Ecological Economics 150 (2018) 184–193

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Confronting Tradeoffs Between Agricultural Ecosystem Services and Adaptation to Climate Change in Mali

Kurt B. Waldman[a,*], Robert B. Richardson[b]

[a] Department of Geography, Indiana University, 513 N. Park Ave., Bloomington, IN 47408, USA
[b] Department of Community Sustainability, Michigan State University, 480 Wilson Rd., East Lansing, MI 48824, USA

ARTICLE INFO

Keywords:
Agricultural ecosystem services
Choice experiments
Climate change adaptation
Gender
Mali
Sorghum

ABSTRACT

Changing climatic conditions present new challenges for agricultural development in sub-Saharan Africa. Sorghum has proven to be an adaptable and resilient crop despite limited funding for crop development. Recent breeding efforts target hybrid and perennial technologies that may facilitate adaptation to climate change. Advantages of perennial crops over their annual counterparts include improved soil quality and water conservation and reduced inputs and labor requirements. In contrast, hybrid crops are often bred for improved grain yield and earlier maturation to avoid variable conditions. We use discrete choice experiments to model adoption of sorghum as a function of attributes that differ between these technologies and traditional varieties in Mali. Overall, the main perceived advantage of perennial crops is agricultural ecosystem services such as soil improvement, while adoption of hybrid crops is hampered by the inability to reuse seed. Women farmers are less concerned about higher labor requirements associated with perennial crops and the ability to reuse hybrids seeds than male farmers. Farmers prefer traditional sorghum to perennial sorghum and are indifferent between traditional and hybrid sorghum. These findings have important policy implications for understanding tradeoffs that are central to farmer decision making when it comes to breeding technologies for climate adaptation.

1. Introduction

Ensuring access to nutritious and environmentally sustainable food to all people at all times is one of the greatest challenges currently facing global society (Hall et al. 2017). Climate change is projected to impact food security in the developing world, especially in countries already facing chronic hunger and malnutrition (Lobell et al. 2008). Climate change is expected to have a direct impact on food production as changes to both temperature and rainfall patterns affect crop yields, water availability, pests and diseases, and livestock health, and smallholder farming systems in Africa (Hall et al. 2017). Countries in sub-Saharan Africa are predicted to be worst affected due to already high temperatures, high dependency on rain-fed agriculture, and economic fragility. The problem is particularly acute in West Africa, where the dual forces of population growth and climate change are likely to exacerbate the persistent challenge of food insecurity. West Africa is also subject to significant rainfall variability and drought occurrences, and this is expected to increase as climate change impacts the region (Mason et al. 2015).

Sorghum is among a limited number of crops that have the resiliency to adapt to changing climate change conditions, particularly increasing drought, soil salinity and higher temperatures (ICRISAT, 2015). Despite these benefits, agricultural policies concerning subsidies and crop improvement have been inconsistent and often do not target sorghum. In the past two decades, domestic production has increased at an average rate of about 1% for sorghum, while maize has increased at an average rate of about 7% (Kelly et al. 2012), despite a steady increase in sorghum grain yield in West Africa since the 1970s (ICRISAT, 2015). Predicted increases in climate variability require strategies that improve the genetic heterogeneity of sorghum traits and improve the capacity for adaptation to increased variability (Haussmann et al. 2012).

Farmers require a diversity of crop options that can utilize different spatial niches of nutrients and water resources, and have different mechanisms for responding to annual variation in precipitation (Altieri 2002; Hall et al. 2017). Diversification is one strategy that allows farmers to spread short-term risk and create a more resilient farm system within the context of increasing climatic variation. Developing crop varieties that are resilient to variable climate conditions can improve the diversity and resilience of these systems (Morton 2007). Farmers in West Africa experience both long-term and year-to-year variability in rainfall and access to diverse crop types can improve their

* Corresponding author.
E-mail addresses: kbwaldma@iu.edu (K.B. Waldman), rbr@msu.edu (R.B. Richardson).

https://doi.org/10.1016/j.ecolecon.2018.04.003
Received 16 November 2017; Received in revised form 4 April 2018; Accepted 6 April 2018
0921-8009/ © 2018 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/BY/4.0/).

resilience (Mason et al. 2015).

Hybrid crops and perennial crops represent two radically different technologies which each have the potential to improve farmers' ability to adapt to variable climatic conditions. Through hybridization, desirable traits from diverse germplasm may be crossed with traditional landraces in order to create more productive varieties and varieties that combine useful traits, such as disease resistance, with regionally adapted and accepted plant morphology. Development of early maturing hybrid varieties of crops is a common way to reduce exposure to climate variability by reducing the amount of time a crop is in the field.

Cultivation of perennial crops on the other hand, is an investment in the long-term resilience of cropping systems. Perennials potentially fill an important niche for farming households and may have numerous ecological and agronomic advantages over their annual counterparts (Glover et al. 2012). While perennial crops often have drawbacks such as lower yields, many of the ecosystem services associated with the perennial nature of the crop make it more resilient and potentially an important component of climate change adaptation, particularly in water scarce areas.

There has been little research to date on preferences for crop duration—or more specifically household-level tradeoffs and preferences for long duration or perennial crops versus short duration, early maturing hybrids—and the prospects for using these technologies for climate adaptation. The literature on the economics of and preferences for perennial crop production in Africa is thin, largely because the development of perennial crops is in a nascent stage. Most of the literature focuses on plant physiology or developing breeding lines that have the capacity to regrow post-harvest and produce yield over successive years (Hayes et al. 2012; Kane et al. 2016). Breeding programs in Africa target a variety of crops from maize and beans to lesser-known or more traditional crops like sorghum and millet but little attention has been paid to the tradeoffs involved with perennial version of these crops.

There has also been relatively little attention to the gender implications of crop preferences. Many rural African smallholder societies are patriarchal and men make most of the agricultural decisions for the household, even though women are often the providers of food for the family. However, in polygamous households, common in Mali, women often manage land and make agricultural decisions independent of their husbands. In addition to examining the differences in tradeoffs embodied by perennial and hybrid crops, we specifically consider the variation in preferences among attributes of hybrid and perennial varieties of sorghum between male and female farmers.

2. Background

Depending on the agroecological region, sorghum, millet, and maize are the primary staple crops in Mali. Sorghum is widely cultivated across the Sudan Savannah and covers a range of agroecological zones characterized by a gradation in rainfall from the edge of the Sahara Desert to the fertile Niger River Delta. Development efforts led by the Malian government have been aimed at improving staple crop yields since the drought years that occurred in the 1970s and 1980s. Initially these efforts involved breeding with foreign genetic material but more recently has been focused on Guinea races that are traditional West African sorghum varieties (Rattunde et al. 2013).

Adaptation requirements for new sorghum varieties are specific to the agroecological zone, and no single variety predominates across all of the sorghum growing areas in Mali (Bazile et al. 2008). Yapi et al. (2000) found that farmers prefer the local sorghum landraces in Mali more than varieties derived from foreign genetic material. Local breeding programs developed both pure Guinea-race hybrids as well as Guinea-caudatum hybrid varieties in response.[1] The Guinea race of sorghum has a relatively broad geographic distribution, and research has shown that it comprises more genetic diversity than other races (Folkertsma et al. 2005). Given the wide range of agroecological zones in Mali and the highly variable climatic conditions there is a need for a diversity of plant types.

The backbone of the green revolution in Asia was the development of high yielding hybrid varieties of crops that respond well to fertilizer (Eicher 1995). Hybridized versions of crops can address specific problems that plague farmers by breeding in pest or disease resistance, drought tolerance, resistance to abiotic stress that may problematic in a given region. Hybrid breeding, particularly with maize in Africa, has focused on improving low yields, but also more recently on developing shorter duration varieties that are more suitable for shortened growing seasons in many regions. There are drawbacks with hybrid crops, notably that hybridized seed tends to be more expensive and can only be planted once before hybrid vigor is lost. Hybrid crops also tend to require greater fertilizer inputs than local varieties to achieve their yield benefits. However, research has shown that despite the higher inputs costs, hybrid crops can return more per acre because of the greater yield advantage, which is true of hybrid sorghum in Mali (Smale et al., 2016).

Perennial lines of sorghum have only recently been tested in Mali and are at this point still hypothetical to farmers. The primary tradeoff with perennial crops is yield reduction since most perennial crops yield less than their annual counterparts (Pimentel et al. 2012). For this reason, efforts to develop perennial wheat in developed countries have focused on improved grain yield, and to a lesser extent grain quality (Cox et al. 2006; Jaikumar et al. 2012; Hayes et al. 2012). There are numerous advantages to perennial crops such as lower seed inputs since they require reseeding every three to five years as opposed to every year like annual crops (Bell et al. 2008). Less tillage also translates into less soil disturbance and erosion. As a result, the farm labor costs, energy usage, and technological inputs required for yearly tillage will significantly decrease in perennial crop systems (Pimentel et al. 2012). Additionally, the large root mass helps retain soil, prevent future erosion, sequester more carbon, and hold more soil water (Glover et al. 2010). Perennial cropping systems also have natural mechanisms that make them more resilient to pests (Van Mele and Chien 2004; Cox et al. 2006). Perennial systems have more soil fauna diversity and natural below ground processes since they have more year-round vegetation (Culman et al. 2013). Perennials are also more efficient than annual crops at absorbing nutrients, so fertilizer requirements are lower and nutrient leaching is reduced.

Perennial crops present attributes and management requirements that are very different from the attributes of the hybrid varieties more commonly found in breeding programs. In many ways, perennial crops are the antithesis of the typical hybrid crop variety, which is often input-intensive, early maturing, and high yielding. Perennial crops are not necessarily high yielding, they have lower labor requirements and are longer duration, but they may be more amenable to the low-input, low-output farm management style in Africa. Perennials are adaptable to climate change through extensive root growth that permits greater access to water and nutrients during dry spells, and they are thus often associated with improved agricultural ecosystem services. Hybrid varieties on the other hand tend to be bred to fit into a new and different cropping system that is characterized by more variable rain or a shorter growing season. Early maturing hybrids can avoid changing climatic conditions and variable rainfall by through crossbreeding with varieties that are short duration. Hybrids can also be bred for tolerance to temporal midseason drought and dry spells, and are often associated with adaptation to climate change.

Hybrid and perennial crops present different tradeoffs to farmers and this paper examines farmers' preferences for these different cropping systems and the associated attributes of each using choice experiments. We employ two sets of choice experiments to look at farmers' preferences for attributes of perennial and hybrid crops using the case of sorghum in Mali. We also chose to design the study with a gender

[1] Including Institut d'Economie Rurale and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) both based in Bamako.

Download English Version:

https://daneshyari.com/en/article/7344071

Download Persian Version:

https://daneshyari.com/article/7344071

Daneshyari.com