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Sustainable Intensification and Farmer Preferences for Crop System Attributes: Evidence from Malawi's Central and Southern Regions

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Summary. — Low soil fertility is a limiting factor to farm productivity, household nutrition, and economic development in many parts of Africa due to the continuous cultivation of maize over centuries. Diversifying maize monocrop with legumes has been proposed as one solution to declining soil fertility. Adoption of legumes in Africa remains low despite the much needed soil fertility and nutrition benefits provided by the crops. We employ choice experiments to examine farmers' preferences for groundnut, soybean, and pigeon pea intercropped with maize and explore barriers and drivers to adoption in Central and Southern Malawi. Overall, farmers significantly discount legume yields in favor of maize yields despite the additional benefits provided by legumes. Labor constraints and market access are potentially more important barriers to legume adoption than previously thought. Results identified three types of farmers with varying preferences for grain yields, the largest group (48%) associated with strongly positive preference for both legume and maize grain yield, a medium-sized group (35%) that values only maize yield, and the smallest group (17%) having preferences only for legume yield. The medium group may be growing legumes for other benefits such as enhanced maize productivity, and the smallest group may be primarily subsistence producers. These findings suggest that uptake of legume maize intercrop systems might be improved if practitioners focus on legumes that have lower labor requirements and better marketability.

Key words — Africa, Malawi, farmer preferences, legumes, maize

1. INTRODUCTION

Low soil fertility is a severe problem in many parts of Africa, often limiting yield potential and creating poverty traps for farmers (Marenya & Barrett, 2009). Soil fertility is particularly limiting in Southern Africa due to the continuous cultivation of maize over centuries. In Malawi, the problem of declining soil fertility is particularly severe since maize is the dominant staple crop and Malawi has one of the highest population densities in Africa. At the same time nutrient deficiencies, most notably vitamin A and iron, are widespread in Malawi (World Bank, 2015), especially for limited resource farmers whose diet largely consists of maize and whom lack income for a more diversified diet.

Diversifying maize monocrop with legumes has been proposed as one possible solution to declining soil fertility as well as improving household nutrition in Malawi (Bezner Kerr, Snapp, Chirwa, Shumba, & Msachi, 2007). Legumes have the capacity to grow in low fertility environments, replenish stocks of soil nitrogen, and recycle nutrients from deep in the subsoil (Phiri, Kanyama-Phiri, & Snapp, 1999). Snapp, Blackie, Gilbert, Bezner-Kerr, and Kanyama-Phiri (2010) found that maize-legume intercrops of longer duration provided stable grain production and used fertilizer inputs more effectively than monocultured maize. Legumes can also link agricultural and nutritional benefits, providing a staple food with much needed protein and micronutrients such as iron, zinc, or vitamin A (Messina, 1999). Legumes vary in their role on a farm, some are primarily grain producers and others are highly vegetative with edible leaves for vegetable use, as well as protein rich fodder for animals and green manure for soil improvement (Snapp & Silim, 2002).

Despite a myriad of benefits, adoption of legumes remains low in Southern Africa. After a decade of promotion, farm area devoted to grain legumes remained below 25% in a Northern Malawi study (Mhango, Snapp, & Kanyama-Phiri, 2013). Home consumption and cash sales remain the major production goals for the most widely grown legumes, groundnut (peanut), soybean, common bean, and pigeon pea (Gilbert, 2004). There are severe land limitations imposed by an average farm size of less than 1 ha, and it is likely that farmers prioritize production of maize and tobacco over legumes. Previous household survey findings from Malawi have identified the high cost of legume seed as one barrier to greater production of pulses, along with pest-susceptibility, limited land availability and variable access to input and output markets for legumes (Snapp, Rohrbach, Simtowe, & Freeman, 2002). A synthesis and review of the conservation agriculture [1] literature finds no consistent determinants of farmer adoption of sustainable agricultural practices and notes that efforts to promote such practices need to be tailored to reflect local context and conditions (Knowler & Bradshaw, 2007).

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Choice experiments (CE) have become an increasingly important tool used to study preferences and behavior regarding the adoption of sustainable intensification practices, since it overcomes limitations of previously used statistical methods. Given that most adoption studies are conducted ex post (after a sufficient time lapse to allow for the accumulation of behavioral data), CEs allow for the ex ante study of adoption of sustainable farming practices to better inform project design (Knowler, 2015). In this study we use choice experiments (CE) to examine farmer adoption of legumes, through intercropping, in the dominant maize cropping systems. We explore the heterogeneity in farmers' preferences for different varieties of legumes (groundnut, soybean, and pigeon pea) and identify barriers and drivers of adoption. The article is organized as follows: Section 2 provides a brief background of legume adoption in Africa. Section 3 describes the data and sample selection. Section 4 presents the choice experiment rationale and procedure. Section 5 reports the results and section 6 concludes.

2. BACKGROUND

In Southern Africa, maize has became the dominant staple crop and is now grown by 97% of farming households and accounts for 60% of total caloric consumption (Denning *et al.*, 2009). Over the last hundred years maize achieved rapid growth and in many areas replaced traditional cereals like sorghum and millet (Smale & Jayne, 2003). This may be due to advantages such as the very high grain yield potential of maize, a C_4 grass adapted to high heat and light that can produce approximately twofold more grain than other staple food crops, when provided sufficient fertility (Egli, 2008). Further, maize is one of the most labor efficient staple food crops with plant traits that include a weed suppressing architecture, and an ear covering that protects the grain from birds and other pests. The development of modern varieties in conjunction with the implementation of Malawi's Farm Input Subsidy Program in 2005 has led to broad access to hybrid maize seeds among smallholder farmers (Lunduka, Fisher, & Snapp, 2012). Maize has been heralded as providing an engine for growth, and the foundation for the green revolution in Africa (Byerlee & Eicher, 1997).

Despite all the benefits maize has brought to Africa, there have also been many tradeoffs. The maize plant is highly sensitive to deficiencies in water, and nitrogen. The grain does not store well and is attacked by weevils and other pests and diseases. Wide-scale production of maize has slowly mined the soil of nitrogen, and ultimately created a reliance on external inputs to maintain previous yields (Snapp *et al.*, 2010). Moreover, maize has one of the highest erosivity factors (*C*-values) among crops grown in the region, contributing significantly to soil loss on susceptible slopes (Lewis, Clay, & Dejaegher, 1988). The crop is largely grown without irrigation in a single growing season and is particularly susceptible to dry spells during flowering, rainfall variability, and growing season length (Rao, Ndegwa, Kizito, & Oyoo, 2011). Additionally, maize lacks essential amino acids, vitamin A, and can be associated with poor nutritional outcomes.

Legumes appear to be a natural response to the deleterious impact that continuous production of cereals has on African soils, and in particular Malawi given the numerous location specific edaphic problems (Snapp, 1998). The agricultural and nutritional benefits of the crop are a potential solution to address problems faced in Malawi, improving the soil and providing much needed protein. Farmer production of legumes, however, remains surprisingly low across most of sub-Saharan Africa and is particularly on the decline in many maize-dominated cropping systems of Southern Africa, including Malawi (Snapp & Silim, 2002). In the low-input, low-output production system that is common across Africa, intercropping certain legumes with maize may make economic sense in certain contexts. In Malawi, research has demonstrated that various legume crops can increase the nitrogen content of residues with a relatively small negative impact on maize yields (Snapp *et al.*, 2002). It is possible that low adoption of legume intercrops is based on a misperception that maize yields are significantly impacted by legume intercropping or it is possible that maize yields are negatively impacted by intercropping with specific legumes in certain contexts. Previous research has suggested that lack of local markets for grain legumes, and household labor constraints may also be a significant factor for low adoption of legumes into maize intercrop (Snapp *et al.*, 2002).

Farmer preferences are likely associated with the differences in the major legume crops cultivated in Malawi. Longer duration legumes like pigeon pea (*Cajanus cajan*) are more efficient at fixing nitrogen, enhancing phosphorus availability and thus maize yields in crop rotations. Shorter duration legumes such as groundnuts (*Arachis hypogaea*) or soybeans (*Glycine max*) tend to have higher yield potential but contributes fewer nutrients for soil enhancement (Giller & Cadisch, 1995). Legume crops that are short duration and early yielding are more amenable to market oriented production whereas the longer duration nature and higher nitrogen fixing properties of pigeon pea make it more suitable for enhancing soil fertility in a subsistence production system (Bezner Kerr *et al.*, 2007). While there are advantages in terms of soil fertility enhancement and food security mitigation, many farmers prefer to cultivate maize for household food security and often grow legumes with the intention of selling them. Legume market prices are typically higher than maize. At the time of the study maize was selling for an average of 60 Kwacha (MWK)[2] per kg, while reported average groundnuts, soybeans, and pigeon pea prices were 112, 138, and 139 MWK per kg, respectively. There are significant spatial dimensions of markets for various legumes in Malawi. Pigeon pea production is common in the Southern parts of the country around the cities of Zomba and Blantyre, where traders purchase pigeon pea for export to India. Smaller regional markets for groundnuts and soybeans exist in Ntcheu and Dedza and via large processors based in Lilongwe such as Transglobal, Global Trading, and Farmers' World.

Given the dominance of monoculture maize production in Malawi and land, labor, and market constraints, legume adoption remains limited. Improving legume performance attributes and soil fertility enhancement through breeding is one possibility for wider scale adoption. Legume yields continue to lag behind those of cereals and are in need of breeding improvements that focus on disease resistance, enhanced nitrogen fixation, and tolerance to soil constraints (Graham & Vance, 2003). Evidence from the applied economics literature point to a mix of (significant and insignificant) results regarding the effects of labor constraints and market access on the adoption of sustainable agricultural practices and highlights the importance of conducting regional studies of these factors on farmer adoption (Knowler & Bradshaw, 2007). Questions remain as to the extent to which legume adoption is constrained in various parts of Malawi and what these constraints are. This study explores these constraints using