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How does adopting hybrid maize affect dietary diversity on family farms? Micro-evidence from Zambia

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ABSTRACT

Maize dominates as a staple food in Zambia, where the government has for many years promoted hybrid seed use in order to enhance the food self-sufficiency of poor rural families. Despite the policy importance of household nutrition in Zambia, we are not aware of any recent analyses that have related the use of hybrid seed to diets among smallholder maize growers. Previous research has demonstrated a linkage between indices of dietary diversity and healthy diets among women and children. We estimate two-stage, instrumental variables, Poisson, and ordered logit regression models to test the association between hybrid seed use and four indicators of dietary diversity: food group diversity (24-h), vitamin A diversity (7-day), food frequency (7-day), and frequency of consuming foods fortified with vitamin A (7-day). Results are robust to econometric method and indicator: women interviewed in maize-growing households that plant hybrid seed have more diverse diets.

Introduction

Zambian smallholder farmers have grown hybrid maize since the 1970s, benefiting from public investments in maize research, two phases of state-managed subsidy programs, and one of the more vibrant seed industries in Eastern and Southern Africa (Howard and Mungoma, 1997; Kassie et al., 2013). Despite this experience, surprisingly little research has been published on the impacts of hybrid maize until recently (e.g., Langyintuo and Mungoma, 2008; Hamazakaza et al., 2013; Mason and Smale, 2013).

Viewed from the perspective of the Green Revolution in wheat and rice in Asia (Joshi et al., 2004), some development practitioners have hypothesized that growing high-yielding crop varieties encourages crop specialization, and may drive farmers to abandon crops that serve as alternative food sources. Others have countered that adoption of high-yielding foodcrops in a land-constrained setting, such as hybrid maize in Malawi, enables farmers to allocate land away from their subsistence crop toward other food crops and remunerative cash crops (Heisey and Smale, 1995). Compared to Malawi, Zambia's maize-based farming systems are land-abundant.

In a detailed study implemented by the International Food Policy Research Institute (IFPRI) during the late 1980s in the Eastern Province of Zambia, Kumar (1994) tested the relationship of hybrid seed use to dietary diversity among smallholder maize farmers. She concluded that while staple food consumption was greater in areas with higher rates of hybrid maize adoption, dietary diversity may have declined due to greater reliance by farmers on their own production and fewer purchased food types. Historically, maize-growing smallholders in Eastern Province, where Kumar conducted her research, grew hybrid maize for cash but continued to grow local maize varieties because of strong consumption preferences for flint-type grain. Thus, the negative relationship between hybrid maize adoption and food intake was a striking result.

The purpose of our analysis is to test the hypothesis that growing hybrid maize affects dietary diversity among smallholder maize-growing families in Zambia, with a particular focus on sources of vitamin A. We have no apriori reason for predicting the direction of effects. Growing hybrid seed could contribute to the diets of smallholder, maize-growing families in contradictory ways. On one hand, growing higher-yielding maize could enable smallholders to meet their staple food needs on smaller land areas, releasing land for the cultivation of other crops that can be consumed or sold. However, families with very limited land areas may simply consume more maize, adding to their caloric intake but not to dietary diversity. On the other hand, growing higher-yielding maize could lead to additional maize sales. Income earned

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form maize sales could enable farm families to purchase new foods, but these do not necessarily lead to more diverse diets. Devoting more land to hybrid maize because it is profitable might narrow the range of crops produced and consumed.

Malnutrition and food security continue to occupy the center stage of agricultural policy in Zambia. In our analysis, we also address a specific element of micro-nutrition—vitamin A. Vitamin A deficiency is a cause of impaired growth, weakened immune systems, and increased risk of death due to infection among children (West, 2002). In Zambia, over half of children under five years of age are considered to be vitamin A deficient, as indicated by low plasma retinol concentrations (NFNC/University of Zambia/MOST/CDC, 2004).

Despite progress in supplementing the consumption of vitamin A through health programs and fortified sugar, vitamin A deficiency persists. Maize meal products are another means of fortifying food. However, although maize is the most commonly consumed food in Zambia, only 23% of households purchase pre-milled roller and breakfast maize—the only maize meal products that are considered to be fortifiable (Fiedler et al., 2012). Since most households rely on their own harvested grain or do not purchase fortifiable maize meal products, improved maize seed is a major vehicle for addressing vitamin A deficiency.

We test our hypothesis by applying econometric models to data collected through personal interviews with 1128 maize-growing farm households in the major maize-producing regions of Zambia in 2011. We define dietary diversity indicators according to recent research advances (Arimond et al., 2010). We specify our estimating equation within the rubric of the non-separable model of the household farm, and apply it with instrumental variables and ordered logit regressions.

Methods

Data sources

The data were collected through face-to-face interviews in a statistical survey that was implemented by the International Maize and Wheat Improvement Center (CIMMYT), and the University of Zambia. The population domain included five provinces (Central, Copperbelt, Eastern, Lusaka, Northern, and Southern), located in three agroecological zones (AEZ I, AEZ IIA, and AEZ III) that represent the major maize-producing zones of Zambia). These three AEZs served as strata.

For reference purposes, AEZ I is a low-rainfall area that includes the Southern portions of Southern and Western Provinces (Luanga-Rift Valley). This zone is the hottest and driest region of Zambia. AEZ IIA runs east to west across the center of the country and includes the Central and Lusaka provinces as well as parts of Southern and Eastern Province. Rainfall and soils are more favorable for farming, and the zone has also received more public investment in agriculture. AEZ III is a higher rainfall area that includes the Copperbelt, Luapula and NorthWestern Provinces, and is more densely populated and urbanized.

The total number of households in the sample was allocated proportionate to population and maize production (20% for AEZ I, 40% each for the other two zones). First-stage sampling units were standard enumeration areas (SEA). Numbering 113, these were selected with probability proportionate to size, by AEZ, from lists maintained by the Central Statistical Office.

The second-stage units were all households living in each SEA. SEAs may comprise more than one village. In each village within the selected SEA, survey team supervisors requested a full current list of farm households from the respective village head(s). If one village spanned more than one SEA, supervisors worked with the village heads to identify the households located within the boundaries of the selected SEA. Supervisors then combined the lists of all farm households across villages in the SEA to obtain one full list of households within the selected SEA.

Ten households were selected in each SEA by simple random sample drawn from a list. By design, data were self-weighted. The full sample consists of 1128 households, of which only 19 cultivated more than 20 ha. These were eliminated in our analysis. In Zambia farmers cultivating less than 20 ha are defined as "smallholders". Data were collected by three survey teams, each including a supervisor and five enumerators, from June to August, 2011. Authors had access to household identification numbers, but not name lists. Data were made anonymous prior to analysis.

We have also made use of secondary data sources for crop commodity prices. District-level retail price data for key crops like maize, cotton, and sweet potato were obtained from the Central Statistical Office's Consumer Price Index database for the two years preceding the survey (2009–2010).

Pixel-level data on rainfall and soil quality were utilized in the analysis. Long-term average rainfall data for the period 1950–2000 were obtained from WorldClim, an online global climate database (Hijmans et al., 2005). Five-year average rainfall data were assembled from CPS Unified Global Daily Precipitation Analysis defined by Optimal Interpolation of gauge observations (Schneider et al., 2011). Short-term average rainfall data for the preceding year, 2010, were retrieved from the GPCC Full Data Product (V6), which is based on quality-controlled data from 67,200 stations worldwide. Information on soil nutrient availability was obtained from the Food and Agriculture Organization (FAO) (FAO/IIASA/ISRIC/ISSCAS/JRC, 2009).

Measurement of dietary diversity

The prevalence and irreversible consequences of micronutrient malnutrition are well-known by researchers and governments. A decade ago, challenges associated with measuring nutrition with anthropometry and testing procedures in developing countries led to the development of indices of household dietary diversity using cost-effective survey instruments based on recall. Research implemented by IFPRI (e.g., Hoddinott and Yohannes, 2002) confirmed that a more diversified diet is associated with improvement in nutritional parameters, including: birth weight; child anthropometric status; improved hemoglobin concentrations; caloric and protein adequacy; percentage of protein from animal sources (high quality protein); and per capita consumption (a proxy for household income). Studies that validated dietary diversity against nutrient adequacy in developing countries confirmed a positive relationship and a consistently positive association between dietary diversity and child growth (Ruel, 2002; Arimond and Ruel, 2002b; Working Group on Infant and Young Child Feeding Indicators, 2006; Moursi et al., 2008).

In an in-depth review of the literature on this topic, Ruel (2002, 2003) concluded that although dietary diversity was universally recognized as a key component of healthy diets, there was a lack of consensus on how to operationalize this concept. Reference periods ranged from 1 to 15 days, and questions remained regarding the classification of foods by group, portion size and frequency of intake, scoring systems, cutoff points, and reference periods for recall.

In a widely-used approach documented by Swindale and Bilinsky (2006), the household dietary diversity score was operationalized as a count over 12 food groups consumed in either a 7-day or 24-h reference period. To consider micronutrients, food groups were expanded and/or regrouped by micronutrient and counted.