International Maize and Wheat Improvement Center

Low Risk, High Returns: How adoption of crop diversification and minimum tillage is a win-win for smallholder farmers in Malawi

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Overview

Rain-fed agricultural production in Africa is characterized by various forms of biophysical, environmental, institutional, and socio-economic risks that affect farmers' production and marketing decisions and welfare. Managing these risks is an important aspect of protecting livelihoods and opening up opportunities for investments and income growth (**see Box 1**). However, this requires adequate risk transfer mechanisms (e.g. insurance or income guarantee schemes). Investment in self-protection is critical in agricultural systems in Africa that feature unmitigated production risks, weak risk transfer mechanisms and weak or non-existent formal social safety nets. Our research demonstrate that most of the cost of risk comes from exposure to crop failure (downside risk) due to biotic or abiotic stresses.

In a developing country like Malawi where institutional innovations (markets for insurance, credit,and off-farm activity, social safety nets) are poorly functioning or largely absent, risk-averse farm households adopt diverse strategies including a portfolio of production practices to manage the multiple risks affecting their income and consumption.

In recognition of this, this brief presents results of a research effort that investigated the effects of various combinations of sustainable intensification practices (SIPs) on food security, on crop failure (downside risk) and on cost of risk.

Win-win Practices Considered

The SIPs examined include crop diversification (maize-legume intercropping and maize-legume rotations) and minimum tillage with residue retention. The improvement in natural resource base associated with these practices can help in improving the underlying biophysical functioning of the farming system enabling crop production to withstand a broader range of variations in moisture, temperature and biotic stressors. For example, reduced frequency of soil tillage and disturbance, and soil and water conservation efforts can have

Box 1: But don't we need farmers to take high risks for high returns?

It is an accepted fact of economic life that taking high risks is one way of making economic progress because households have to stake resources (sometime large amounts of it) in ventures whose outcomes are not certain but provide high return. If all risks in a farming are to be borne by the individual, then it can easily constrain the ability of these individuals or households to invest in risky but high return production options. Therefore, many households will make sub-optimal investments in high- yielding technologies. This is the case especially in subsistence framing systems where own-farm food production is a critical determinant of food security. In such cases, the risk of crop failure (and therefore failing to meet subsistence food needs) can have a devastating impact on the household welfare.

beneficial impact on soil nutrient recapitalization and improved soil quality, better water holding capacity of soils. Crop diversification can lead to improved control of diseases and pests and increase farmers' yield of both grains and legumes while reducing their risk exposure in terms of weather and market risks (e.g. fluctuations of grain prices).

Sampling, Data and Methods

We base our analysis on nationally representative farm household survey data collected in 2010 and 2011 in maize-legume farming systems of Malawi. The data was collected by the International Maize and Wheat Improvement Center (CIMMYT) under the Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) program and Maize CRP in collaboration with the Department of Agricultural Research Services (DARS) of Malawi. The survey covered 16 districts. A multi-stage sampling procedure was employed to select villages from each district and households from each village. A total of 1,925 households operating on 2,937 maize plots were randomly selected from the north, central and southern regions of the country. Data was collected on household socio-demographics, assets, social capital and network, trust, subsidy and farm and plot characteristics such as perceived soil fertility status, yields and input use.

Main Findings

Adoption effects on crop yield

We compare expected maize yield under the actual case that farm households adopted a particular package of SIPs and the case that they did not (**see Box 2 above**). Our results revealed that the adoption of SIPs significantly increased crop yield (60-75%). Higher yield effect (839 kilograms/hectare, or kg/ha) was obtained from the joint adoption of minimum tillage and crop diversification. This suggests complementarity in benefits. Furthermore, results showed that farm households that actually adopted SIPs would have harvested less maize yield if they had not adopted.

Adoption effects on downside (crop failure)risk exposure

The effect of the SIPs on downside risk showed that most of the yield distributions were below the average yield reported in the survey. In fact, the results showed that more than 50 percent of yields were concentrated left of the mean, with some extreme values to the right; suggesting the yield distributions were skewed to the right. We also found that higher expected yields are accompanied by higher variance and hence considering attitudes towards risk may be important in understanding famers' production behavior. So what are the

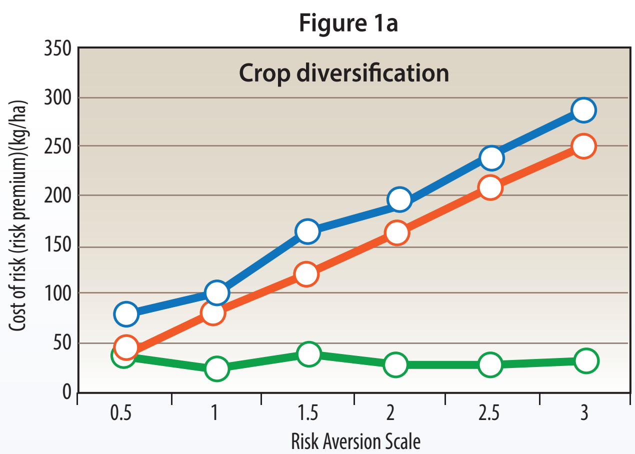
Box 2: A note on methods

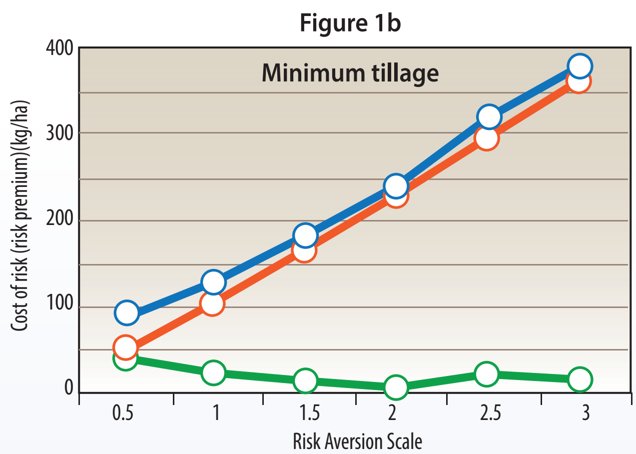
Farmers' technology adoption decisions are likely to be influenced systematically both by observed and unobservable characteristics that also explain yield and exposure to crop failure (which are outcome variables in this study). For example, better-off farmers with more experience and farming skills may be able to choose the more productive SIP combinations. This presents an estimation challenge in so far as these unobserved factors affect both the outcome and technology choice. In our research estimation, the impact of such unobserved factors must be removed if an accurate impact estimation of adoption is to be done. We model farmers' choice of combinations of SIPs and impact of adoption using Multinomial Endogenous Switching Regression (MESR) in a conterfactual framework where multinomial logit model used to correct the unobserved factors. The analysis considers the adoption of SIPs as a treatment, and the adoption effects for adopters are estimated comparing the outcomes that the adopters currently obtain with the outcome that they could have obtained if they had not adopted. Risk was estimated as the deviation of yield below a mean level and the cubed deviation was used as a proxy for downside risk (crop failure). The cost of risk was measured by risk premium considering the risk preference of farmers using the quantile moments (mean, variance and skewness) based approach. It is dominated by maize yield (kg/ha).

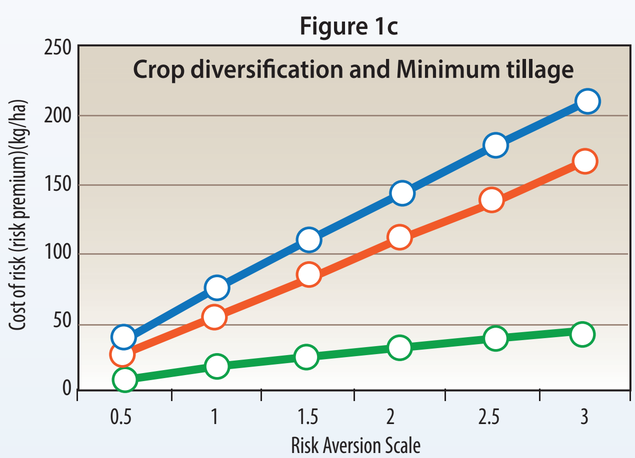
implications of adopting the SIPs on downside risk? We found evidence that adoption of crop diversification or minimum tillage individually or in combination significantly increased yield skewing to the right, that is decreased the exposure to crop failure. As was the case with crop yields, the reduction in probability of crop failure was higher (72 percent) with joint adoption of SIPs than when they were adopted individually (30-42 percent). The estimation of downside risk approach doesnot capture farmers risk preference and upside risk. The cost of risk measured based on quantile approach overcome these limitations.

Adoption effects on cost of risk

Results on the link between adoption and the cost of risk are summarized in Figure 1. The results indicated that the cost of risk is higher for non-adopters compared with their adopting counterparts. The higher cost of risk reduction is achieved when SIPs were adopted in combination (see Figure 1c). Joint adoption reduces the cost of risk by 4 per cent of the maize yield compared with non-adoption under moderate risk aversion. Our findings showed that the cost of risk associated with the downside risk (crop failure) can be quite large: it accounted for about 49-90 percent (average being 64 percent) of the total risk premium for adopters and 58-90 percent (78 percent on average) for non-adopters. These results underline the economic significance of the risk of crop failure (downside risk) and the importance of analyzing yield and risk assessment outcomes not just by looking at the mean outcome and variance but also the higher order moments (how skewed yields are going to be). In general, findings from this study revealed that the adoption of SIPs and more importantly adopting them in combinations was a win-win strategy – which increased food security and decreased the likelihood of crop failure.







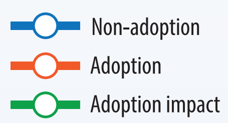


Figure 1. Cost of risk under different SIPs.

Policy Lessons

Adoption of crop diversification and minimum tillage was a risk-reducing strategy in maize production. The highest crop yield and reduction in downside risk as well as reduction in the cost of risk was achieved when farmers adopted crop diversification and minimum tillage jointly rather than individually. These results have important policy implications for building farmers' risk mitigation behavior. In an effort to achieve sustainable smallholder agriculture in developing countries, and thus address household food security and income needs, joint adoption of better agronomic practices (such as minimum tillage and crop diversification studied here) can be considered as an ex-ante strategy to reduce production risk exposure. In dealing with production risks and considering the issue from a policy or programing perspective, these practices could complement other risk-reduction strategies such as insurance, subsidies and social safety nets schemes to improve farmers' food security status through investment in agriculture.

Considering the production risks farmers face and considering the issue from a policy or programming perspective, SIPs could compliment other risk reduction strategies such as insurance, subsidies and safety net schemes. Therefore, the adoption of suites of agronomic and resource management practices should be considered in designing and developing risk protection strategies.

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Maize under conservation agriculture (CA), with residues of the previous crop, in Malawi.

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