Key areas of conservation agriculture research in South Africa

Researchers from the ARC and North-West University, Potchefstroom and the Co-ordinator of the Maize Trust discussed Conservation Agriculture research at the meeting held on 31 August 2011, and the following key areas of CA research and their rationale were discussed. Subsequently, inputs from CA Farmers, Andre de Villiers, Mpumalanga, Hannes Otto and attendees at the KZN No-Till club conference at Drakensville, on 6 & 7 September 2011, were incorporated in the document. Substantial consultation occurred between researchers representing the various institutions and disciplines involved in Conservation Agriculture research. The inputs of experts from Argentina where CA is successfully implemented were included in this document. These key areas, as accepted by the Maize Forum should provide additional direction to the funding of research and be conducive to collaborative research between South African scientists. The research for conservation agriculture will be focused on those areas that can make a practical contribution and application in various areas. Results need to ensure sustainability and a tool for farmers to apply in the fields.

Conservation Agriculture is best achieved through community driven development processes whereby local communities and farmer associations identify and implement the best options for CA in their location.

Local, regional and national farmer associations, working through community workshops, farmer-to-farmer training, sharing experience, and with technical backing from conservation professionals, are the main players in the promotion of CA.

1. **Equipment for conservation agriculture. Development and availability of equipment and practices that will allow good germination of the crop while, at the same time, minimizing soil disturbance and sowing the seed and banded fertilizer into loose and anchored stubbles in the various production areas.**

Farmers in areas other than those of the No-Till Club in KwaZulu Natal, have practical problems with traditional planters. The transition from traditional planters to no-till planters is still to be investigated. This will be a challenge in the sandy soils.

Farmers have to make a paradigm shift from mechanization by planting in a well prepared seedbed to planting in an undisturbed surface covered with organic material residues from the previous crop.

Direct seeding involves growing crops without mechanical seedbed preparation and with minimal soil disturbance from the harvest of the previous crop. The equipment penetrates the soil cover, opens a seeding slot and places the seed into that slot. The size of the seed slot and the associated movement of soil are to be kept to the absolute minimum. Ideally the seed slot is completely covered by mulch again after seeding and no loose soil should be visible on the surface.

Land preparation for seeding or planting under no-tillage involves slashing or rolling the weeds, previous crop residues or cover crops; or spraying herbicides for weed control, and seeding directly through the mulch. Crop residues are retained either completely or to a suitable amount to guarantee the complete soil cover, and fertilizer and amendments are either broadcast on the soil surface or applied during seeding.

The top cover of organic material can be blown by the wind in clustered heaps and this is a practical problem that needs investigation.

2. Investigating effective soil covering in an 18 months fallow system. The residue of the previous crop has normally decomposed by the time the next planting takes place, leaving the soil bare.

A permanent soil cover is important to protect the soil against the effects of exposure to rain and sun; to provide the micro and macro organisms in the soil with a constant supply of "food"; and alter the microclimate in the soil for optimal growth and development of soil organisms, including plant roots.

Means and practices:

- Use of appropriate/improved seeds for high yields as well as high residue production and good root development.
- Integrated management and reduced competition with livestock or other uses e.g. through increased forage and fodder crops in the rotation.
- Use of various cover crops, especially multi-purpose crops, such as replenishing nitrogen, soil-porosity-restoring, pest repellent, etc.
- Optimization of crop rotations in spatial, timing and economic terms.

3. Crop rotation. Efficient profitable crops available in all production areas.

Rotating crops will have to be identified for each homogeneous area and genetic improvement programs implemented.

The rotation of crops is not only necessary to offer a diverse "diet" to the soil micro organisms, but as they root at different soil depths, they are capable of exploring different soil layers for nutrients. Nutrients that have been leached to deeper layers and that are no longer available for the commercial crop, can be "recycled" by the crops in rotation. In this way the rotation crops function as biological pumps. Furthermore, a diversity of crops in rotation leads to a diverse soil flora and fauna, as the roots excrete different organic substances that attract different types of bacteria and fungi, which in turn, play an important role in the transformation of these substances into plant available nutrients. Crop rotation also has an important phytosanitary function as it prevents the carryover of crop-specific pests and diseases from one crop to the next via crop residues.

4. Cover Crops. Intercropping and application in semi-arid areas of the western production areas.

While commercial crops have a market value, cover crops are mainly grown for their effect on soil fertility or as livestock fodder. In regions where smaller amounts of biomass are produced, such as semi-arid regions or areas of eroded and degraded soils, cover crops are beneficial as they:

- Protect the soil during fallow periods. Protecting the soil, when it does not have a crop.
- Mobilize and recycle nutrients.
- Improve the soil structure and break compacted layers and hard pans.
- Permit a rotation in a monoculture.
- Can be used to control weeds and pests.
- "Targeted" use of herbicides for controlling cover crop and weed development. Rye is used in Argentina as a successful cover crop and can be killed through herbicide just before the reproductive phase and the upright carcasses of the plants left untouched to protect the soil against wind erosion. Oats as a cover crop has a negative allelopathic effect on the next crop.

Cover crops are grown during fallow periods, between harvest and planting of commercial crops, utilizing the residual soil moisture. Their growth is interrupted either before the next crop is sown, or after sowing the next crop, but before competition between the two crops starts. Cover crops energize crop production, but they also present some challenges.

The incorporation of cover crops will be a challenge for the central and western summer rainfall areas in South Africa. The main objective is to conserve ample moisture in the fall to suit the soil profile. Planting a cover crop on the fields will reduce the available plant moisture for the next crop. This will be an area for research.

5. Pest and disease balance. Soil healthiness and composition of soil micro organisms.

When conservation agriculture is practised correctly, pest and disease incidence will be lower compared to conventional tillage due to crop rotation and the use of cover crops. Consequently, the cost for treatment will also be reduced.

It was observed during the past favourable climatic conditions that yield losses occurred in maize due to severe lodging and pathogen build-up. The causes of the imbalance in soil microbe compound need to be investigated.

Integrated pest management (IPM) should also be added to the CA set of recommendations, since if one of the requirements is to promote soil biological activity, minimal use of toxic pesticides and use of alternative pest and weed control methods that do not affect these critical soil organisms are needed.

Baseline data for the impact of agricultural management practices (AMP) on soil microbial populations is limited for South African soils. This information is essential to ensure that accurate recommendations are provided to farmers on AMP to sustain soil health and quality, in order to maximize profitability. Microbial community biodiversity plays an integral part in soil quality and maintenance of ecosystem functioning. Both the size and activity of microbial communities need to be analysed. This enzyme activity can act as biological indicators for soil degradation.

Soil nematode communities are sensitive to disturbance in food and changes in their environment. There are relationships, positive and negative, between non-plant-parasitic nematodes and soil nutrient concentrations. Since soil and plant nematodes are relatively easily extractable and identifiable, they could be used as indicators of soil quality and crop health status. This could only be possible when interrelations are studied holistically.

The implication of pest and rodent infestation as a result of CA is not known, although no negative incidents were reported. Rodents are a severe problem in the maize production areas and termites may be a problem in the western areas.

6. Economic aspects of Conservation Agriculture. Adoption of Conservation Agriculture.

Unfortunately, short-term solutions and immediate benefits always attract farmers and the full technical and economic advantages of conservation agriculture only materialise in the medium to long-term, when its principles (no-tillage, permanent cover crop and crop rotation) are well established within the farming system.

CA requires a new way of thinking of all concerned. Along with this "new way of thinking agriculture", there is already enough technical and agronomic evidence that could positively influence farmers contemplating the adoption of CA principles. It is, however, important to demonstrate to farmers that the technical and agronomic aspects are directly related to the management and economic ones and, therefore, any technical and agronomic improvements obtained by applying CA principles need to be quantified in monetary and economic terms.

There are four requirements for the adoption of CA practices:

- It must bring the farmer a visible and immediate benefit, economic or otherwise.
- The benefit must be substantial enough to convince the farmer to change ongoing practices.
- For the technology to be disseminated, the costs incurred must be able to be covered by the farmer.
- The introduction of CA should be followed-up by an extension service for a long period of time.

The potential conservation agriculture adopter may be confronted with additional capital investments such as a planter and spraying equipment. Cash flow constraints for production inputs such as herbicides during the fallow period will result in substantial savings. A complete cost analysis will be useful for financial planning.

7. Effect on crop yield. Statistically reliable data needs to be collected - proving yield levels in South Africa.

In general, conservation agriculture can produce equivalent or higher yields compared to conventional tillage systems. Crop yields may be lower in the initial phases of CA adoption, and will only rise above conventional tillage figures when the CA system has stabilised.

8. Conservation Agriculture in smallholder and development communities. The areas should be identified and representative demonstration sites for each area needs to be started and supported.

The objective should be to achieve a reduction of rural poverty through contributing to a more productive, sustainable, competitive, market-oriented farming by smallholders.

Basic research is not a priority, however, the transfer of knowledge, financial and technical support, will greatly assist these groups.

9. Implementation of CA on Sandy soils (Water table)

The unique water table of sandy soils of the Northern West Free State requires special management to implement CA successfully. Annual ripping, herbicide application, crop rotation, row width, wind and water erosion, effective planting practices need to be addressed.

10. Agronomic changes

The following agronomic practices need investigation:

<u>Row width</u>. The traditional practice of 2.3, 1.5, 0,91, 0.76 m rows will have to be investigated. The current row width in Argentina is 52 cm for a rainfall area of 1 000 mm. Practical planting, stubble handling, harvesting actions will have to be addressed.

<u>Seedbed Preparation</u>. Placement of seed, handling of stubble, placement of fertilizer and herbicides, correction of compaction.

<u>Soil acid correction</u>. Efficient application of lime to the soil profile and root growing zone.

<u>Row direction in follow-up crops</u>. Practical issues need to be addressed. This may not be a problem in narrow rows of 52 cm. However, it will need to be tested.

<u>Precision farming</u>. Successful CA farmers use technology for collecting yield data, applying nutrition and correcting the soils based on needs and potential needs.