Feed the Future Innovation Lab for Food Security Policy

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Does Sustainable Intensification of Maize Production Enhance Child Nutrition? Evidence from Rural Tanzania

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Introduction

In many developing countries including Tanzania, food insecurity and child malnutrition remain persistent problems. Globally about 155 million children under age five are stunted, which is the result of chronic malnutrition; more than one third of these children live in sub-Saharan Africa (SSA) (UNICEF, WHO, and World Bank Group 2017). Malnutrition is a leading cause of child mortality, making children more vulnerable to severe diseases. Approximately 45% of global deaths of children under age five are linked to malnutrition and the mortality rate of children in SSA is the highest in the world (Black et al. 2013; Fund UNCS 2014). Tanzania is the third worst affected country in SSA with respect to child malnutrition, exceeded only by Ethiopia and the Democratic Republic of Congo (Muhimbula and Issa-Zacharia 2010).

Agriculture and nutrition are closely linked because the majority of undernourished people still live in rural areas and many of them are smallholder farmers (Sibhatu, Krishna, and Qaim 2015; Pinstrup-Andersen 2007). Agriculture can affect the level of nutrition of smallholder farming households in primarily two ways: (1) through production of food crops in different quantities and qualities, and at different levels of diversity that households then consume directly; and (2) through the sale of agricultural output, which can raise household incomes and, in turn, affect food purchases and consumption (Jones, Shrinivas, and Bezner-Kerr 2014; Hawkes and Ruel 2006). These agriculture-nutrition linkages imply that the adoption of improved agricultural technologies at the farm household level may play a pivotal role in reducing the level of child malnutrition through higher crop yields and returns.

Key Findings:

- We explore the effects of different combinations of three soil fertility management practices (inorganic fertilizer, organic fertilizer, and maize-legume intercropping) used on rural Tanzanian households' maize plots on the nutrition outcomes of children within the household.
- For children under age five (0-59 months), their household's adoption of *SI* (joint use of inorganic fertilizer with organic fertilizer and/or maize-legume intercropping) practices for maize production raises children's height-for-age z-score (HAZ) and weight-for-age z-score (WAZ) by 0.60 units and 0.43 units, respectively, compared to those in non-adopting households. These are sizeable increases relative to the sample mean HAZ and WAZ of -1.78 and -0.96, respectively.
- For children aged 25-59 months, who are less likely than younger children to be breastfed and may be more directly affected by household diet changes associated with changes in agricultural practices and production, our results consistently suggest that adopting practices in the SI group increases HAZ and WAZ by 0.36 and 0.58 units, respectively,.
- On the other hand, adoption of *Intensification* (use of only inorganic fertilizer) and *Sustainable* (use of only organic fertilizer, only maize-legume intercropping, or both) have either no statistically significant effects on HAZ and WAZ or the esimates are not robust across model specifications.
- Overall, joint use of inorganic fertilizer with maize-legume intercropping and/or organic fertilizer appears to be the most beneficial for child nutritional outcomes.

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Although the adoption of conventional agricultural intensification practices such as high-yielding crop varieties and inorganic fertilizer substantially contributed to reductions in food insecurity in SSA for the past several decades (Godfray et al. 2010), such forms of intensification might not be sufficient to sustainably raise agricultural productivity and could have negative environmental consequences (Pingali 2012; Kassie et al. 2015). In this context, agricultural sustainable intensification (SI) has been gaining attention as a possible solution to simultaneously address nutrition/food security and environmental security challenges (Petersen and Snapp 2015). Narrowly defined, SI entails raising agricultural productivity while preserving or improving the natural resource base, but broader definitions of SI require that it also maintain or enhance human well-being, including child nutrition (Zurek, Keenlyside, and Brandt 2015). It is an open question, however, whether adoption of practices that contribute to SI from an environmental standpoint do indeed improve child nutrition. To begin to address this question, this study uses data from Tanzania to analyze the child nutrition effects of rural households' adoption of farming practices that contribute to the SI of maize production, an important staple food that is widely grown by smallholder farmers. To do this, we apply a multinomial endogenous treatment effects model using three-waves of nationally representative household panel survey data (the Tanzania National Panel Surveys of 2008/09, 2010/11, and 2012/13) conducted by the Tanzania National Bureau of Statistics in conjunction with the World Bank.

Sustainable Intensification of Maize Production in Tanzania

SI of maize production is particularly important in Tanzania because maize is the main staple food and the most common complementary or weaning foods for children in the country are maize-based (Kimanya et al. 2010). This study focuses on three soil fertility management (SFM) practices (alone and in combination) that have the potential to contribute to SI in maize-based systems: (1) inorganic fertilizer, (2) organic fertilizer, and (3) maize-legume intercropping. We group households into four categories based on their use of these practices on their maize plots: *Non-adoption*; *Intensification* (use of only inorganic fertilizer); *Sustainable* (use of only organic fertilizer, only maize-legume intercropping, or both); and *SI* (joint use of inorganic fertilizer with organic fertilizer and/or maize-legume intercropping on the same plot) (see Table 1). We then estimate how households' adoption of each SI category affects nutritional outcomes of children within the household. Out of 4,269 maize growing households across the three rounds of survey data used in the study, about 41% fall in the Sustainable category. The Intensification and SI categories are much less prevalent, at 6% and 9% of maize-producing households, respectively (Table 1).

Table 1. SI of Maize Production Categories and Prevalence among Maize-Growing Households in Tanzania

Case	Inorganic fertilizer	Organic fertilizer	Maize-legume intercropping	SI category	% of maize-growing HHs in this category
1				Non-adoption	44.3
2	√			Intensification	6.1
3		√		Sustainable	40.8
4			√		
5		√	√		
6	√	√		SI	8.8
7	√		√		
8	√	√	√		

Source: Author's calculations based on Tanzania National Panel Survey (TNPS 2008/09, 2010/11, 2012/13).

Child Malnutrition in Tanzania

In studies on child malnutrition, nutritional status is usually measured with two indicators: weight-for-age z-score (WAZ), and height-for-age z-score (HAZ). These measures reflect long-term factors such as deficiencies in nutrition, frequent infections, and inappropriate feeding practices. WAZ and HAZ measure nutritional status in the form of z-scores derived by comparing children's weight-for-age or height-for-age with these outcomes for children in a well-nourished reference group. For example, WAZ is the difference in standard deviations of a child's weight-for-age from the median weight of children of the same age and gender in the reference group. A child is considered underweight if his/her WAZ is below -2, and stunted if his/her HAZ is below -2. The national prevalence of underweight children under age five in Tanzania steadily decreased from 16% in 2008/09 to 13% in 2012/13. Stunting also declined from 43% in 2008/09 to 37% in 2012/13 (Table 2). However, child malnutrition rates in rural areas continue to be substantially higher than in urban areas (See Table 2).

Findings and Policy Implications

The full regression results from the multinomial endogenous treatment effects model are reported and discussed in the working paper associated with this policy brief. For simplicity, this policy brief focuses on the key factors explaining the adoption of SI categories and the local average treatment effects of adoption of the various categories on child nutritional outcomes. Consistent with previous studies, we found that access to off-farm income, more secure land tenure, market distance, and livestock ownership are key factors explaining the adoptin of different SI categories. In addition, the results suggest that the producer price of maize plays an important role in the adoption decisions: increases in this price positively affect adoption of Intensification but negatively affect adoption of Sustainable maize production practices in Tanzania. The results further suggest that access to extension advice and subsidized fertilizer, and the presence of farmers' cooperatives in the community are important determinants of the adoption of the various SI categories.

Table 3 summarizes the effects of adoption of the various SI categories on child nutritional outcomes among maize-growing households in Tanzania. The upper panel in Table 3 shows the results for the full sample of children under age 5 (0-59 months). These findings suggest that the SI category increases children's HAZ and WAZ by 0.60 units and 0.43 units, respectively, compared to those in non-adopting households. These are sizeable increases relative to the sample mean HAZ and WAZ of -1.78 and -0.96, respectively.However, the negative impact of the Intensification category on HAZ is counter-intuitive because the use of inorganic fertilizer is expected to raise maize yields relative to the Non-adoption group, which we expect to either positively affect child nutrition outcomes or have no statistically significant effect. We therefore treat this result with caution and as shown below, this finding is not robust in sub-sample analysis. Because children aged 0-24 months who are largely breastfed may not be as responsive to food intake, we re-estimate the models using the sub-sample of children aged 25-59 months. The sub-sample results (shown in the lower panel of Table 3) suggest that adopting practices in the SI groupincreases HAZ and WAZ by 0.36 and 0.58 units, respectively, on average.

Table 2. Trends in the Malnutrition Status of Children under Age 5 in Tanzania

	Underweight (%) (WAZ < -2)			Stunting (%) (HAZ < -2)		
	2008/09	2010/11	2012/13	2008/09	2010/11	2012/13
Tanzania	15.9	13.6	12.5	43.0	34.8	37.4
Urban	9.8	9.2	9.3	30.2	24.1	29.5
Rural	17.1	14.6	13.3	45.6	37.2	39.3

Source: Tanzania National Bureau of Statistics 2014.

Table 3. Estimated Effects of the Adoption of Each SI Category on Child Nutritional Outcomes (Changes relative to Non-Adopters)

Full sample: 0-59 months (n=2,898)		
	HAZ	WAZ
Intensification	- 0.54	No effect
Sustainable	No effect	No effect
SI	+0.60	+0.43
Sub-sample: 25-59 months (n=1,453)		
	HAZ	WAZ
Intensification	No effect	No effect
Sustainable	No effect	No effect
SI	+0.36	+0.58

Notes: Base category is Non-adoption. No effect indicates that the result is not statistically different from zero. All other results reported in the table are statistically significant at the 10% level or lower.

Overall, the robust finding in this study is that the adoption of the SI treatment group substantially improves both HAZ and WAZ. These effects are mainly among children age 25-59 months who are less likely to be breastfed and may be more directly affected by household diet changes associated with changes in agricultural practices and associated changes in crop production and/or incomes.[1] These findings may be due to various benefits from adopting packages in the SI group – e.g., better access to nutritious legumes from use of maize-legume intercropping and synergistic effects between practices such as larger increases in crop yields when inorganic fertilizer is used jointly with organic fertilizer and/or maize-legume intercropping.

Our results have two main implications for agricultural policy and future research. First, it is important for policy makers to find effective ways to increase joint use of these practices by Tanzanian maize farmers. At present, Tanzania has much lower adoption rates of inorganic fertilizer, organic fertilizer, and maize-legume intercropping than other countries in eastern and southern Africa such as Kenya, Malawi, and Ethiopia (Kassie et al. 2015). Our results suggest that agricultural extension and subsidies for inorganic fertilizer may be effective strategies to promote these practices; however, additional research is needed to confirm these findings and to identify cost-effective extension approaches and input subsidy designs to promote SI. Second, future research could examine if SI of maize production also enhances household food security and could identify the pathways through which SI of maize production affects child nutrition (and potentially household food security).

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[1] In the working paper associated with this policy brief, we examine differential effects of the SI treatment groups on the nutritional outcomes of younger children (i.e., children aged 6-24 months) but we do not find evidence of statistically significant child nutrition effects.

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