Does minimum tillage with planting basins or ripping raise maize yields? Meso-panel data evidence from Zambia

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Meeting rising food demand (Deininger, 2013; Laurance et al., 2014) pose challenges in sub-Saharan Africa (SSA).

Compounded by variable climate, productivity losses and price spikes.

How can farmers raise crop productivity to meet rising food demand?

The crux of the matter is how to balance higher crop yields and resilience.

Conservation agriculture (CA) could help through

- optimized input use, early planting, soil fertility improvements etc

CA includes minimum tillage (MT), in-situ crop residue and rotation.

CA promoted nearly two decades in Zambia and much of SSA.
Introduction

Figure 1: Components of minimum tillage

- Planting basins
- Ox-drawn ripping
- Zero Tillage
- Mechanized ripping

Min. Till = planting basins & ripping in the context of this study

Source: CFU

Hambulo Ngoma (HH-NMBU)  Minimum tillage yield effects  ICAE 2015
Limited and mixed evidence on CA crop yield impacts under typical smallholders (Giller et al., 2009).

Adoption is mainly partial (Andersson and DSouza, 2014; Arslan et al., 2014).

Is the agronomic rationale for CA at odds with CA outcomes under smallholders?

Three issues with current evidence base:
- the bulk comes from experimental plots or small samples
- most rely on only bivariate mean comparisons
- many are based on weaker identification strategies.

We focus on MT and estimate the ceteris paribus maize yield effects of planting basins and ripping
Data and Methods

- We use Crop Forecast Survey (CFS) data from 48,000 maize plots: 2008-2011 in Zambia (pooled cross sections from same EAs)
- CFS is the largest and updated survey of smallholders in Zambia, ca. 13,600 hh sampled per year.
- We estimate a quadratic production function of the form

\[ y = f(\text{tillage}, \ X, \ Z), \]  

(1)

where \( y \) is maize yield (Kg/ha), \textit{tillage} is a dummy of tillage variables, \textbf{X} is a vector of other inputs and hh characteristics, \textbf{Z} is a vector of AEZ variables.
Empirical model

- The full empirical model derived from Eq.(1) is

\[ y_{sij} = \text{tillage}_{sij} \beta_1 + X_{sij} \beta_2 + Z_{sij} \beta_3 + \text{year} \beta_4 + c_s + \mu_{sij} \] (2)

- We estimate Eq.(2) at national level and for the low rainfall agro-ecological zones - AEZs 1 and 2a

![Zambia Agro-Ecological Zones](image)

**Figure 2:** Zambia agro-ecological zones

- Yield effects are simulated with tillage before vs during the rains
The main issue to estimate the causal effects in Eq. (2) is the potential endogeneity of tillage choices. Farmer choices of basins and ripping (and other tillage and inputs), may be correlated to unobserved factors affecting maize yields. For example, farmer ability, business acumen and soil quality.

First, we used as many household and plot level controls as possible. Then, we used the correlated random effects (CRE) approach for the remaining $c_s$. CRE requires adding EA-means of all time-varying covariates in Eq. 2.
Main results: descriptives

- First, we looked at CDFs to compare yields for ripping vs plow tillage, and basins vs hand hoe.

![Cumulative distributions of smallholder maize yields by tillage method](image)

**Figure 3:** Cumulative distributions of smallholder maize yields by tillage method
Econometric results

- Selected average partial effects (APEs) (Figure 4). National results in top panel, and AEZ results in lower panel.

![Graph showing average marginal effects with 95% CIs]

**Figure 4:** Average partial effects (APEs), (dependent variable: maize yield (kg/ha))
Econometric results

- Selected average partial effects (APEs) (Figure 4). National results in top panel, and AEZ results in lower panel.
Econometric results

- Simulated yields effects are shown Figure 5.

**Figure 5**: Average marginal effects on yield; planting basins vs. hand hoe tillage; ripping vs. plowing, by timing of tillage
Econometric results

- Simulated yields effects are shown Figure 5.
Discussion of main results

Planting basin vs hand-hoe tillage yield effects
No statistically significant difference in maize yields on planting basins vs. hand-hoed plots on average overall (Figure 4), but basins raise maize yields by 191 kg/ha when tillage is done before the rains (Figure 5).

Ripping vs plow tillage yield effects
Maize yields are statistically significantly higher on plots prepared with ripping than plowing, ceteris paribus (Figure 4). These gains are highest in the lower rainfall agro-ecological zones (AEZ 1 and 2a) compared to the national models; averaging 821 kg/ha vs. 577 kg/ha.
Conclusions

- Our results reinforce the importance of early land preparation (and planting) to maize productivity.
- They also point to the significance of minimum tillage in improving smallholder maize productivity in Zambia and the region.
- Therefore, it is important to encourage MT farmers to prepare land and plant early.
- Given larger yield benefits of ripping vs plowing, access to rippers and ripping services could help raise smallholders maize yields in Zambia.

For more, see published article:
References


