PhD Thesis: Conservation agriculture systems for smallholder farmers in Malawi: An analysis of agronomic and economic benefits and constraints to adoption

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Abstract

Conservation agriculture (CA) based on minimum mechanical soil disturbance, permanent organic soil cover and crop rotation is increasingly promoted to overcome problems associated with conventional tillage (CT) such as soil fertility decline, low and unstable crop yields and high production costs. Because of the resilience of the CA farming system, CA may be a tool to assist farmers as they adapt to variable and erratic rainfall resulting from the influence of climate change in sub-Saharan Africa (SSA). This study evaluates the agronomic and economic benefits of CA and constraints to its widespread adoption among smallholder farmers in Malawi. This study draws its empirical data from collaborative work between the International Maize and Wheat Improvement Centre (CIMMYT); the regional non-governmental organisation, Total Land Care (TLC); Agricultural Research and Development Programme (ARDEP); the Malawi Government extension services; the Department of Agricultural Research Services (DARS); farmers and farmer focus groups that were conducted between 2005 and 2012. The study was conducted in 12 target communities of 10 Extension Planning Areas (EPAs) in 8 districts in central and southern Malawi. Using on-farm researcher-managed trials in various agro-ecologies; the performance of CA systems was compared with CT in terms of soil quality, water infiltration, weed biomass, grain yield, labour productivity and economic returns. We administered and evaluated a structured questionnaire to capture farm household data on the factors that influence farmers' decisions to adopt and extend the use of CA on their fields. Using modelling tools, on-station trials and projected weather data for 2010-2030, the likely agronomic and economic and risk reduction potential of CA under the influence of climate change were evaluated.

Not surprisingly our results showed that CA without fertilizer provides few benefits to farmers in all agro-ecological zones studied. Maize (*Zea mays*) yields were 11% and 18% lower with no-tillage without mulch than with CT and no tillage with mulch, respectively. However, a combination of no tillage and mulch did not result in lower yields in the first seasons of practice and registered yield benefits over CT from season one in low rainfall areas and from season five in high rainfall areas. Associating maize and legume crop under CA did not result in significant yield reduction compared with CA maize monocropping, thus selected legume crops i.e. pigeonpea (*Cajanus cajan* L.) and cowpea (*Vigna unguiculata* L.) may be considered as 'a bonus' in CA systems without significant labour requirements. Furthermore, intercropping maize and pigeonpea under CA significantly increased crop biomass than CT. Mulch use suppressed weeds and improved water infiltration that improves the sustainability of the agro ecosystem in the long term. Soil fauna measured as earthworm and termites increased by more than 300% in CA than CT. Due to low cattle populations there is little competition for grazing crop residues; however, for CA to be successful communities must be engaged to address the issue of burning crop residues to hunt rodents and prepare fields. CA reduced labour costs by 28% due to reduced labour for land preparation and herbicide use, which provided farmers an opportunity to diversify their cropping enterprises by shifting labour to the production of cash crops. However, input costs increased from 230$USD in CT to 332$USD and 350$USD in CA maize monocropping and CA maize-legume intercropping, respectively. Nevertheless, net returns and returns to labour

were greater under CA than CT. Where herbicides were not used, labour savings in land preparation were offset by increased labour requirements for weeding.

Despite the potential of CA to increase and stabilize yields and increase labour productivity, its adoption by smallholders is skewed towards better resource endowed farm households which challenges equity dimension of CA among all groups of farmers. In addition, its adoption by smallholders is partial and adopters currently allocate less than half of their total cultivated land to CA – again challenging the potential of CA to improve ecosystem services at scale. However, this study has shown the characteristics of early adopters and the role of social learning in influencing adoption and extent of use of CA by smallholders. CA has been shown to have the potential to adapt the agricultural systems to climate change. Simulations of maize yield from 2010-2030 showed larger variation in yield under CT (3131 kg ha^{-1} to 5023 kg ha^{-1}) than CA systems (3863 kg ha^{-1} to 4905 kg ha^{-1}). CT and CA gave 50% and 10% cumulative probability of obtaining yield below the minimum acceptable limit of 4000 kg ha^{-1} respectively, suggesting that CA offers better prospects than CT, and might thus be preferred by risk-averse farmers in uncertain climatic conditions.

The skills and capabilities of field staff working with farmers become important in field characterization, choices of crops for different fields, possible combination of intercrops and crop sequences, farmer group formation to link farmers to farm inputs and produce markets, and training of farmers in correct herbicide use among others. Given small landholdings, intercropping maize and pigeon pea under CA appears to be a promising sustainable intensification system for smallholder farmers in Malawi. This is supported by the high possibility for farmers to retain crop residues as mulch and the continuing political will to support farmers with chemical fertilizers.