Lessons from the field – Zimbabwe's Conservation Agriculture Task Force

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Abstract

In the drier areas of southern Africa, farmers experience drought once every two to three years. Relief agencies have traditionally responded to the resulting famines by providing farmers with enough seed and inorganic fertilizer to enable them to re-establish their cropping enterprises. However, because of the lack of appropriate land and crop management interventions, vulnerable farmers are not necessarily able to translate these relief investments in seeds and fertilizer into sustained gains in productivity and incomes.

A broad-based Task Force, led by the FAO (Food and Agriculture Organization of the United Nations) Emergency Office in Zimbabwe, is showing that relief and development are not mutually exclusive. Relief investments can be structured so as to yield both short- and long-term impacts.

In 2004 the Task Force brainstormed a conservation farming strategy appropriate to the needs of vulnerable households with limited or no draft power. The strategy encompasses four major principles: (i) high management standard; (ii) minimum tillage – for instance, using planting basins which concentrate limited water and nutrient resources to the plant with limited labor input; (iii) the precision application of small doses of nitrogen-based fertilizer to achieve higher nutrient efficiency (from basal applications of organic and/or inorganic sources); and (iv) combining improved fertility with improved seed for higher productivity. These basic principles are taught and demonstrated to farmers who choose crop mixtures adapted to their local conditions and household resource constraints. This Precision Conservation Agriculture (PCA) spreads labor for land preparation over the dry seasons and encourages more timely planting, resulting in reduction of peak labor loads at planting, and higher productivity and incomes.

Over the past three years, the PCA approach has been promoted by non-governmental organizations and national agricultural research and extension departments throughout Zimbabwe. It has consistently increased average cereal yields by 50 to 200% in more than 40,000 farm households (with the yield increase varying by rainfall regime, soil types and fertility, and market access). Rather than simply handing free seed and fertilizer inputs to farmers, teaching farmers PCA principles enables them to apply inputs (water, fertilizer and seed) more efficiently. The pursuit of input-use efficiency provides higher and more sustainable productivity gains needed to achieve better food security in drought-prone farming systems.

The Task Force has generated (and quantified) substantial impacts in a short period; laid the foundation for sustainable development in a poor, drought-prone country; and provided lessons for future relief investment initiatives that will be valuable throughout sub-Saharan Africa.

Introduction

In the drier areas of southern Africa, farmers experience drought once every two to three years. Relief agencies have traditionally responded to the ensuing food shortages by providing farmers with enough seed and fertilizer to enable them to re-establish their cropping enterprises. However, because of the lack of appropriate land and crop management interventions, vulnerable farmers are not necessarily able to translate these relief investments in seeds and fertilizer into sustained gains in productivity and incomes (Rohrbach et al. 2004, 2005).

To improve crop production in the marginal rainfall regions of southern Africa, farmers have to adopt cultural practices that conserve fragile soils and extend the period of water availability to the crop, be it grain or forage (Gollifer 1993, Twomlow and Hagmann 1998). National and international research and development organizations have mostly focused on developing improved genotypes, tillage/soil management systems and integrated pest/ disease management packages. Unfortunately, many of these outputs, although technically sound, have failed to perform well in farmers' fields. They were largely developed and tested in researcher-managed trials, with limited consideration to the problems and priorities of smallholder farmers for whom they were intended (Anderson 1992, Ryan and Spencer 2001, Shiferaw and Bantilan 2004, Twomlow et al. 2006).

Conservation agriculture (CA) is being promoted as a potential solution to the production problems faced by smallholder farming families in sub-Saharan Africa (Haggblade and Tembo 2003, Hobbs 2007). Conservation agriculture is a suite of land, water and crop management practices that aim to improve productivity, profitability and sustainability (IIR and ACT 2005). The primary principles promoted for hand-based and draft animal powered cropping systems are:

- disturb the soil as little as possible;
- implement operations, particularly planting and weeding, in a timely manner;
- keep the soil covered with organic materials (crop residues or cover crops) as much as possible; and
- mix and rotate crops (IIR and ACT 2005).

In order to ensure that a consistent message on CA was delivered by the many non-governmental organizations (NGOs) working in Zimbabwe, the United Kingdom Department for International Development (DFID) Protracted Relief Programme for Zimbabwe, on behalf of other humanitarian relief agencies, tasked the FAO (Food and Agriculture Organization of the United Nations) Emergency Office for Zimbabwe to establish a broad-based partnership that would coordinate CA activities. The CA Task Force for Zimbabwe was initiated in March 2004.

In this paper we summarize the evolution of CA in southern Africa with a strong focus on Zimbabwe and the activities undertaken by the Zimbabwean Conservation Agriculture Task Force (ZCATF) to support the relief efforts and facilitate the uptake of hand-based Precision Conservation Agriculture (PCA) interventions promoted by NGOs under a range of humanitarian relief initiatives that have been operating in Zimbabwe since 2004.

Evolution of CA in southern Africa

Conservation agriculture is generally defined as any tillage sequence that minimizes or reduces the loss of soil and water; and operationally is tillage or tillage and planting combination, which leaves at least 30% or more mulch or crop residue cover on the surface (SSSA 1986, IIR and ACT 2005). In the drylands of southern Africa, CA has been loosely applied to any tillage system that conserves or reduces soil, water and nutrient loss, or reduces draft power (human, animal and mechanical) input requirements for crop production. With the cropping period in most semi-arid regions being relatively short, the timing of field operations is critical (Twomlow et al. 2006).

The following CA techniques have been evaluated and actively promoted in Zimbabwe since the 1980s: no-till tied ridging; mulch ripping; no-till strip cropping; clean ripping; hand-hoeing or zero till; tied furrows (for semi-arid regions) and open plow furrow planting followed by mid-season tied ridging (Nyagumbo 1998, Mupangwa et al. 2006, Twomlow et al. 2006). These have frequently been promoted in combination with mechanical structures such as: graded contour ridges; dead level contour ridges with cross-ties (mainly for semi-arid regions); infiltration pits dug at intervals along contour ridge channels; *fanya juus* (for water retention in semi-arid regions); vetiver strips and broad-based contour ridges (mainly used on commercial farms) (Twomlow and Hagmann 1998, Mupangwa et al. 2006).

Unfortunately, despite nearly two decades of development and promotion by the national extension program and numerous other projects, adoption has been extremely low in the smallholder sector, compared to other continents such as South America, North America and Europe due to various constraints (Hobbs 2007, Derpsch 2008, Gowing and Palmer 2008). These constraints include: a low degree of mechanization within the smallholder system; a lack of appropriate implements; a lack of appropriate soil fertility management options; problems of weed control under no-till systems; access to credit; a lack of appropriate technical information for change agents and farmers; blanket recommendations that ignore the resource status of rural households; competition for crop residues in mixed crop-livestock systems and the availability of labor (Twomlow et al. 2006).

Despite these constraints, a number of different initiatives have recently begun to re-examine the potential for CA to improve crop production within the smallholder sector of Zimbabwe. For the purpose of this paper, we have adopted the terminology of the ZCATF, as it has been noted that many organizations use the terms CA and conservation farming (CF) interchangeably in their reports and proposals as if they were the same, yet the two are different:

- Conservation agriculture is a broader term that encompasses activities such as minimum tillage and zero tillage, tractor powered, animal powered and manual methods, integrated pest management, integrated soil and water management, and includes

CF. As generally defined earlier, it is any tillage sequence that minimizes or reduces the loss of soil and water.

- Conservation farming is the particular technology developed by Brian Oldrieve using planting basins and soil cover. This is a modification of the traditional pit systems once common in southern Africa and is a variation on the *Zai* pit system from West Africa, which may also be considered a CF technology.

The interventions currently being promoted/tested in Zimbabwe include:

- **Basin tillage and shallow planting furrows** using a hand hoe;
- **Ripper tines** attached to the beam of the moldboard plow, to prepare planting lines in un-plowed soil for households with draft power; and
- **Specialized no-till/direct planting seeders** aimed at the emerging commercial farmers with draft power.

All these interventions are being compared with the traditionally applied practice of overall spring plowing with an animal-drawn moldboard plow and planting, sometimes referred to as 'Third Furrow Planting'. Seed is dropped into every third or fourth furrow opened by the plow. The next pass of the plow covers the seed, which is then left to germinate in a weed-free seedbed. Unfortunately, many households with limited or no access to draft animals often have to wait until better-resourced households have completed their own planting before they may borrow or hire a team of draft animals. This means that the poorer-resourced, most vulnerable households, typically plant 4 to 6 weeks later than other households, with some plantings occurring as late as January.

Overview of current CA/CF initiatives in Zimbabwe

River of Life Church – Operation Joseph. The oldest CA initiative in the country is 'Operation Joseph' run by the River of Life Church. Operation Joseph builds on the 'Hinton Estates Out-Reach Program' initiated by Brian Oldrieve in the 1990s. The program focuses on the promotion of either basin tillage or shallow planting furrows in conjunction with a set package of inputs (seed and fertilizer) for a cereal-legume rotation. In the early stages of this program, beneficiaries were closely associated with the Church and were encouraged to follow a strict set of agronomic guidelines that were periodically assessed over two to three cropping seasons. The program enforces a three-strike rule and households that fail to adhere to the strict protocols are given three chances before being ejected from the program.

Promotion of CA in smallholder maize-based systems. A second initiative is run by the International Maize and Wheat Improvement Center (CIMMYT), with originally German Federal Ministry for Economic Cooperation and Development (BMZ) and now International Fund for Agricultural Development (IFAD) funding, with the aim of facilitating the widespread adoption of CA in the maize-based systems of Malawi, Tanzania and Zimbabwe. In Zimbabwe the target population for this initiative is the emerging commercial maize farmers who have the financial and draft power resources to invest in animal-drawn no-till equipment such as direct seeders. The project partners have imported and are evaluating a range of equipment developed in South America. The focus of this project is on the promotion of commercial standard applications (and targets) (Wall, personal communication; http//:www.cimmyt.org).

Commercialization of smallholder farming. A third initiative was established in 2004/05 by the FAO Emergency Relief Office and the three Farmers' Unions of Zimbabwe (ZFU: Zimbabwe Farmers Union; ZCFU: Zimbabwe Commercial Farmers Union; CFU: Commercial Farmers Union). The project attempts to pass on the experiences of commercial farmers to communal farmers, with the objectives of improving food security and "commercializing" communal farming in Natural Regions II and III. The project is site specific, and with the support of resident extension staff, planning is based on local conditions and farmers' experience. The focus here is on commercial standard applications (and targets).

Promotion of conservation agriculture through humanitarian relief program – The Conservation Agriculture Task Force. This is by far the largest initiative in Zimbabwe and is focused on vulnerable households, building on the earlier seed and fertilizer relief programs in Zimbabwe (Rohrbach et al. 2005, Twomlow et al. 2007), funded by DFID and the European Commission Humanitarian Aid Office (ECHO). For the purpose of this paper, a vulnerable household is defined as a poor household experiencing food production shortfalls, and includes female-headed households, those with orphans, and households with draft power constraints. All these households have been classified as vulnerable and are in receipt of seed and fertilizer relief investments distributed through a range of NGOs operating within Zimbabwe.

The Zimbabwean Conservation Agriculture Task Force (ZCATF)

In 2003 a Task Force on CF was formed involving donor organizations, NGOs, CIMMYT, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), FAO and the Department of Agricultural Research and Extension (AREX) with a mandate to promote CF in Zimbabwe. Over time the Task Force has seen fit to amplify its scope of interest to include other forms of CA. The initial focus of the ZCATF is to support the various relief initiatives in the promotion of the 'Vulnerable Households Package', and coordinate the different monitoring and evaluation exercises to assess and document the impacts of the program. FAO's Emergency Office coordinated many of these activities and kept a database of what and where each NGO was operating in the country to ensure complementarities of effort and reduce duplication of activities in the same ward by different NGOs, which has happened in the past (Rohrbach et al. 2004).

The specific activities of ZCATF include:

- monitoring and dissemination of information on CA activities in Zimbabwe;
- offering advice to all stakeholders, including government agencies, donors and NGOs, on CA development activities;
- analyzing and publicizing the results of CA activities in the country;
- monitoring and supporting CA training opportunities in Zimbabwe;
- advocating and monitoring CA-related research and studies, including farmer and stakeholder surveys; and
- providing a link for stakeholders with and between national, regional and international CA networks.

Organizations implementing CA activities have been encouraged to:

- provide the Task Force with information on their respective CA activities;
- provide the Task Force with information on results of their CA activities when appropriate, including monitoring and evaluation reports;
- allow the Task Force to monitor their CA-related activities; and
- participate actively in the Task Force.

The CA packages promoted under these protracted relief initiatives have been developed by the ZCATF through consultation with various experts and are summarized in Table 1. Based on the possible crop rotations outlined in Table 1, three CF packages were recommended by the ZCATF for households with different resource statuses:

- 'Full package' (households with no labor or financial constraints) – see Table 2 for comprehensive agronomic details.
  - Three plots, each 0.25 ha
  - Cereal-cash crop-legume rotation
- 'Standard package' – see Table 3 for comprehensive agronomic details.
  - Two plots, each 0.25 ha
  - Cereal-legume rotation

Table 1. CF cropping packages recommended for natural regions in Zimbabwe.

Natural region (NR)[1]	Rainfall (mm)	Rainfall characteristics	Cropped area	Crops/rotation
II	650 to 800	Good distribution	3 × 0.25 ha	Maize-Cotton-Legume (groundnut/soybean)
III	650	30 to 40 rainy days	3 × 0.25 ha	Maize-Cotton-Legume (groundnut/cowpea/soybean)
IV	500 to 650	30 rainy days	3 × 0.25 ha	Maize/Sorghum/Pearl millet Groundnut/Cowpea Sunflower/Cotton
V	Less than 500	16 to 30 rainy days		Sorghum/Pearl millet/Maize Groundnut/Cowpea

1. Zimbabwe is divided into five agroecological regions, also known as Natural Regions I to V. Natural Region I and II receive the highest rainfall (at least 750 mm per annum) and are suitable for intensive farming. Natural Region III receives moderate rainfall (650–800 mm per annum), and Natural Regions IV and V have fairly low rainfall (450–650 mm per annum) and are suitable for extensive farming (adapted from Vincent and Thomas 1960).

Table 2. ZCATF detailed cropping recommendations for households with no financial or labor constraints – the full package.

Package	NR II	NR III	NR IV	NR V
Plot size	3 × 0.25 ha	3 × 0.25 ha	3 × 0.25 ha	3 × 0.25 ha
Cereals	Maize (0.25 ha)	Maize or red sorghum (0.25 ha)	Maize, millet or sorghum (0.25 ha)	Millet or sorghum (0.25 ha)
Legumes	Soybean, groundnut (0.25 ha)	Soybean, groundnut, cowpea (0.25 ha)	Cowpea, groundnut (0.25 ha)	Cowpea, groundnut (0.25 ha)
Cash crop	Cotton, sunflower (0.25 ha)	Cotton, sunflower (0.25 ha)	Cotton, sunflower (0.25 ha)	
Spacing (Cereal/Cash crop)	75 cm × 60 cm (44,000 plants ha^{-1})	75 cm × 75 cm or 90 cm × 60 cm (37,000 plants ha^{-1})	75 cm × 75 cm or 90 cm × 60 cm (37,000 plants ha^{-1})	75 cm × 75 cm or 90 cm × 60 cm (37,000 plants ha^{-1})
Spacing (Legumes)	Same but plant 5 seeds per basin	Same but plant 5 seeds per basin	Same but plant 5 seeds per basin	Same but plant 5 seeds per basin
Fertilizer for cereals	Basal/Topdress[1]	Basal/Topdress[1]	Basal/Topdress[1]	Basal/Topdress[1]
Liming	Based on soil samples	Based on soil samples	Based on soil samples	Based on soil samples
Planting date	Early to mid November with first good rains	Mid to late November with first good rains	Late November to early December with first good rains	Early December with first good rains

1. A minimum of 80 kg ha^{-1} Compound D (1 level beer bottle cap per basin); a minimum of 80 kg ha^{-1} ammonium nitrate (1 level beer bottle cap per basin).

Table 3. ZCATF detailed cropping recommendations – the standard package.

Package	NR II	NR III	NR IV	NR V
Plot size	2 × 0.25 ha	2 × 0.25 ha	2 × 0.25 ha	2 × 0.25 ha
Cereals	Maize (0.25 ha)	Maize or red sorghum (0.25 ha)	Maize, millet or sorghum (0.25 ha)	Millet or sorghum (0.25 ha)
Legumes	Soybean, groundnut (0.25 ha)	Soybean, groundnut, cowpea (0.25 ha)	Cowpea, groundnut (0.25 ha)	Cowpea, groundnut (0.25 ha)
Spacing (Cereals)	75 cm × 60 cm (44,000 plants ha^{-1})	75 cm × 75 cm or 90 cm × 60 cm (37,000 plants ha^{-1})	75 cm × 75 cm or 90 cm × 60 cm (37,000 plants ha^{-1})	75 cm × 75 cm or 90 cm × 60 cm (37,000 plants ha^{-1})
Spacing (Legumes)	Same but plant 5 seeds per basin	Same but plant 5 seeds per basin	Same but plant 5 seeds per basin	Same but plant 5 seeds per basin
Fertilizer for cereals	Basal/Topdress[1]	Basal/Topdress[1]	Basal/Topdress[1]	Basal/Topdress[1]
Liming	Based on soil samples	Based on soil samples	Based on soil samples	Based on soil samples
Planting date	Early to mid November with first good rains	Mid to late November with first good rains	Late November to early December with first good rains	Early December with first good rains

1. A minimum of 80 kg ha^{-1} Compound D (1 level beer bottle cap per basin); a minimum of 80 kg ha^{-1} ammonium nitrate (1 level beer bottle cap per basin).

- Package for 'vulnerable households' – The focus of the Protracted Humanitarian Relief Initiative – see Table 4 for comprehensive agronomic details.
  - 0.25-ha plot
  - 0.2 ha cereals, 0.05 ha legumes
  - Option for cereal-legume intercrop

Once the various packages had been agreed, they were further developed into an Implementation Protocol for the Implementing Partners of DFID's Protracted Relief Programme (PRP 2005), with a strong emphasis on timeliness and precision. This document covered the following areas:

- The purpose of CF for vulnerable households
- Expected benefits
- Constraints
- General principles
- Fundamentals of CF
- Targeting and extension approach (clusters/groups/ lead farmers)
- Site selection
- Scale (number of farmers per cluster, number of clusters per district per NGO, etc)
- Notes on the technical package
- Farmers' measurements
- Resources required in terms of fertilizer, seeds and equipment
- Training
- Follow-up visits
- Monitoring and evaluation through simple paired plot demonstrations

Components of CF practice promoted in Zimbabwe

The basic components of CF as agreed by ZCATF are discussed (PRP 2005).

Winter weeding. The first step in preparing a field using CF methods is to remove all weeds. This should be done soon after harvesting in May/June. Weeding is done using implements such as hand hoes and machetes that disturb the soil as little as possible. The importance of weeding before land preparation is to ensure that the plot is weed-free at basin preparation and also to prevent the dispersal of weed seeds.

Table 4. ZCATF detailed cropping recommendations for vulnerable households – the vulnerable household package[1].

Package	NR II	NR III	NR IV	NR V
Plot size	0.25 ha	0.25 ha	0.25 ha	0.25 ha
Cereals	Maize (0.2 ha)	Maize or red sorghum (0.2 ha)	Maize, millet or sorghum (0.2 ha)	Millet or sorghum (0.2 ha)
Legumes	Soybean, groundnut (0.05 ha)	Soybean, groundnut, cowpea (0.05 ha)	Cowpea, groundnut (0.05 ha)	Cowpea, groundnut (0.05 ha)
Spacing (Cereals)	75 cm × 60 cm (44,000 plants ha^{-1})	75 cm × 75 cm or 90 cm × 60 cm (37,000 plants ha^{-1})	75 cm × 75 cm or 90 cm × 60 cm (37,000 plants ha^{-1})	75 cm × 75 cm or 90 cm × 60 cm (37,000 plants ha^{-1})
Spacing (Legumes)	Same but plant 5 seeds per basin	Same but plant 5 seeds per basin	Same but plant 5 seeds per basin	Same but plant 5 seeds per basin
Fertilizer for cereals	Basal/Topdress[2]	Basal/Topdress[2]	Basal/Topdress[2]	Basal/Topdress[2]
Liming	Based on soil samples	Based on soil samples	Based on soil samples	Based on soil samples
Planting date	Early to mid November with first good rains	Mid to late November with first good rains	Late November to early December with first good rains	Early December with first good rains

1. In initial years plant cereals to address food security issues. Consider introducing the legumes in year 3 or 4.
2. A minimum of 80 kg ha^{-1} Compound D (1 level beer bottle cap per basin); a minimum of 80 kg ha^{-1} ammonium nitrate (1 level beer bottle cap per basin).

Digging planting basins. Planting basins are holes dug in a weed-free field into which a crop is planted and are prepared in the dry season from July to October. The recommended dimensions of the basin are 15 cm × 15 cm × 15 cm, spaced at either 75 cm × 60 cm for Natural Regions II and III and 90 cm × 60 cm for Natural Regions IV and V. The basins enable the farmer to plant the crop after the first effective rains when the basins have captured rainwater and drained naturally. Seeds are placed in each basin at the appropriate seeding rate and covered with clod-free soil. The advantage of using basins is that they enhance the capture of water from the first rains of the wet season and enable precision application of both organic and inorganic fertilizer as it is applied directly into the pit and not broadcast.

Application of crop residues. Crop residues are applied on the soil surface in the dry season, soon after harvesting. The residues must provide at least 30% soil cover. The mulch buffers the soil against extreme temperatures (thereby reducing soil evaporation), cushions the soil against traffic, suppresses weeds through shading and improves soil fertility.

Application of manure. Fertility amendments are applied soon after land preparation in the dry season. In CF, the application of both organic and inorganic fertilizers is recommended as they complement each other. Organic fertilizers such as manure and/or composts are applied at a rate of at least a handful per planting basin. More can be used in wetter areas.

Application of basal fertilizer supplied by the NGO through the relief program. Inorganic basal fertilizer (Compound D 8:14:8) is also applied soon after land preparation before the onset of the rains. One level beer bottle cap is applied per planting basin and covered lightly with clod-free soil. This is equivalent to 80 kg of compound fertilizer per ha. Application rates can be increased in wetter areas and may depend on crop types.

Application of topdressing supplied by the NGO through the relief program. Nitrogen fertilizer (ammonium nitrate – 34% N) is applied to crops at the 5- to 6-leaf stage soon after the first weeding at one level beer bottle cap per basin. This is equivalent to 80 kg of ammonium nitrate fertilizer per ha. Application is done on moist soils. Precision application ensures that the nutrients are available where they are needed. Application rates can be increased in wetter areas and may depend on crop types.

Timely weeding. In conventional tillage systems, farmers plow/cultivate repeatedly in order to suppress weeds. With reduced tillage, weeds can be a problem requiring more effort initially. One strategy is to weed in a timely manner (ie, when the weeds are still small) preventing the weeds from setting seed. Timely weeding in combination with mulch should eventually lead to effective weed control.

Crop rotation. Rotating crops is one of the key principles of CF. Cereal/legume rotations are desirable because there is optimum plant nutrient use by synergy between different crop types. The advantages of crop rotation include improvement of soil fertility, controlling weeds, pests and diseases, and producing different types of outputs, which reduce the risk of total crop failure in cases of drought and disease outbreaks.

The planting basins

The central component of the 'basin tillage package' is the planting basin. Seeds are sown, not along the usual furrow, but in small basins – simple pits that can be dug with hand hoes without having to plow the whole field. The technology is particularly appropriate to southern Africa, given that the majority of smallholder farmers struggle to plant their fields on time because they lack draft animals (Twomlow et al. 1999, 2006). The basin tillage concept was first developed by Brian Oldrieve (1993) in Zimbabwe, subsequently modified and promoted in Zambia by the Zambian Farmers Union Conservation Farming Unit (Haggblade and Tembo 2003). This PCA practice spreads labor for land preparation over the dry seasons and encourages more timely planting, resulting in reduction of peak labor loads at planting and a concentration of available soil fertility amendments.

Planting of the basins occurs in November/December after the basins have captured rainwater (and then drained naturally) at least once. Smallholder farmers without draft power can plant soon after an effective rainfall event rather than wait for draft animals to become available several weeks into the season [An effective rainfall event is 30 mm for sandy soils and >50 mm for heavier soils (Twomlow and Bruneau 2000)]. In addition, farmers are encouraged to spread whatever crop residues might be available as a surface mulch to prevent soil losses early in the season, conserve moisture later in the season, and enrich the soil with nutrients and organic matter as the residues decompose.

Four years of impacts

The PCA concept was introduced by NGOs and donors in 2004/05 to a very small group of farmers. Since then the number of farmers practicing PCA has increased significantly over the intervening seasons (Fig. 1). Over the three seasons for which data is available from a nation-wide system of 0.2-ha paired plots (0.1 ha under basins and 0.1 ha under CF), the basin packages have consistently increased average yields by 15 to 300% (Fig. 2) in more than 15,000 farm households, with the yield increase varying by rainfall regime, soil types and fertility. In the 2007–2008 cropping season, the PCA package was promoted to more than 50,000 communal/ smallholder farmers by NGOs working within the protracted relief programs in Zimbabwe.

Use of volunteer farmer clusters, rather than lead farmers or farmer field schools to demonstrate these principles, is leading to higher spontaneous uptake

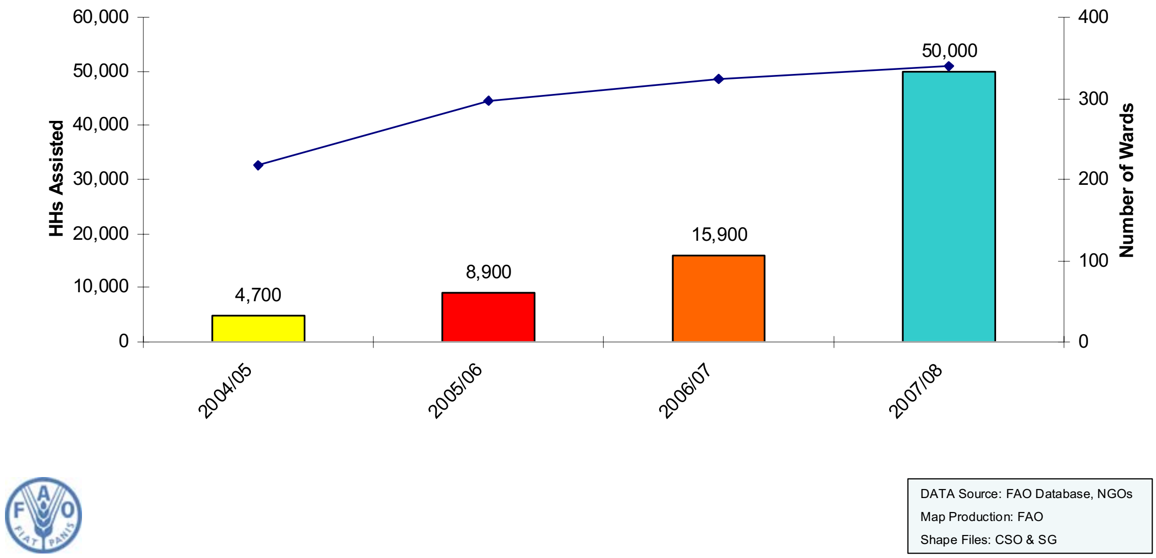

Figure 1. Promotion of Precision Conservation Agriculture (CF) in Zimbabwe between 2004 and 2008 showing the number of households (HHs) receiving seed, fertilizer and technical support each season through the relief programs and the number of wards the NGOs are active in.

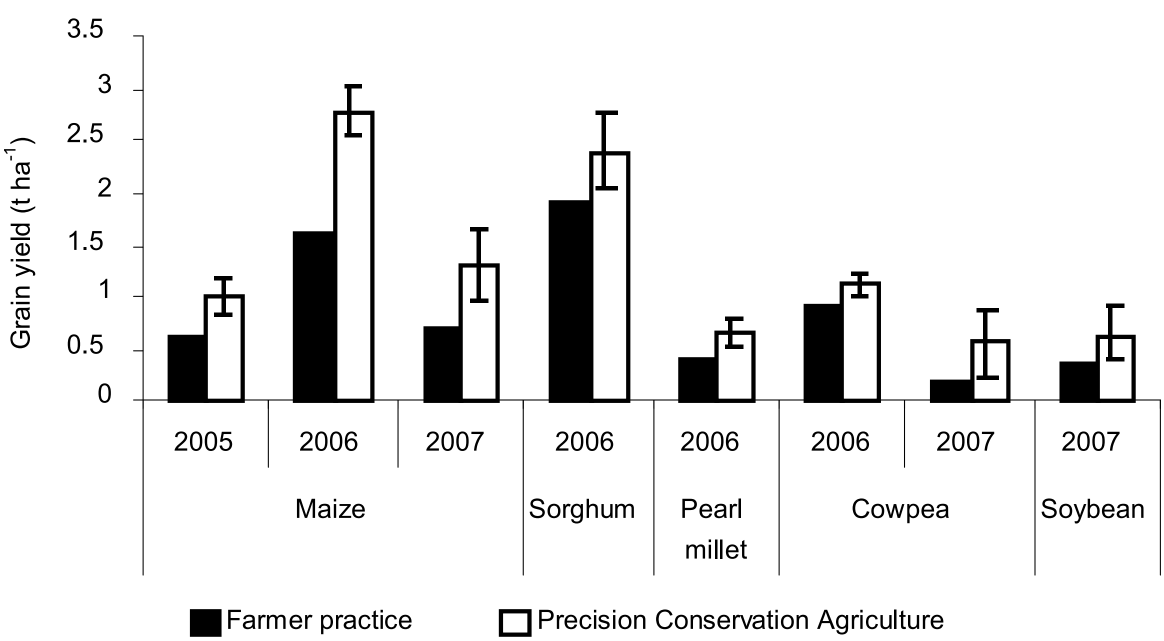

Figure 2. Cereal and legume grain yield responses to conventional farmer practice and Precision Conservation Agriculture (PCA) (planting basins) over three seasons averaged across 13 districts in semi-arid areas in Zimbabwe (Note: Error bars represent the standard error of differences between the means of the treatments for each crop in each season of observation).

(Mazvimavi et al. 2007). For instance, in two wards in southern Zimbabwe, where paired plot demonstrations were established on less than 10% of farms, more than 1000 farm households have invested their own capital and other resources, representing spontaneous uptake by nearly 90% of the population. Although the area under PCA is not large enough yet to create a marketable surplus, food security has increased substantially. As expected, these farmers are adopting these techniques slowly. The area they have applied PCA has doubled from 1/4 to 1/2 acre (0.1 to 0.2 ha) and this small area is accounting for 35% of household cereal requirements on average. Precision conservation agriculture also enables diversification in cropping patterns and more reliable legume production. Returns to labor have been about twice higher than conventional practices (Table 5). Maintaining all other production costs constant, CF remains more profitable than conventional farmer practice, even when significant yield gains can be achieved from farmer practice in higher rainfall conditions with fertilizer use.

These swift yield gains from planting basins are achieved because the technology enables farmers to plant in a timely manner and to carry out all field operations at the right time. Generally farmers depend on third party tillage (plowing) of their land. In CA, farmers can prepare their plots by hand in the off-season. Delayed planting after the optimum planting date reduces the yield potential by around 30% per month. The concentration of water and available soil fertility amendments within the planting basin is reducing the risk of crop failure, even under drought conditions.

It is estimated that in most Natural Regions if a household devotes at least 0.6 ha to CA it would meet their basic cereal requirements in all but the worst rainfall season, with many seasons producing a surplus (Mazvimavi et al. 2007). This would then allow farmers to diversify the crops they are growing on the rest of their land holdings, making crop rotations feasible and giving many the option of cash crop production and sustainable livelihood improvement and commercialization. Additionally, yield increase and stabilization will produce more biomass for mulching and/or stockfeed.

Conclusions

Conservation agriculture is being promoted throughout sub-Saharan Africa as a solution to low productivity levels, reducing smallholder farmers' vulnerability to drought, addressing low draft power ownership levels, and combating increasing levels of soil degradation and loss of fertility. The ZCATF has generated (and quantified) substantial impacts in a short period; laid the foundation for sustainable development in a poor, drought-prone country; and provided lessons that will be valuable throughout sub-Saharan Africa.

Since 2004 the PCA approach has been promoted to more than 50,000 farm households (with the yield increase varying according to rainfall regime, soil types and fertility, and market access) through a combination of partnerships with NGOs and national agricultural research and extension departments, and has consistently increased average cereal yields by 50 to 200 percent.

Table 5. Sensitivity analysis for Precision Conservation Agriculture (CF) versus conventional practices under high-, normal-, and low-rainfall situations in Zimbabwe (microdosing with 28 kg N ha^{-1}).

		Precision conservation farming practice		Conventional farmer practice	
Description		First year	Second + year	No fertilizer	With fertilizer
High rainfall					
Maize grain	kg ha^{-1}	2000	2650	678	1120
Gross margin	US$ ha^{-1}	654	867	197	357
Cost per kg	US$ kg^{-1}	0.07	0.07	0.15	0.12
Returns to labor	US$ day^{-1}	6.3	7.0	3.3	4.9
Normal rainfall					
Maize grain	kg ha^{-1}	1750	2200	560	728
Gross margin	US$ ha^{-1}	529	697	153	19
Cost per kg	US$ kg^{-1}	0.10	0.08	0.17	0.18
Returns to labor	US$ day^{-1}	5.5	6.3	3.0	3.3
Low rainfall					
Maize grain	kg ha^{-1}	1520	1780	368	400
Gross margin	US$ ha^{-1}	473	535	71	48
Cost per kg	US$ kg^{-1}	0.09	0.10	0.25	0.32
Returns to labor	US$ day^{-1}	5.2	5.3	1.9	1.5

Rather than simply handing out free inputs to farmers, this PCA approach, based on strong and comprehensive extension support, enables them to apply relief inputs of fertilizer and seed more productively. The pursuit of input-use efficiency provides higher and more sustainable productivity gains needed to achieve better food security in drought-prone farming systems.

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