Conservative agriculture in Africa: study cases

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Introduction

Sub-Saharan Africa is facing a multitude of challenges affecting crop production and income of smallholder farmers (Sanginga and Woomer, 2009). Soils are inherently poor, often depleted or acid in their nature with soil carbon levels below 1% (Nyamangara et al., 2014). Due to population pressure, unsustainable land-use, burning and overgrazing, soils are often overused leading to various forms of physical, chemical and biological degradation (Oldeman et al., 1990). Climate change, one of the biggest threats to mankind is increasingly affecting current farming systems through high temperature, more erratic or intense rainfalls, making farming for smallholders more uncertain (Cairns et al., 2013). It is estimated that the temperature will on average rise by 2.1-2.6°C by 2050 while production of the main staple crops will decline by 15-30% unless adaptive measures are implemented (Cairns et al., 2013, Lobell et al., 2008). This has called for more sustainable and climate-smart cropping systems in southern Africa (Thierfelder et al., 2017).

Since 2004, cropping systems based on the principles of conservation agriculture (CA) and other related technologies have been tried and tested at the plot, farm and community level to adapt CA to local environments and circumstances. Conservation agriculture is a cropping system based on the principles of minimum soil disturbance, crop residue retention and crop rotations (Kassam et al., 2009). Besides these three key principles it is supported by good agriculture practices to overcome site specific challenges. Conservation agriculture has originally been developed in the Americas and Australia, where it has now become the “conventional” system. However, different from other parts of the world, CA in Africa is mostly implemented on smallholder farmers and in the majority of cases in manual and animal traction systems.

CIMMYT’s approach and trials in southern Africa

In 2004, the International Maize and Wheat Improvement Centre (CIMMYT) started an initiative to “Facilitate the widespread adoption of conservation agriculture in Eastern and Southern Africa” with financial support from the German Government and later through the International Fund for Agriculture Development (IFAD). This work was increasingly expanded and supported by many donors and has now led to research on all aspects of the cropping system. The objectives of this research is to: a) evaluate the effects of different CA seeding systems and diversification on crop productivity; b) test the longer term performance of CA under the conditions of contrasting agro-ecologies; c) evaluate the effects of CA on soil health; d) test the effects on pest and weed dynamics; e) evaluate water and nutrient dynamics; f) evaluate adaptation to climate change; g) assess profitability of CA farming systems (mostly on-farm); h) calibrate APSIM/DSSAT to the environments of southern Africa; h) explore diversification options through green manure cover crops and i) develop smallholder mechanization. The current research is established in 8 long-term on-station trials, on component trials in 11 research stations on specific challenges, more than 30 replicated on-farm trials and numerous Lead Farmer and Outscaling Plots. While CIMMYT provides scientific leadership on trials and research, there is a range of partners (NGOs, National Research and Extension Partners, Universities from Africa, Europe and the USA) that collaborate with CIMMYT on in-depth agronomic and socio-economic research. Through partnerships and successful scaling, the program has reached more than 200,000 farmers adopting CA practices in Malawi, Zambia, Zimbabwe and Mozambique with an increasing trend and its results have been institutionalized to all countries in southern Africa.

Key results and lessons learned

Conservation agriculture is a sustainable cropping system that shows its benefits after 2-5 cropping seasons when compared with a conventionally tilled system (Thierfelder et al., 2015a). The reason for a slow increase in yield benefits lies in the slow development and change in soil quality and health under the conditions of southern Africa; the way it is implemented by farmers and practitioners; the challenges and constraints (e.g. residue retention, weed control, pest and diseases, lack of adequate machinery and input, and the need for diversification) amongst others (Thierfelder et al., 2015b). However, despite these obvious challenges, yield benefits towards this cropping systems have been measured in more than 80% of cases when CA systems were compared with conventional practices in maize and legume systems (Figure 1a and b)

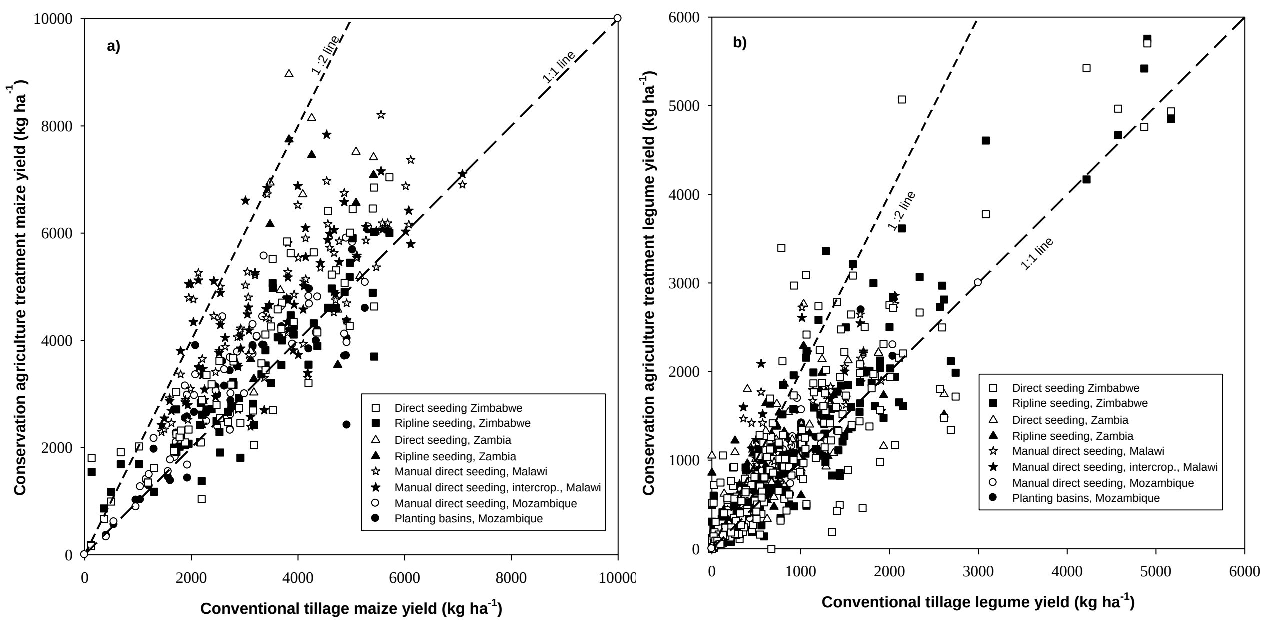

Figure 1a and b: The overall relative advantage of conservation agriculture cropping systems over conventional tillage systems across sites and across seasons in southern Africa for maize (a) and legumes (b). Adapted from Thierfelder et al. (2015c)

Case studies from Zambia, Zimbabwe and Malawi show that improvements in infiltration and soil moisture happen almost immediately after the implementation of CA principles (Thierfelder and Wall, 2009). This research also found that surface crop residue retention as mulch increased biological activity, reduced water run-off and top soil loss, and increased rainfall effectiveness (Thierfelder and Wall, 2010a). Crop residues reduce evaporation losses and increase the soil biological activity which in turn improve the crop water balance (Mupangwa et al., 2013, Thierfelder and Wall, 2010b). This could help farmers adapting to climate change-related drought stress (Cairns et al., 2013) as it results in crop moisture stress being less frequent and intense (Thierfelder and Wall, 2010a, Mupangwa et al., 2008).

Reported socio-economic benefits from CA research include reduced traction and labour requirements for land preparation and weeding if herbicides are used (Figure 2a and b), saving costs of manual labour (mostly women and youth), reduced animal draft power needs and fuel depending on the farming system used (Ngwira et al., 2013, Johansen et al., 2012, Mazvimavi et al., 2008, Thierfelder et al., 2016b).

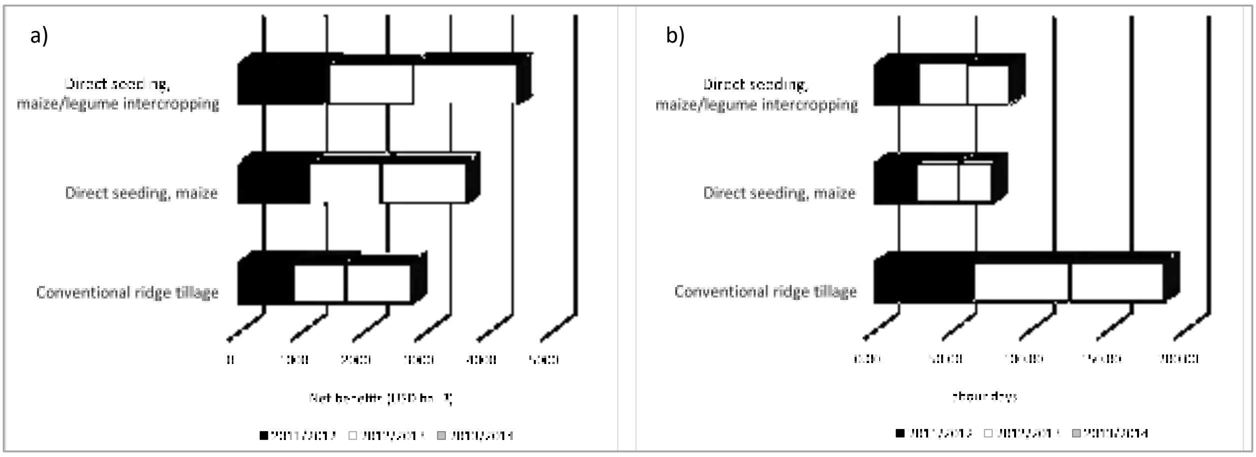

Figure 2a and b: Net benefits and labour days of two CA cropping systems and a conventional control in Mwansambo, Central Malawi, 2011-2014. Adapted from Thierfelder et al. (2016a)

In the long-term, CA may also increase soil organic matter, develop more resilient soil structure, change its bacterial communities, improve nutrient availability, and enhance its water-holding capacity (Thierfelder et al., 2013b, Thierfelder et al., 2013a, Thierfelder et al., 2012, Rusinamhodzi et al., 2012, De la Cruz-Barrón et al., 2017), although some of those indicators are variable and often site-specific depending on crop residue availability and diversification strategy (Cheesman et al., 2016, Powlson et al., 2016). A recent study found that CA systems adapt very well to a changing climate and are therefore more resilient, they increase the productivity and profitability for farmers but there are significant knowledge gaps and uncertainties to what extend it reduces GHG emissions and sequesters carbon, which require further research (Thierfelder et al., 2017).

Research needs and future collaborations

While significant progress has been made to adapt CA systems to the needs and conditions of smallholders in Africa, challenges to the widespread adoption and uptake have been highlighted by various scholars (Giller et al., 2015, Giller et al., 2009, Andersson and D'Souza, 2014) and need to be addressed by biophysical and socio-economic research. This requires concerted action and collaboration amongst international research centres and advanced research institutions. The following research is urgently needed:

1) Residue retention dynamics and processes in the soil need to be better investigated and understood

2) Processes in the soil when changing from conventional tillage to conservation agriculture (bacteria, mycorrhiza fungi, etc.) are only superficially understood
3) The role of intercropping systems in the suppression of pests and diseases needs increased attention
4) How can green manure cover crops be integrated into smallholder farming systems to increase soil fertility, feed, and nutrition without farmers being solely dependent on mineral fertilizer
5) Weed control and factors affecting their feasibility, profitability and viability
6) Smallholder mechanization and developing successful business models for scaling
7) What are the spatial benefits of CA at different scales?
8) What are the socio-economic challenges and constraints hindering faster and more widespread CA adoption?
9) What scaling strategies are the most efficient and viable to increase adaptation and adoption?

If the challenges that smallholder farmers in southern Africa face have to be reduced or overcome these research questions need to be looked at to provide farmers with more sustainable systems and a future in agriculture. The threats of declining soil fertility and climate change will need farmers to change their way of farming or will lead to increased migration from the south to the north within the next decades.

Abstract

Southern African farming systems are confronted with a range of challenges affected crop production and livelihoods of smallholders. These are declining soil fertility, degradation and increased impacts of climate variability and change. Conservation agriculture (CA) systems, based on the three principles of minimum soil disturbance, crop residue retention and crop rotations have been tried to improve current extractive farming systems. Key results from regional on-station and on-farm results show that CA systems are well adapted to the environment and improve crop yields after 2-5 cropping season. These improvements in productivity are in response to increased water infiltration and soil moisture as well as enhanced soil quality and health resulting from simultaneous implementation of CA principles and practices. However, there are still a range of pertinent knowledge gaps that need to be resolved to achieve greater adoption and uptake of cropping system to avoid starvation and rural exodus in the future.

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