The Impacts of Conservation Agriculture on Resilience to Weather Shocks in Zimbabwe

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BACKGROUND AND CONTEXT

Smallholder agriculture is a driver of economic development, particularly for the 75 percent of the world's poor who live in rural areas. While productivity improvements are required to feed a growing population, agricultural production is straining natural resources. Climate change also threatens agricultural production and food security, especially in Sub-Saharan Africa. In response, policy makers are encouraging the adoption of 'climate smart' agricultural technologies, including conservation agriculture (CA). Three principles associated with conservation agriculture include minimum soil disturbance (tillage), retention of crop residue or other soil cover (mulching), and crop rotations. The expected gains from adopting CA include increased productivity, increased resilience to weather shocks (through reduced run-offs and better retention of water in soils), and improved soil quality.

Despite its potential, there is little rigorous evidence of impact of CA on smallholder farmers in Africa, especially at scale over multiple crops and cropping seasons. At the same time, there is growing evidence that—outside of project contexts—adoption rates are low. To fill this evidence gap, researchers from the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) and the University of Illinois estimate the impacts of CA on yield and gross revenues of small farmers in Zimbabwe for a variety of crops over a four year period that included high, normal and low rainfall years.

DATA AND METHODOLOGY

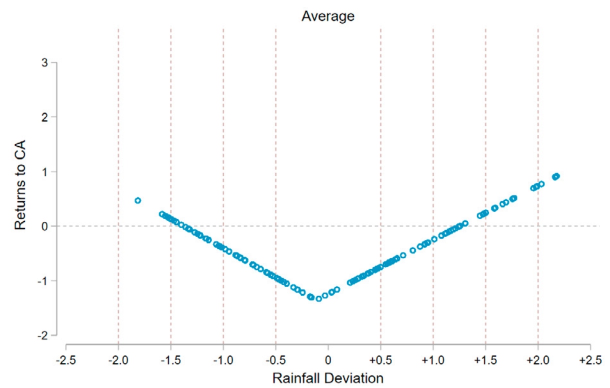
The study uses four years of panel data collected by ICRISAT from smallholder farmers in Zimbabwe from 2007 to 2011. Starting in 2004, ICRISAT was involved in promoting CA—based on hand-hoe prepared planting basins—in Zimbabwe. Through ICRISAT research and field trials, several modifications to CA had been made, and this survey was setup to assess trends in technology adoption. The nationally representative sample consists of 728 households across 45 wards. The data include detailed information about five crops—cowpea, groundnut, maize, pearl millet, and sorghum. Households are defined as adopting CA if they report using minimum tillage methods. Household survey data is combined with rainfall data from the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS), which provides daily rainfall measurements from 1981 to present and has 0.05 degree resolution.

Measuring the impact of conservation agriculture on yields is complicated—one issue is that adopters also use more inputs such as fertilizer. The decision to use CA is related to smallholder characteristics that are not observed and are constant over time, including tolerance for risk and farming ability. The study controls for biases from time variant unobserved shocks using an instrumental variable technique, and analysis included detailed control for inputs. The variable used in this study is the number of households in a ward that received non-governmental organization support as part of the Zimbabwe Protracted Relief Program (PRP) between 2007-2011.

CA ADOPTION RESULTS IN HIGHER YIELDS THAN TRADITIONAL CULTIVATION ONLY IN TIMES OF ABNORMAL RAINFALL

Impact on yields from the use of CA is positive for households that experience rainfall shocks, though the benefits vary by crop. Yields tend to be more resilient to both abnormally high and abnormally low rainfall for smallholders who practice CA than for those who use traditional cultivation practice. For instance, in the case of maize, the returns are positive only when rainfall is one and a half standard deviations below the average or one standard deviation above the average. When the cumulative rainfall in a season is closer to average, yield returns for CA in maize are negative. For sorghum, the yield gain with CA is positive regardless of the extent of rainfall shortage, and close to zero for above average rainfall. For a typical household with multiple crops, households need to experience a shortage of rainfall greater than one and a half standard deviations from the mean or surpluses greater than one standard deviation from the mean before yield returns to CA become positive (Figure 1).

Figure 1. Yield gain from CA for average smallholder compared to traditional practice for different levels of rainfall

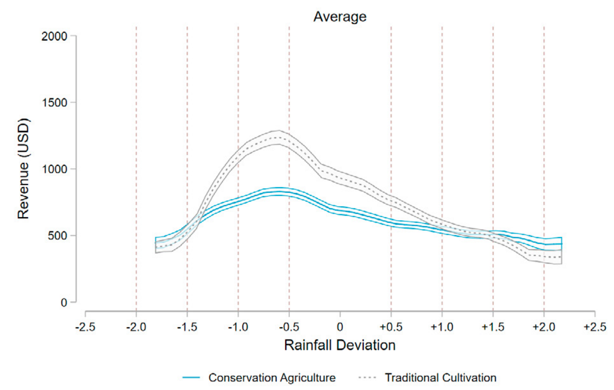


Note: Dots represent individual predicted yield returns, and lower density of dots represents fewer observations and less confidence. X-axis: standard deviation in rainfall (shortages are to the left of zero). Y-axis: average returns, is weighted average of crop specific yield returns where weights are the number of observations for each crop in the data.

In average rainfall periods, the use of CA has no significant positive impact on yield for any of the five crops. In fact, compared to traditional cultivation practices, CA likely has a negative effect on yields (i.e., reduces yields). This is in contrast to previous evidence documenting positive correlation between CA and yields.

Gross revenues to CA are also sensitive to intensity of rainfall shocks. On average, CA generates less revenue than traditional practice over a large portion of the rainfall distribution. CA produces more revenue at the far ends of the distribution (Figure 2). The differences in Figure 1 and Figure 2 are driven by a combination of which crops are more resilient to rainfall shocks when CA is used and the prices those crops command in the market.

Figure 2. Predicted gross revenue to CA and traditional cultivation practices averaged over all crops for different levels of rainfall



Note: X-axis, rainfall surpluses and shortages (shortage are to the left of zero). Vertical lines are drawn at plus/minus half a standard deviation from the mean.

Smallholders' reluctance to adopt conservation agriculture practices may be rational given their costs to implement (inputs, labor), and CA performance during times of normal rainfall. However, with climate change expected to increase the variation in rainfall, CA could help smallholders to mitigate risk. This study did not examine the long-term benefits of CA on other outcomes (e.g., soil fertility). Since adoption of CA increases resilience but with trade-offs, a nuanced understanding of the full range of costs and benefits will help better targeting.

SOURCE

Michler, J.D., Baylis, K., Arends-Kuenning, M., and Mazvimavi, K. (2018). *Conservation agriculture and climate resilience*. Journal of Environmental Economics and Management. 93: 148-169. https://doi.org/10.1016/j.jeem.2018.11.008

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