Conservation Agriculture Practices and Adoption by Smallholder Farmers in Zimbabwe

By

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Conservation Agriculture Practices and Adoption by Smallholder Farmers in Zimbabwe

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Abstract
This study is based on a panel survey interviewing 416 farmers practising conservation agriculture for at least five cropping seasons. Farmers obtained higher yields on conservation agriculture plots than on non-conservation agriculture ones. The mean maize yield on conservation agriculture was 1546 kg/ha compared to 970 kg/ha for non-conventional draft tillage plots across all 15 districts. However, the contribution of conservation agriculture to total household food security requirements was limited due to small plot sizes. Labor and land still remains a major challenge that limits the expansion of conservation agriculture area. Winter weeding remains a challenge, with 63% of farmers practicing it. Application of residues is still limited (56% of farmers practising it). Fertilizer application is largely dependent on access to free fertilizer. The survey results show that the 78 % of the respondent farmers were initially selected by the NGOs and were provided with inputs such as seed and fertilizer. The other 22% of the farmers in the sample were selected as spontaneous adopters, who did not initially receive any NGO support to implement conservation agriculture practices. Eleven percent of the interviewed farmers had stopped conservation agriculture practices by the 2008/09 cropping season due to withdrawal of input support by NGOs. Research should continue to explore different recommendations for different areas as farmers face dynamic agro-ecological and soil environments. Conservation agriculture should not be introduced as a blanket technology for all areas, but should be flexible and adaptable to local conditions.

Key words: *conservation agriculture, planting basins, yield gains, adoption labor, and fertilizer*

1. INTRODUCTION

Close to half of Zimbabwe's population – about 6 million people − are currently food and nutrition insecure (UN, 2009). The key reasons for this state of affairs are the continuing low agricultural productivity, deteriorating soil fertility (Donovan and Casey 1998, Mupangwa, et al., 2008), dysfunctional input and output markets (Jama and Pizzaro, 2008) and the unfavorable macro-economic environment. Smallholder farmers in the semi-arid regions are most affected by this situation. In Zimbabwe, the response to this crisis has been the wide-scale relief distribution of food aid and direct agricultural input assistance without an exit strategy for sustaining some of the new technologies promoted within the context of relief aid (DFID, 2009). This has led to a call on a need to focus on relief assistance that targets sustainable crop production techniques that also aims at improving soil fertility and improve on environment protection. One technology option for promoting soil fertility and water management has been the conservation of soil water, nutrients, and farm power using a variant of conservation agriculture techniques.

In Zimbabwe, conservation agriculture (CA) and conservation farming (CF) have been clearly differentiated. Digging planting basins and following principles like mulching and crop rotation is termed conservation farming while conservation agriculture encompasses all other minimum tillage methods like rippers and knife rollers and the principles of mulching and crop rotation and integrated pest management apply (Twomlow et al., 2008). The only difference is the tillage system; conservation farming is part of conservation agriculture. An increasing number of non-governmental organizations (NGOs) through funding from

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multiple donors are now promoting conservation agriculture and the package has recently been accepted by the government as a group of technology interventions that have the potential to sustainably increase yields of a wide range of crops by resource-poor farmers even in drier agro-ecological regions. Farmers across Zimbabwe have shown a growing interest in the conservation agriculture technology with evidence of yield gains of between 10 and more than 100% depending on input levels and the experience of the farm household (Mazvimavi et al., 2009). Cases of spontaneous adoption are being observed in areas where demonstrations and training programs have been well supported by NGOs and research institutes.

The conservation agriculture impacts achieved in improving food security for poorer farmers in the semi-arid region of Zimbabwe need to be protected, sustained, and promoted so that more smallholder households benefit from the technology. This study aims at assessing the impact of this multi-year donor-funded program and determines how conservation agriculture using planting basins as the tillage method can contribute to sustained gains in food security and improve livelihoods of rural farm-based communities. The study will compare the relative success of farmers in adopting different components of conservation agriculture technology over time; and assess the socioeconomic impacts of conservation agriculture technologies to vulnerable farm households.

2. METHODOLOGY

The study is based on a panel survey approach that started in 2006/2007 and repeated in 2007/2008 and 2008/2009. This paper is based on data from the 2008/2009 panel study carried out in the months of March to May 2009.

2.1. Study sample

The study was implemented in 15 districts of Zimbabwe where different NGOs under the Department for International Development's (DFID's) Protracted Relief Programme (PRP), European Union (EU), and European Commission Humanitarian Aid Office (ECHO) funding have been promoting CA over the past five years. These districts are Bindura, Binga, Chirumhanzu, Chivi, Hwange, Insiza, Mangwe, Masvingo, Mt. Darwin, Murehwa, Chipinge, Gokwe South, Seke, Nkayi, and Nyanga (Table 1). A total of 416 households were interviewed in the 15 districts through a household questionnaire.

2.2. Yield Measurements

Yield measurements were taken from 10m x 10m sub-plots marked in both CA and non CA plots (and, in most instances, whole plots). Farmers were given empty 50kg bags to measure their harvests. Each farmer was asked to count the number of 50kg bags of unshelled cobs and/or grain upon harvesting from the plots. This was because the crops had not matured enough for harvesting at the time of the survey. When the harvest data was collected, bags of cobs or grain were weighed in order to determine the actual yield from the plots.

Table 1. Number of farmers interviewed in 2009 panel survey

Natural Region (NR)[a]	District	Number of Respondents
II	Bindura	30
	Murehwa	29
	Seke	30
III	Chirumhanzu	30
	Masvingo	31
	Mt. Darwin	29
IV	Gokwe South	27
	Insiza	23
	Nkayi	25
	Nyanga	30
V	Binga	23
	Chipinge	29
	Chivi	30
	Hwange	28
	Mangwe	22
	Total	**416**

[a] Zimbabwe is divided into five agro-ecological 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 (650–800mm per annum) and Natural Regions IV and V have fairly low annual rainfall (450–650mm per annum) and are suitable for extensive farming (Vincent and Thomas, 1960).

3. RESULTS

3.1. Characterization of CA Households

Conservation agriculture promotions in the context of NGO support have essentially targeted vulnerable farmers. However, these farmers are not necessarily of the same resource and social endowments. Different household characteristics influence technology adoption differently. Across the 15 districts, there is no significant difference in the numbers of male- and female-headed households targeted by NGOs (Table 2). This is despite the fact that NGOs deliberately target female-headed households for relief assistance. The gender of household head is equally shared with 49.9% being male-headed and 50.1% being female-headed households.

The average age of the household head is above 50 years, with the exception of Mt Darwin, Nyanga, Chipinge and Binga where it ranges from 44 to 48 years. There does not appear to be any significant age difference across the 15 districts. This can be attributed to the targeting process of households by the NGOs, which includes the elderly as part of the vulnerable households. On average, farmers have 6.4 years of formal education. This means that household heads across the surveyed districts have attained up to primary level of education and are generally literate. The education level has less to do with the targeting procedure of NGOs but is vital in assessing the ability of farmers to appreciate and grasp new principles or concepts.

In general, all the household heads have farming experience with Binga having the least with 19 years and Gokwe South the most with 38 years. This information helps to characterize the farmers participating in conservation agriculture. These farmers have experience with their environment and natural resources. They are thus more likely to appreciate a new technology that has potential for better crop yields.

Farmers are expected to realize greater yields from conservation agriculture as they gained experience with the technology over time. Households interviewed in the study had some experience with conservation agriculture, with the majority of farmers having at least a minimum of three years of practice with the technology. The most experienced farmers were in Bindura, with more than six years of conservation agriculture practice. This is where River of Life (RoL) pioneered conservation agriculture, with some farmers claiming to have started in the late 1980s. Districts such as Binga, Chipinge, and Chirumhanzu had relatively less experienced farmers, averaging less than three years because conservation agriculture promotions by NGOs in these areas has only recently been introduced. Farmers in areas such as Masvingo, Murehwa, and Insiza were in their fourth season of conservation agriculture practice.

Table 2 shows that the majority of the farmers in the survey sample started practicing conservation agriculture after being selected by NGOs. NGOs targeted farmers perceived to be vulnerable to food production shortfalls and provided them with training on conservation agriculture and free inputs as an incentive to try out the new technology.

In all the districts there is some evidence of chronic illness, which directly limits conservation agriculture labor availability in the household (Table 2). On average, about 20% of the households have chronically ill people. Seke, Bindura, and Chivi had the highest cases of chronically ill household members. In Seke NGO targeting was based primarily on HIV/AIDS indicators. The average household size across the survey sample is six, with fewer contributing to full-time labor on the farm (3.7 persons per household). Binga had the largest average household size of nine individuals. Marriage arrangements in that area are typically polygamous (Manyena et al.,2008), resulting in larger household size.

Table 2. Household characteristics by agro-ecological regions and districts

Natural region	District	Gender of household head (%)		Mean age of household head (years)	Mean education level of household head (years)	Mean farming experience (years)	Mean conservation agriculture experience (years)	Initially selected by NGO for input support (%)		Presence of chronically ill persons (%)	Mean labor access (Adult eq.)	Mean current household size (persons)
		Male	Female					Yes	No			
NR II	Murehwa	33.3	66.7	59.1	6.4	37.3	4.1	62.5	37.5	20.7	3.6	6.3
	Bindura	38.9	61.1	59.5	4.7	34.8	6.0	81.8	18.2	26.7	2.9	4.7
	Seke	32.0	68.0	56.2	6.6	31.4	3.4	79.4	20.6	41.4	3.3	5.8
	Average	**34.5**	**65.5**	**58.0**	**6.0**	**34.0**	**4.4**	**74.7**	**25.3**	**29.5**	**3.3**	**5.6**
NR III	Mt Darwin	61.9	38.1	47.9	6.0	26.6	3.6	74.2	25.8	13.8	4.1	6.1
	Chirumhanzu	41.7	58.3	50.7	7.2	26.8	2.8	43.8	56.3	20.0	3.5	5.8
	Masvingo	50.0	50.0	58.9	6.2	34.8	4.3	68.3	31.7	16.1	3.5	6.0
	Average	**52.7**	**47.3**	**52.9**	**6.3**	**29.9**	**3.7**	**62.5**	**37.5**	**16.7**	**3.7**	**6.0**
NR IV	Nyanga	28.6	71.4	46.2	7.1	23.4	3.9	100.0	0	16.7	3.1	5.4
	Gokwe South	72.7	27.3	55.2	6.2	38.0	3.2	93.1	6.9	10.7	3.3	6.3
	Nkayi	75.0	25.0	61.5	7.1	36.8	3.3	64.0	36.0	20.0	4.6	8.3
	Insiza	53.8	46.2	53.4	6.2	23.6	3.8	76.9	23.1	17.4	3.3	6.4
	Average	**56.9**	**43.1**	**53.7**	**6.7**	**30.9**	**3.5**	**85.2**	**14.8**	**16.0**	**3.6**	**6.6**
NR V	Chivi	53.3	46.7	53.3	7.2	28.3	3.7	94.7	5.3	23.3	3.8	6.7
	Hwange	71.4	28.6	52.9	5.0	25.9	3.4	72.7	27.3	17.9	4.1	6.2
	Mangwe	22.2	77.8	53.6	6.7	22.3	3.9	95.7	4.3	13.6	2.8	5.5
	Chipinge	45.0	55.0	47.9	6.9	24.5	2.8	100.0	0	19.4	4.0	6.5
	Binga	100.0	0	44.1	6.4	19.5	2.6	93.1	6.9	8.7	5.2	9.0
	Average	**55.6**	**44.4**	**50.4**	**6.5**	**24.1**	**3.3**	**91.2**	**8.8**	**17.2**	**4.0**	**6.8**
NR II −V		**49.9**	**50.1**	**53.8**	**6.4**	**29.7**	**3.7**	**78.4**	**21.6**	**19.9**	**3.7**	**6.3**

3.2. CA Adoption Trends

Of the 416 farmers who were interviewed in 2009, 369 (89%) dug planting basins which is the central component of CA during the 2008/09 cropping season. This means that 11% of the farmers did not dig planting basins. The main reason for dropping out of conservation agriculture was the withdrawal of input support by NGOs to these particular farmers, compounded by the general lack of inputs such as seed and fertilizer at the local markets. The 89% of farmers practicing conservation agriculture adopted various components of the technology as shown in Table 3.

Table 3. Proportion of farmers using the following components of CF techniques (%)

Technique	Cropping season				
	2004/05[a]	2005/06[a]	2006/07	2007/08	2008/09
Winter weeding	51	87	76	71	63
Application of mulch	40	75	69	70	56
Digging of basins	100	99	99	97	89
Application of manure	89	88	89	87	80
Application of basal fertilizer	71	75	74	66	38
Application of top dressing	94	92	92	88	70
Post-planting timely weeding	94	98	99	96	85
Crop rotation	8	13	13	18	19

[a] Data for 2004/2005 and 2005/2006 seasons was obtained during the 2006/2007 survey

3.3. Digging Planting Basins

Most farmers are knowledgeable on when and how planting basins are dug. The digging of planting basins is generally done using hand hoes and may require more labor in clay soils. Though farmers with labor constraints would prefer to dig basins in sandy soils, there is a risk of having the basin destroyed by wind (especially in Chipinge where dust storms are a frequent phenomenon), as well as heavy rain and animals that roam freely in unfenced plots. However, it must be noted that most farmers tend to start digging planting basins in the months of September to October (even up to November), as a result they consider digging of planting basins a laborious exercise yet they squeeze in the basin digging phase into a short space of time before the onset of the rains (ZCATF, 2009).

3.4. Weed Management

Weed pressure causes a major threat to the sustainability of conservation agriculture. Although farmers are generally aware of the advantages of keeping the fields weed-free, there were variations on the levels of weeding managements recommended for conservation agriculture practices. Post-planting weeding, despite contributing to significant labor demands, is generally practiced by conservation agriculture farmers compared to winter weeding.

3.4.1. Post-Planting Timely Weeding

Farmers practising CA are expected to keep their plots weed free throughout the season. Weeding should commence as soon as weeds appear. This activity is taken seriously by farmers. Most farmers indicated that labor peaks are experienced during weeding. Conservation agriculture plots require an average of 2−3 times weeding per season compared to once for conventional draft tillage plots. Most farmers have an understanding that weeding has to commence as soon as the first weeds emerge. Results from Table 3 show that 85% of the respondents practiced post-planting timely weeding, and the proportion was even higher in the earlier seasons with virtually every farmer weeding in the 2006/07 season.

There is still some confusion on when timely weeding has to end; with results showing that 28.6% of the respondents who don't do post-planting timely weeding were not aware of the need to keep the field weed-free even when crops had reached maturity (Table 4). As the crop matures, farmers tend to leave the weeds in the fields as they believe crop yield will not be compromised at this stage. During this period, farmers prioritize labor to other off-field activities.

Table 4. Reasons for not practicing post-planting timely weeding (N=62)

Reason	Proportion of respondents (%)
Land was water logged	16.6
Labor constraints	21.4
Lack of knowledge	28.6
Plot was weed free	28.6
Burnt weeds after harvest	4.8
	100

3.4.2. Winter weeding

Winter weeding was a not a priority with 63% of the farmers practicing this activity in the 2008/09 cropping season (Table 3). Because of other off-season household commitments, winter weeding is regarded to be of less priority. Observations made during follow-up visits off-season to farmers' fields were that farmers had not weeded after harvest (Table 5).

During the survey, it appeared that there was some confusion on the definition of winter weeding and 30% of farmers did not practice winter weeding due to this lack of knowledge. According to most farmers, winter weeding entails weeding as they dig or just before they dig basins in September and October. Some respondents (8%) said there was no need to weed off-season as livestock would graze whatever is growing in the fields in the winter season whereas 4.0% of the farmers indicated that they burnt weeds after harvest as a form of weed, pest, and disease control measure (Table 5).

Table 5. Reasons for not practicing winter weeding (N=153)

Reason	Proportion of respondents (%)
Fewer weeds due to water logging	14.0
Lack of knowledge/yet to practice	30.0
Labor constraints	20.0
Weeds and crop residues eaten by livestock	8.0
Plot was weed free	24.0
Burnt weeds and crop residues	4.0
Total	100.0

3.5. Mulching

Forty-four percent of the interviewed farmers did not mulch their plots during the 2008/09 cropping season. These farmers indicated that their fear was that the mulch would be destroyed by animals and termites (17%, Table 6). There were also some farmers who tried mulching, but discontinued since they could not really notice any immediate benefits. This is understandable since some research in the driest areas of Zimbabwe have also indicated that the obvious benefits associated with mulching may take a longer time to be realized and the quality of the mulch is very important for soil organic matter build up. Mashingaidze et al., (2009) study on the contribution of mulch to yield in the short term confirm this. There are some farmers (16%) who still did not have any knowledge about the benefit of mulch which includes aiding in moisture retention and building up of soil organic matter in the long term (Table 6).

In general, however, farmers seem knowledgeable about mulching although there are misconceptions that mulching can only be done using crop residues. Generally, there is low production of biomass in smallholder farms which may not allow farmers to meet the 30% mulch cover as a minimum recommendation for conservation agriculture (Giller et al., 2009). However, various other materials can also be used as mulch including leaf litter and grass. Stone bunds may also be a viable option since they help in moisture conservation through reduction of runoff and allow more water to infiltrate (Donovan and Casey, 1998)

There is also competition for use of crop residues which may limit its use as mulching material. Farmers prefer to feed their crop residues, especially maize stover, to livestock. The communal nature of the fields and grazing system in the areas means that it is difficult for conservation agriculture farmers to control animals that wander into their plots for grazing. This means that most of the stover is lost to animals as they graze and this issue is exacerbated by the lack of fences in most of the fields. Legume stover (e.g., cowpea, soyabeans and groundnuts) that may be left in the fields is quickly decomposed so that at the start of the planting season there is little of the stover on the soil surface. .

Table 6. Reasons for not applying crop residue as mulch (N=183)

Reasons	%
Labor constraints	17.0
Lack of knowledge	16.3
Gave residues to livestock	31.2
Did not practice CF this season	17.0
Crop residues destroyed/given to livestock	17.0
Burnt weeds and crop residues/left weeds to dry up	1.5
Total	100

3.6. Manure Application

Farmers are aware of the need to apply manure and the one-handful per basin concept to increase fertility within the basin for the crop. Access to manure remains an issue to those farmers without livestock. Despite having the knowledge of manure application, the study revealed that farmers have little knowledge and limited experience on the treatment of manure for cropping purposes. The general trend is to heap cattle dung from cattle pens. The manure applied in the basins is usually not fully decomposed and may 'burn' the crop especially if it comes in direct contact with the seed. The timing of manure application is also another important issue that farmers tend to disregard. Farmers apply manure during planting, which increases the labor involved during the planting phase under conservation agriculture. Since most farmers are rushing to finish the application of manure and planting (done on the same date), they tend to disregard the fact that the seed-manure contact may affect germination rates. In drier areas, some farmers claimed that manure would 'burn' crops particularly when the season is characterized by long dry spells. This shows that there is need for better understanding by farmers on the right quantities that have to be applied, especially in the climatically risky semi-arid regions. Some farmers also believe that manure increases weed pressure.

3.7. Fertilizer Application

Use of basal fertilizer in conservation agriculture plots has been on the decline since 2005/06 (from 75% of respondents using it to only 38% in 2008/09). Ninety five percent of those not applying fertilizer in 2008/09 indicated unavailability as the reason for failing to use it (Table 7). Generally fertilizer was in short supply across the country in 2008/09 and only a few NGOs provided fertilizer to selected recipients. There was a small proportion (2.2%) of farmers who did not apply fertilizer to basin plots because they had used manure instead. In some areas fertilizer was delivered late and in the case of basal fertilizer those respondents ended up using the Compound D as topdressing. There are also issues related to fertilizer types, with some farmers getting confused with CAN/LAN which are similar to Compound D in color.

Table 7. Reasons for not applying fertilizer (N=258)

Reasons	%
Applied manure	2.2
Fertilizer not available	94.7
Lack of knowledge	0.9
Other	2.2
Total	100

3.8. Crop Rotation Practices

Crop rotation is the conservation agriculture component that has hardly been adopted by farmers across the 15 districts of Zimbabwe. Only 19% of the respondents (Table 3) practiced crop rotation on their conservation agriculture plots in the 2008/09 cropping season. The reasons for not practicing rotation varied with many farmers (30.6%) preferring to continue growing the staple food plot on their most fertile plot, which is the conservation agriculture plot. Seventeen percent claimed ignorance of the recommended practice (Table 8).

Many farmers (32.2%, Table 8) claimed that they had just started conservation agriculture and had not yet attained the stage of rotating the fields. Other farmers said they had not been taught how to incorporate legumes in basins as the basin spacing seemed more suitable for cereals whereas legumes required smaller spacing and a higher plant population. Some, however, were practicing a cereal–cereal rotation where they planted maize one year, followed by sorghum and/or pearl millet the following year. Legume seed shortage was another reason for not practicing rotation; the 19% (Table 3) who had practiced rotation received seed from the supporting NGOs.

Table 8. Reasons for not practicing rotation (N=337)

Reasons	%
Changed plot	0.9
Yet to practice. Just started CF practice	32.2
Lack of alternative seed for rotation	10.7
Prefer cereals to legume, cereal is staple crop	30.6
Lack of knowledge	17.0
Did not practice CF this season	6.4
CF spacing not suitable for legumes	0.9
Other	1.3
Total	100

3.9. Source of Inputs for Conservation Agriculture Plots for 2008/2009 Cropping Season

The NGO relief programs were the main source of inputs for the 2008/09 season. (Table 9). A large proportion of farmers also relied on maize seed from previous harvests kept in their own stock. Most of this seed was Open Pollinated Varieties (OPV) that is usable over multiple seasons. Market sources of seed, as expected, were limited largely due to unfavorable market conditions that prevailed during the course of the season. Farmers relied on own stocks saved from previous harvests for sorghum, pearl millet, groundnut and cowpea seed. Fertilizer sources were mainly from NGO and government relief programs (about 50%). A significant number of farmers also managed to purchase some fertilizer from retail sources (42%).

Table 9. Source of seed and fertilizer for conservation agriculture plots

	Maize	Sorghum	Pearl millet	Groundnut	Cowpea	Fertilizer
NGO	11.1	29.7	8.0	17.0	30.3	27.5
NGO previous season	18.0	20.5	20.0	12.8	18.4	2.9
Own stock	24.3	34.9	62.4	56.4	30.3	0.6
Retail shop	22.2	2.6	3.2	5.3	0.9	42.2
GMB*	16.1	7.4	4	4.8	14.4	17.3
Local farmer	7.6	4.4	1.6	3.7	4.9	8..5
ICRISAT	0.5	0	0	0	0.8	0.4
Seed fair	0.2	0.5	0.8	0	0	0.6
Total	100	100	100	100	100	100

**GMB – Grain Marketing Board*

3.10. Changes in Conservation Agriculture Plot Sizes

Land area allocated to conservation agriculture in some cases increased whereas it remained the same in others due to labor constraints, or adverse field conditions such as hard soil and infertility. Other farmers did not increase the land sizes citing shortages of seed, particularly where an NGO originally supporting conservation agriculture had pulled out of the area. Farmers who have been practicing conservation agriculture since 2004/05 have increased plot sizes over the years (Figure 1). This has mostly been a response to increased yield gains, particularly for farmers located in the high rainfall potential areas of NR II.

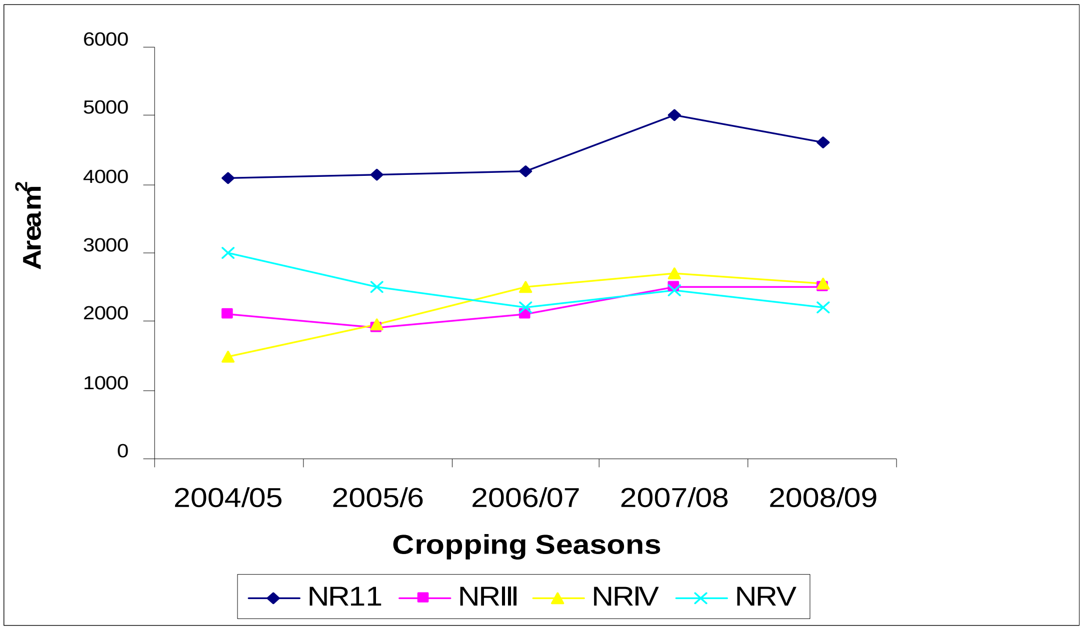

Figure 1. Changes in conservation agriculture plot sizes by agro-ecological regions

3.10.1. Influence of NGO Support to Conservation Agriculture Plot Size

Conservation agriculture promotions have commonly been associated with free input packages where farmers are given seed and fertilizer for their plots. These input handouts are usually just enough for small conservation agriculture plots. There is evidence to show that access to inputs influences the area allocated to conservation agriculture. Farmers tend to expand the area under conservation agriculture on the basis of input availability from NGOs. The initial message from NGOs was to target a conservation agriculture area of 0.25 hectares (Twomlow et al., 2008). Farmers have started to allocate closer to 0.5 hectares to conservation agriculture (Figure 2). The capacity to acquire inputs from alternative sources has limited the capacity for farmers to expand conservation agriculture plot sizes.

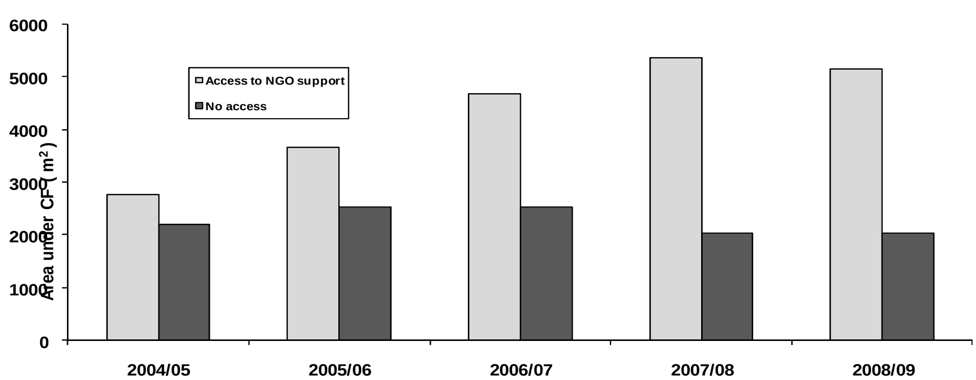

Figure 2. Influence of NGO support on conservation agriculture plot area

3.10.2. Influence of Gender on Conservation Agriculture Plot Size

Evidence from the survey results indicate that male-headed households take up conservation agriculture technology at a larger scale than female-headed households (Figure 3). Female-headed households are more likely to face a bigger land constraint. Figure 3 shows that male-headed households have a larger conservation agriculture plot area than their female counterparts except for the first 2004/05 season where the conservation agriculture area was similar for both male- and female-headed households. This is largely because it was the first season for most farmers and they tended to stick to smaller plot sizes regardless of land availability.

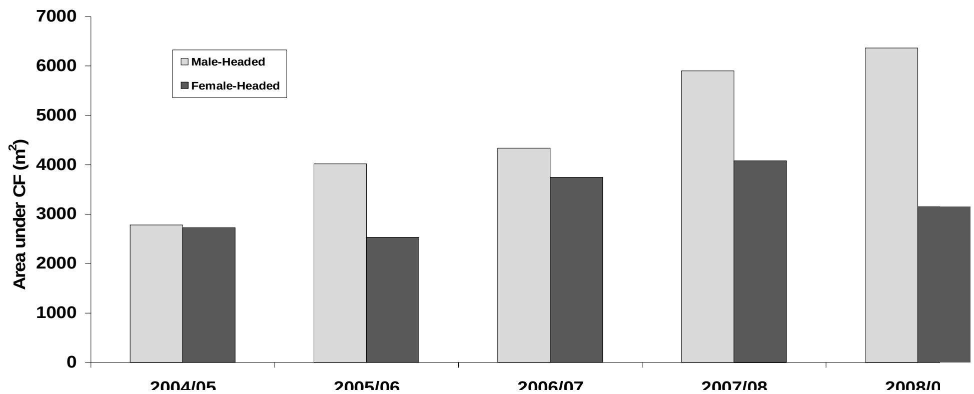

Figure 3. Influence of gender on conservation agriculture plot area

3.10.3. Influence of Labor Access on Conservation Agriculture Plot Sizes

Conservation agriculture is a labor-intensive technology and farmers have generally cited labor availability as one of the main constraints to increasing plot sizes. Figure 4 shows that farmers with more labor available are more likely to expand their area over time. If a household has two adults at most, the expansion of conservation agriculture plot size is limited compared to a household with more than two adults.

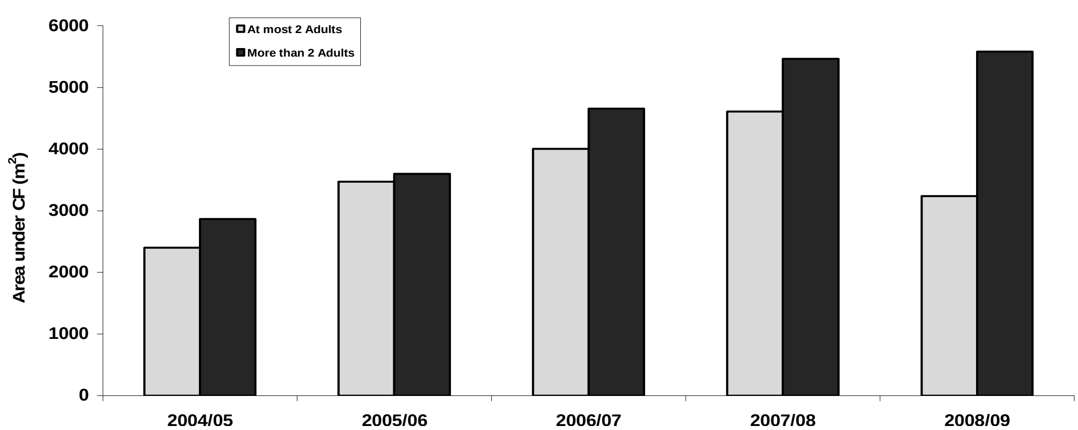

Figure 4. Influence of labor access on conservation agriculture plot size

Conservation agriculture plots are ideally supposed to be maintained for a number of seasons, allowing the basins to accumulate fertility. Farmers are expected to maintain the same planting stations and plots, which in theory should reduce the labor required in subsequent seasons. However, this poses challenges in rotations due to differences in cereal and legume spacing. Also, maintaining the same basins becomes difficult if they are no longer visible in the next season. Farmers are sometimes forced to change plots due to safety concerns from livestock or to look for more fertile land. Table 10 highlights reasons for changing conservation agriculture plots and planting stations.

Table 10. Reasons for changes in conservation agriculture plot and basin station

Why change CF plot?	**%**	**Why change basin station**	**%**
Looking for a more fertile plot	25.8	Instructed by NGO	1.1
Instructed by NGO staff	6.7	To change basin size	9.3
Plot infested by termites	1.5	Different spacing after rotation	20.9
To enable rotation	26.3	CF plot changed	28.5
Plot was far from homestead	1.5	Basins no longer visible	16.9
Plot prone to water logging	3.6	Spreading fertility across CF plot	5.6
Plot unprotected from livestock	2.1	Did not practice CF	17.7
Did not practice CF	32.5		
Total	**100**	**Total**	**100**

3.11. Production Impacts

In general, yields from conservation agriculture plots are higher than those from conventional draft tillage plots (Table 11). Maize, which is the main crop grown in all the districts, yielded on average 1546kg/ha on conservation agriculture and 970kg/ha on conventional draft tillage plots in the 2008/2009 cropping season. This can be attributed to the efficiency of the technology in providing good results across the four natural regions surveyed.

Table 11. Maize yields from conservation agriculture (CA) plots and non CA plots for 3 cropping seasons

Natural Region	**District**	**2006/2007**		**2007/2008**		**2008/2009**	
		CA	**Non- CA**	**CA**	**Non-CA**	**CA**	**Non- CA**
NR II	Bindura	1950	920	1109	510	1490	1208
	Murehwa	–		2266-	897	2132	1412
	Seke	–		-		1635	962
NR III	Chirumhanzu	1162	789	1207	340	1428	914
	Masvingo	1735	725	3060	557	2439	1355
	Mt Darwin	1105	701	1011	368	1190	877
NR IV	Gokwe South	2056	421	766	285	1433	713
	Insiza	-	-	800	247	1646	1105
	Nkayi	1244	789	1175	398	1579	792
	Nyanga	1917	1250	1247	787	1308	874
NR V	Binga	-	-	500	250	1384	868
	Chipinge	-	-	222	79	1262	1105
	Chivi	1500	910	1061	270	1658	874
	Hwange	1464	385	561	424	1563	713
	Mangwe			614	283	1048	792
Total Average Yield		**1570**	**765**	**1114**	**407**	**1546**	**970**

Larger yield gains are realized in conservation agriculture than conventional draft tillage plots because the technology promotes improved management and targeted application of fertilizers, timeliness of operations like planting, frequent weed control, and timely fertilizer application. There is potential for even greater yield responses given a favorable rainfall season.

While the season had normal to above-normal rainfall in the survey districts, the planted area is not enough to meet household food requirements to next harvest for most districts. Figure 5 shows the contribution of conservation agriculture to household food security. Assuming that an average household of six people requires 900kg of cereal in a year and does not have cash to access the market to buy grain, only farmers in Murehwa, Mt Darwin, Gokwe South, Masvingo, Chivi, Nkayi, Hwange, Chipinge, and Binga are likely to meet food security requirements till the next season. The proportional contribution of conservation agriculture to total cereal grain production was more than 50% only in Bindura, Masvingo, and Seke. The rest of the areas indicate more production on conventional draft tillage plots.

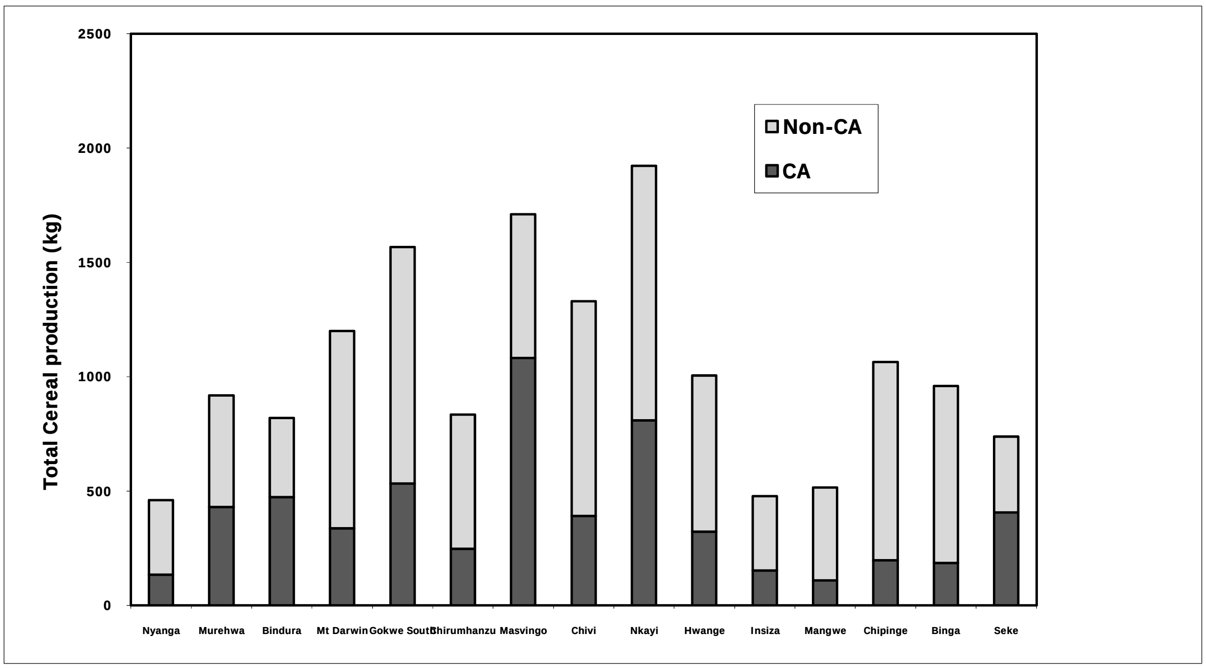

Figure 5. Contribution of CA to household food security (total cereal production in kg)

4. RECOMMENDATIONS FOR IMPROVING CONSERVATION AGRICULTURE TECHNOLOGY TRANSFER

The promotion of conservation agriculture technology has thus far been characterized by a mix of positive experiences and some apparent challenges. It therefore becomes critical to strategize on the best ways to address the challenges and sustain efforts of enhancing the potential benefits that have been realized this far. The following section is a discussion of some issues that have arisen in the transfer of conservation agriculture and strategies to address those:

4.1. Targeting farmers for conservation agriculture promotion

The promotion of conservation agriculture has primarily targeted vulnerable households as a way of mitigating the effects of food insecurity and chronic poverty. There is some concern however, about the extent to which these vulnerable groups can maximize input and technology support. In some instances, vulnerable farmers face severe labor constraints and chronic illnesses. This limits productivity particularly due to high labor demands associated with digging basins and timely weeding. Targeting has often excluded better resource endowed farmers, who could be better positioned to maximize on conservation agriculture practices. As a result, such farmers have, in most cases, not been exposed to training on conservation agriculture principles, yet they traditionally drive crop production and other related enterprises that provide livelihood means to the resource-constrained community members. Such exclusion has limited the technology transfer to diverse resource groups within the communities. It is therefore important to include both resource endowed and vulnerable households in the promotion of CA.

4.2. Level of NGO Support

Since 2004 NGOs within the context of conservation agriculture have spearheaded humanitarian efforts to address the lack of input access and low food production by providing seed and fertilizer to help farmers re-establish their farming operations. As a result, farmers tend to associate conservation agriculture adoption with access to free inputs. Farmers are therefore prone to stop practicing conservation agriculture when input support is withdrawn. Sustained conservation agriculture promotions should move away from NGO-related input support and encourage market-led interventions such as input credit facilities through seed and fertilizer companies and other public institutions, such as the Grain Marketing Board.

4.3. Weeding Practices

Farmers can derive considerable yield benefits from increased weeding frequency. The fact that farmers failed to practice winter weeding due to poor understanding of its importance and low prioritization due to other labor commitments calls for increased training. Off-season conservation agriculture activities such as winter weeding have been implemented with some difficulty. There has also been limited emphasis in training on the appropriate time to start winter weeding and farmers often do so just before digging the basins in August/September. Winter weeding is also a challenge because of conflicting demands for off-season labor. Farmers tend to concentrate on their gardens and other off-farm activities and are less willing to continue to weed their conservation agriculture plots. It is also socially uncommon and perceived strange to continue tending to the rainfed fields during the off-season; hence, farmers are reluctant to do so as a way of avoiding embarrassment.

Future conservation agriculture scaling out initiatives should consider the introduction of herbicides where appropriate to reduce labor requirements associated with weeding. Encouraging the use of cover crops and other mulch sources can also assist in weed suppression.

4.4. Mulching in Conservation Agriculture

The importance of mulching does not seem apparent to farmers. Close to half of the interviewed farmers did not apply mulch in the 2008/09 cropping season. Some farmers have also tended to limit mulching to the application of crop residues. There is competition between the use of crop residues as mulch and for livestock feed. Communal grazing laws commonly demand the use of crop residues as livestock feed, making it difficult for conservation agriculture farmers to reserve residues for mulching purposes. Plots are usually unfenced and grazing cattle enter during the off-season period. As a way of addressing this conflict there are instances where some farmers have removed the residues from their fields to store them in a safe place usually at their homes and put them back on after digging basins. While this provides a practical and feasible option in unfenced fields, it defeats the concept of permanent soil cover provision of conservation agriculture and increases labor for farmers.

Mulching has not shown any immediate benefits to crop productivity, largely because of the limited quantity of mulch (less than the 3t/ha optimum level). Mashingaidze et al.,(2009) in a two season study report no yield benefits from mulching. As such farmers are still skeptical about the benefits of continued application of crop residues as mulch. Availability of mulch remains a challenge owing to low biomass production, particularly in the drier Natural Regions IV and V (Giller et al. 2009) and therefore this requirement could be inappropriate given farmers' agro-ecological resource base. Future trainings should emphasize alternative ground cover methods that could be more accessible to the farmer such as grass and leaves.

4.5. Fertilizer Use

Inorganic fertilizer has consistently proved to be an important factor in yield improvement, even in low rainfall areas. Farmers applying fertilizer at an appropriate time will significantly improve their yield even in drier areas. Availability and accessibility of fertilizer however, remains a challenge and farmers largely depend on the NGO input packs and government subsidies. Farmers usually substitute basal fertilizer with organic fertilizers such as manure and compost when fertilizer is unavailable. Top dressing is still critical because of lack of substitute organic soil amendments.

Farmers' perceptions on fertilizer use are shifting and many farmers now appreciate the benefits of using fertilizer. There is need to improve fertilizer access through markets and credit facilities to ensure continued use of fertilizer among smallholder farmers. Alternative soil amendments such as *termitaria*, compost and manure should also be promoted. Farmers should be trained on treatment and preparation of these alternative soil fertility amendments to ensure they obtain maximum benefits from their use

4.6. Labor Demands

Labor demand has been a limiting factor in the expansion for conservation agriculture area. This labor constraint becomes even more adverse if targeted households have limited labor due to HIV/AIDS, chronic illness, or are child headed. NGO targeting criteria has often focused on such households for conservation agriculture promotions, leading to overwhelming labor demands.

Some labor demanding components such as weeding can be reduced through introduction of herbicides. While the study is assessing labor requirements in conservation agriculture, care should be taken to consider not only the labor requirements but, in addition, labor productivity since increased labor input also translates to increased production. Thus, any comparisons between conservation agriculture and conventional draft tillage benefits should focus on labor productivity i.e. the returns per unit labor invested.

4.7. Mechanization of Conservation Agriculture

Future conservation agriculture promotions should explore innovative ways that address the high labor requirements associated with the technology. There is need for mechanizing some of the operations such as basin preparation and weed control. The use of jab planters that are also labor saving can be alternatives for vulnerable farmers (Bishop-Sambrook et al.2004**)**. On the other hand, for resource endowed farmers, the use of rippers and direct seeding equipment could be good options particularly if the linkages to both input and output markets are secured for improved profitability.

4.8. Institutional Support

Extension provides an important link between the technology and farmers and ultimately sustains conservation agriculture adoption. However, this role has so far been limited due to resource constraints in the national extension service. It is important to strengthen the role of AGRITEX to implement and promote improved cropping technologies to farmers. NGO promotions of conservation agriculture are not permanent; therefore, this practice can only be sustained through involvement of the national extension service. Institutionalization of the technology promotions through AGRITEX will significantly contribute to sustained conservation agriculture adoption.

Current economic development efforts in Zimbabwe to open up markets will likely lead to improvements in the function of the commercial sector, including rural agro-dealers. Linking farmers to input markets such as commercial agro-dealers and distributing relief inputs through local retail outlets is likely to play an important role in sustained CF gains. This will include the use of vouchers to purchase seed and fertilizers that have generally been distributed freely to vulnerable farmers. Government plays a vital role in creating a favorable policy environment that will ensure the possibility of continued CF promotion and adoption. The role of policy support should ideally be able to create: accessible input markets, strengthened extension support to farmers, link farmers to credit facilities, and create output markets.

5. CONCLUSION

This panel study provides indications that there are some benefits to CA across different agro-ecological regions. Most farmers are now experienced in CA, having had at least three years of practicing the technology. Notable benefits include timely planting and better moisture conservation leading to increased yields. The most significant and sensitive yield factors in CA included good management as reflected in plot size, weeding frequency, and application of top dressing fertilizer. There are however some aspects of the CA technology that farmers are still finding difficult to fully practice. In most instances, winter weeding is not being done at the recommended time, which is soon after harvesting up until planting time. This is because of the labor constraint and competition for other off-season activities. Mulching is also done to a limited extent as farmers do not seem to see its immediate benefits, and also because of crop residue shortages and conflicting uses as livestock feed. There is need to promote other mulching materials that could be more readily available for use as ground cover. Crop rotation is still very limited due to legume seed shortage and farmer priorities towards cereal staple food crops.

Fertilizer use has consistently shown to have high payoffs to yield improvement but its use is limited by unavailability and unaffordability to farmers. Farmers have generally attained good yields on CA plots, with an average CA yield of 1.5 tons per ha compared to 1.0 tons per ha under the conventional farmer practice. CF practice has however been closely influenced by NGO support. Farmers who fail to get input support often stop practicing CF. Only in three of the 15 survey districts did CF production contribute to more than 50% of household food security requirements. This limited contribution is due to small area size for CF plots which limits total production. High CF labor demands and input shortages often force farmers to operate on small plots. Extension support has thus far been led by NGO-driven programs. The national extension service has had limited activity in transferring the CF technology to farmers, largely due to operational challenges in AGRITEX in the face of economic challenges that were prevailing in the country. There is still need for improvements in CF technology transfer strategies, incorporating research and extension, and favorable policies to ensure sustained CF uptake.

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