Determinants of adoption and disadoption of minimum tillage by cotton farmers in eastern Zambia

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ABSTRACT

Conservation agriculture (CA) is heralded as a means to increase yields and reverse land degradation in sub-Saharan Africa, but low adoption levels have led to concerns about its suitability for smallholder farming systems. Combining data from surveys and semi-structured interviews, we examine farmers' motivations for adopting CA and the determinants of adoption and disadoption of hand-hoe and oxen-drawn minimum tillage (MT), a key component of CA. Farmers generally hold favorable opinions about MT, though not for its benefits to the soil but primarily for how it reduces crop losses from erratic rainfall. MT use rates in communities with the highest adoption rates are relatively low (12% of cotton area and 20% of maize area) and disadoption is common (25% of all farmers). Many farmers are interested in adopting MT but the available MT technologies do not match their resource endowments. Labor constraints limit use of hand-hoe basins while equipment costs limit ox-ripping. These results show that farmers are not stuck in traditional hoeing and plowing but are carefully evaluating the benefits and costs of adopting MT. Widespread adoption of CA will require adapting MT technologies to match a broader range of resource endowments.

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1. Introduction

There is increasing concern about the food security of smallholder farmers in southern Africa due to increasingly unpredictable rainfall patterns and expectations of declining rainfall with global climate change (Boko et al., 2007). Growing demographic pressure on farmland and the resulting reduced fallow periods are also causing land degradation, soil erosion and nutrient mining (World Bank, 2007).

As efforts proceed to develop and introduce new agricultural technologies to help mitigate the effects of climate change and land degradation in sub-Saharan Africa, much of the discourse focuses on conservation agriculture (CA) – a set of management practices including minimal soil disturbance, permanent soil cover and rotation or association with diverse crops (FAO, 2014). There is solid evidence from on-farm experiments that CA can improve soil fertility, resulting in improved maize production compared to conventional tillage when used with herbicide and fertilizer (Thierfelder et al., 2015). But after almost 20 years of promotion,

adoption of CA in southern Africa is low, at less than 1% of arable land (Hove et al., 2011). There are many documented challenges for implementing CA in the farming systems of the region, such as increased weed pressure, immobilization of nitrogen by cereal residues and a lack of markets for legumes (Giller et al., 2009).

Furthermore, there is growing evidence that CA benefits come from the interaction of minimum tillage (MT) with mulching and rotations (Thierfelder et al., 2013b). However, mixed cropping systems with free-range livestock are common in much of Africa and residues may be more profitably used as livestock feed than mulch (Homann-Kee Tui et al., 2015). Despite all these challenges, MT use in Eastern Province, Zambia has been steady or increasing for over a decade, though at low levels (5–15% of farmers; see Arslan et al. (2014) and Grabowski et al. (2014)).

This research aims to understand the drivers and limits of MT use in Eastern Zambia. It combines qualitative interviews with farmers and a survey of all farm activities to answer the following research questions:

a Given evidence of persistent use of MT in Zambia, how are farmers implementing the technology and overcoming the challenges of controlling weeds and maintaining residues?

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b What characteristics of the technology motivate farmers to consider MT and what socio-economic characteristics of farmers enable some to actually use it?

c Why do some farmers disadopt MT and what are the socio-economic characteristics associated with disadoption and non-adoption?

MT adoption studies in southern Africa primarily use econometric analysis of multi-purpose household surveys (Arslan et al., 2014; Ngoma et al., 2014), which lack details on farmers' underlying reasons for adoption (Andersson and D'souza, 2014). For this reason, Giller et al. (2011) emphasize the need for mixed methods research on adoption and disadoption. This study provides a unique MT adoption study that combines qualitative findings with econometric analysis.

The focus of this study is on smallholder farmers who grow cotton in Zambia's Eastern Province, though it includes analysis of all crops. Zambia is the country with the highest number of MT farmers in southern Africa (Hove et al., 2011; Haggblade et al., 2010). Farmers who grow cotton in Eastern Province provide a sub-population where MT has been successfully promoted and adopted without using material goods (e.g. food aid, fertilizer) as incentives. This allows us to analyze farmers' perceptions of the performance of MT and the constraints to its use where we know that promotion has been adequate,[1] the environment is reasonably suitable and adoption is more than a temporary response to material incentives. Challenges with MT technologies identified for this group are likely to be even more important among the general population of smallholders.

1.1. Conservation agriculture promotion in Zambia

In Zambia three MT technologies have been promoted: hand-hoe basins, ox-drawn ripping and tractor ripping (Grabowski et al., 2014). Basins are dug in a precise grid and each hole is approximately 20 centimeters (cm) deep, 30 cm long, and the width of a hoe blade. Farmers with animal traction can use a locally engineered ripper to open a furrow approximately 5 cm wide and 15 cm deep where the seeds can be sown and fertilizer or manure can be applied (Kabwe, Donovan, and Samazaka, 2007). Where tractors are available, tractor-drawn rippers can be used.

1.2. Adoption of CA in Zambia

Despite almost 20 years of MT promotion in Zambia's moderate-rainfall zones, national adoption rates remain low (Arslan et al., 2014; Grabowski et al., 2014). MT adoption in Eastern Province, Zambia is below 15% of households (Arslan et al., 2014; Ngoma et al., 2014). Nationally, where MT has been promoted, adoption correlates spatially with higher rainfall variability, suggesting that farmers use MT to reduce their vulnerability to an unpredictable climate (Arslan et al., 2014; Ngoma et al., 2014). For communities where cotton is grown, adoption correlates with greater herbicide availability, longer promotion and better demonstrations by lead farmers (Grabowski et al., 2014).

Adoption is often temporary, particularly when development agencies provide material incentives to adopters. Arslan et al. (2014) report 88% disadoption of MT in Eastern Province from 2004 to 2008. The authors attribute disadoption to the discontinuation of free or subsidized inputs, as has been documented elsewhere in

Zambia (Ngoma et al., 2014; Baudron et al., 2007; Haggblade and Tembo, 2003).

In contrast, thousands of cotton farmers have adopted MT without incentives in Zambia, making them the largest group of adopters (Haggblade and Tembo 2003). Cotton companies, which provide inputs on contract to smallholder growers, have actively promoted MT since the late 1990s (Kabwe et al., 2007). NWK Agri-services (previously known as Dunavant) and Cargill are the two largest cotton companies and strongest private sector promoters of MT (Haggblade et al., 2010). Herbicides and rippers have become more available to farmers on credit through both companies since 2010 (Grabowski et al., 2014). NWK encourages each of its distributors to have a MT demonstration plot for training. Cargill buyers hold "cotton schools" to train farmers on MT and cotton production practices. Numerous development agencies have also promoted MT in Eastern Province since the mid-1990s (Baudron et al., 2007; Arslan et al., 2014).

2. Materials and methods

We used a mixed methods approach to gain an in-depth understanding of the factors affecting farmers' decision to adopt MT or not. We used semi-structured qualitative interviews to document farmers' motivations and to guide the subsequent development of a survey instrument. The goal of the survey was to enable statistical analysis of the determinants of adoption and disadoption. We used thematic analysis to analyze the qualitative data and econometric analysis for the survey data.

2.1. Study area

Eastern Province is a high agricultural potential region where 24% of all households are smallholders, the highest rate in the country (Siegel, 2008). The province has unimodal rainfall and receives between 600 and 1200 millimeters annually. Though overall population density is relatively low (24.6 people/km^2– CSO, 2011), localized land scarcity exists, especially around large villages. Eastern Province has two agro-ecological zones: the *valley* zone has lower rainfall, higher temperatures and lower cattle populations because of tsetse fly infestation and the upland *plateau* regions have greater population density (40–70 people/km^2– CSO, 2011) and higher rainfall. This study focuses only on the plateau portion of the province (Fig. 1).

2.2. Selection of respondents

This study surveyed 245 respondents among farmers who sell cotton to Zambia's two major cotton ginning companies, NWK Agri-services and Cargill. The broad reach of these companies and their history of MT promotion provided a unique opportunity to study MT adoption across Eastern Province. NWK uses a system of distributors (lead farmers earning a commission from 50 to 100 cotton farmers) to provide training, distribute seed and chemicals, monitor fields and buy the harvest. Cargill employs buyers (who may not be farmers) to carry out similar functions but overseeing 200–500 farmers. The distributors and buyers of these companies keep lists of farmers in their communities, and these lists provided the sampling frame for this study.

Approximately 64% of farmers in Eastern Province grow cotton (Tembo and Sitko 2013). On average cotton farmers cultivate more land, own less cattle and earn a larger portion of their income from agriculture (Haggblade et al., 2011). This bias in our sample does not allow us to directly generalize to the broader community of smallholders, but understanding how these farmers are different allows us to interpret the likely implications of the results for the population as a whole.

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[1] We consider adequate promotion to be where programs have provided training and demonstrations so that most farmers are aware of what MT is and have had a chance to observe and evaluate if they would like to use it or not.