Paris agreement was signed

“More than ever our wellbeing, climate, and future lies in our soils, and in your hands”

Walter Jehne
THANK YOU

Grain SA Conservation Agriculture
http://www.grainsa.co.za/grain-research/conservation-agriculture
Hendrik.smith@grainsa.co.za