What Explains Minimal Usage of Minimum Tillage Practices in Zambia? Evidence from District-Representative Data

H. Ngoma,[1] P.B. Mulenga,[2] and T.S. Jayne[3]

[1] Norwegian University of Life Science, School of Economics and Business, Post Box 800, 1432, Ås, Norway, Email hambulo.ngoma@nmbu.no +47 6496 5705
[2] Indaba Agricultural Policy Research Institute, Post Net 99, 26A Middleway, Kabulonga, 10101, Lusaka, Zambia
[3] Department of Agricultural, Food, and Resource Economics, Michigan State University, East Lansing, Michigan 48824. USA.

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1.0 INTRODUCTION

Conservation agriculture or conservation farming (CF) as it is often called in Zambia, is widely believed to have potential for promoting sustainable agricultural productivity growth (Haggblade and Tembo, 2003; Baudron *et al*., 2007; Arslan *et al.,* 2013). CF technologies practiced in Zambia involve dry-season land preparation using minimum tillage methods (zero tillage, ripping and/or planting basins); retention of crop residue from prior harvest; planting and input application in fixed planting stations and crop rotations. Although CF has been promoted for more than two decades in Zambia, there is a dearth of reliable nationally-representative evidence on the extent to which CF practices have been adopted by farmers. Available evidence is based on case studies, small samples, and one-season snap-shots in selected regions, leading to widely differing impressions about the extent to which farmers are taking up CF practices as a means to raise their productivity and as a response to climate change (e.g., Haggblade and Tembo, 2003; Baudron *et al*., 2007; Nyanga 2012).

This study was designed to fill this gap by providing nationally-representative evidence on trends in two of the most important CF practices (planting basins and ripping) over a 5-year period. The study objectives were fourfold: i) To examine trends and spatial patterns in the use of planting basins and ripping from 2008 to 2012; ii) to determine factors influencing farmers' decisions to use planting basins and ripping; iii) to determine the influence of lagged rainfall shocks on farmers' decision to use planting basins and ripping; and, iv) to identify the factors affecting how much land farmers cultivate using minimum tillage practices.

2.0 MATERIALS AND METHODS

The study used pooled cross-sectional data from Crop Forecast Surveys (CFS), collected annually by the Central Statistical Office (CSO) and the Ministry of Agriculture and Livestock (MAL) for the period 2008 to 2012. CFS data are collected annually from about 13,600 farm households across the country, giving a total sample of roughly 63,000 households over the 5 year period in the current analysis. These farmers are exposed to CF promotion programs for varying durations depending on in their specific locations. We also used rainfall data for the corresponding agricultural seasons obtained from the Zambia Meteorological Department (ZMD). We report

trends in minimum tillage use (defined here as using either planting basins or ripping as the main form of land preparation on any field by a farm household). Instrumented bivariate probit and double hurdle econometric models were used to determine factors influencing farmers' decisions to use minimum tillage and the amount of land allocated to particular minimum tillage practices, while controlling for potential endogeneity resulting from "program placements effects" of CF promotion activities. Because such programs only operate in selected areas, there are likely to be non-random unobserved characteristics that may influence CF adoption. We therefore use an Instrumental Variables approach to address the potential endogeneity problem. The IV used was a bivariate variable identifying districts where the Dunavant Company operated its programs in Zambia.

3.0 RESULTS AND DISCUSSIONS

3.1 DESCRIPTIVE RESULTS AND DISCUSSIONS

National trends in use of ripping and/or planting basins among smallholder crop farmers from 2008-2012

Results show an estimated 51,000 farmers, or only 3.9% of Zambia's smallholder farmer population, practiced minimum tillage in 2012. However, there has been an upward trend in CF use since 2008, when only 1.8% of farmers practiced minimum tillage (Figure 1). Planting basins is the more common form of minimum tillage, being used by 39,000 (3.0%) of farmers nationwide in 2012, compared to only 12,000 (1.0%) for ripping. Use of planting basins has more than doubled over the 2008-2012 period, while use of ripping only increased marginally. However, use rates for both planting basins and ripping were highly variable between 2010 and 2012. Moreover, and perhaps surprisingly, the percentage of farmers using either form of minimum tillage was less than 10% even in the four provinces where CF has been most actively promoted in Zambia. Given the apparently huge benefits associated with the use of minimum tillage and conservation farming in general (e.g., Haggblade and Tembo, 2003) and the fact that the technology has been promoted for over two decades, the stubbornly low use rates observed in the districts where CF has been most actively promoted for over two decades raises questions about the constraints that farmers face in utilizing these practices.

What explains low and variable use of minimum tillage in Zambia?

Results from focus group discussions (FGDs) held in Chama, Choma and Petauke districts highlighted two main reasons for low use of minimum tillage in Zambia: i) high labor requirements of some practices like basins at times when labor is engaged in other activities; ii) high cash costs associated with purchase of requisite implements (Chaka hoes for basins and ox-drawn implements for ripping) and inputs like herbicides, hybrid seed and mineral fertilizers. Other reasons for low CF uptake drawn from literature on sub-Saharan Africa include competing uses for crop residues, farmers' inability to use mulch on land used for grazing, difficulties with implementing cereal-legume rotations proposed by CF because most farmers do not grow cereals and legumes on the same scale, and market access problems for legumes grown in excess of household consumption requirements (Andersson and Giller, 2012).

3.2 ECONOMETRIC RESULTS AND DISCUSSIONS

Factors influencing use of planting basins and ripping by smallholder farmers between 2008 and 2012 in Zambia

Empirical results presented in Table 1 indicate that male-headed households were more likely to use ripping than female-headed households and would cultivate larger parcels of land using minimum tillage in general. Additionally, results suggest that increasing landholding size is associated with higher probabilities that farmers would use minimum tillage and cultivate larger parcels of land. For each one hectare increase in landholding size, the vast majority of non-CF farmers would not increase their use of CF at all, but farmers already practicing CF would increase land cultivated under basins and ripping by 0.49 and 1.12 hectares, respectively. Our results also indicate synergies between CF and climate variability. We find that farmers in the current season are more likely to use minimum tillage practices in the season following a drought, and less likely to use these practices in the season following a flood, indicating farmers' perceptions that planting basins and ripping are appropriate for conserving moisture during drought stress, but inappropriate when rainfall is excessive. Moreover, the area under CF cultivation increases among users of minimum tillage after a year of low rainfall, and declines after years of excessive rainfall. We also find that farmers in districts where conservation farming programs have been operating are significantly more likely to use ripping and minimum tillage in general. Cattle disease is found to significantly reduce the use of using ripping, which is expected as ripping requires oxen for it use.

4.0 CONCLUSIONS AND IMPLICATIONS

In summary, the main conclusions from this study are:

1. Despite having been actively promoted for over two decades, minimum tillage use by smallholder farmers in Zambia is less than 5% at national level and less than 10% in the top 10 districts with the highest use rates over the study period of 2008 – 2012.
2. There is need to revolutionize development facilitation in the area of conservation farming and design extension programs that provide farmers with economic incentives (such as phased cost share agreements for the purchase of CA equipment) to overcome constraints on the sustainable use of conservation farming practices.
3. More support should be given to institutions gathering and disseminating weather information in order to guide farmers' decisions regarding tillage methods, as prospects of low rainfall raise farmers' incentives to use ripping and planting basins, while the prospects of excessive rainfall make these practices less appropriate.
4. There is need to support programs addressing animal disease outbreaks and those linking farmers to use of tractor drawn rippers and zero tillage planters as alternative ways to implement ripping.
5. There is need to initiate a more detailed nation-wide panel survey of farmers capable of better identifying the factors associated with adoption and dis-adoption of CA in Zambia.

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Figures and Tables

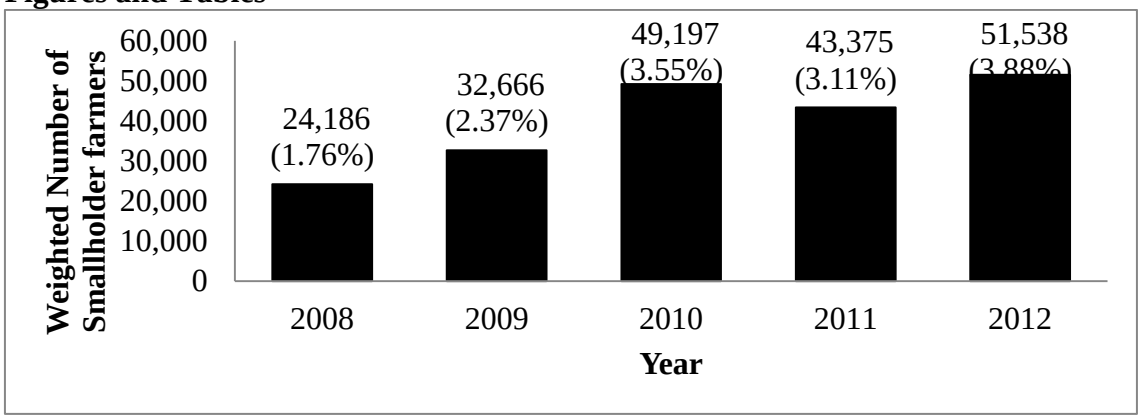

Figure 1: Trends in the total weighted numbers of smallholder farmers using ripping and/or planting basins by year from 2008-2012 in Zambia: Source: CFS 2008-2012

Table 1: Determinants of use of planting basins, ripping and minimum tillage from the Bivariate Probit model

	(1)	(2)	(3)
Variables	**Planting basins**	**Ripping**	**Minimum Tillage**
Male headed household (=1)	-0.0027*	0.0038***	0.0083**
	(0.0015)	(0.0015)	(0.0034)
Age of the household head (years)	0.0001*	0.0000	0.0001**
	(0.0000)	(0.0000)	(0.0000)
Land holding size (ha)	0.0018**	0.0060***	0.0065***
	(0.0008)	(0.0009)	(0.0010)
Rainfall stress(# of 20 day periods	-0.0002	-0.0004	-0.0001
with less than 40mm of rain	(0.0006)	(0.0006)	(0.0007)
Positive rain deviation (mm)	-0.0268***	-0.0341***	-0.0474***
	(0.0069)	(0.0082)	(0.0078)
Negative rain deviation (mm)	0.0110	0.0412**	0.0276
	(0.0131)	(0.0171)	(0.0187)
Agro ecological zone 3 (=1)	-0.0085***	-0.0075***	-0.0163**
	(0.0031)	(0.0026)	(0.0064)
Agro ecological zone 2a (=1)	0.0096***	-0.0060**	-0.0128***
	(0.0025)	(0.0024)	(0.0044)
Agro ecological zone 2b (=1)	0.0050	-0.0050**	-0.0111**
	(0.0031)	(0.0020)	(0.0054)
CFU has operations	0.0010	0.0328**	0.0788***
	(0.0048)	(0.0139)	(0.0279)
Agro ecological zone 2a * negative rain	0.0500***	0.0033	0.0454**

deviation (1, mm)	(0.0183)	(0.0138)	(0.0223)
Cattle disease (=1)	-	-0.0108***	-0.0187***
	-	(0.0030)	(0.0025)
Joint provincial dummy	187.77***	77.51***	205.70***
Joint year dummy	168.72***	194.07***	171.75***
Number of observations	62,708	62,708	62,708
Log Likelihood	-27,045.6	-23,738.1	-28,906.7
Bootstrap replications	100	100	100

Notes: Average partial effects with bootstrap standard errors in parenthesis; ***, **, * Significant at 1%, 5% and 10% respectively; Base ag. Zone is 1 (<800mm): Base year: 2008