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Farmers' preferences for sustainable intensification attributes in sorghum-based cropping system: evidence from Mali

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Abstract

Agriculture plays an important role in poverty alleviation and food security in sub-Saharan Africa, especially given its subsistence nature. However, agricultural development is constrained by limited adoption of agricultural intensification technologies, which could partly be because technology development does not properly consider the technical traits that farmers value most. The aim of our study was to assess farmers' preferences for sorghum technology attributes from the lens of sustainable intensification using a discrete choice experiment based on a survey involving 567 farmers in southern Mali, and a mixed logit model for data analysis. We considered six attributes corresponding to different domains of sustainable intensification: grain yield, yield instability, soil fertility, nutrition, labor requirement, and fodder yield. The findings revealed that farmers are strongly interested in transitioning from their existing sorghum-based cropping systems to those that closely align with the domains of sustainable intensification. The farmers placed more value on nutrition outcome. However, there are considerable heterogeneous preferences across the entire distribution of the farmers and between distinct sub-groups of farmers characterized by their social networks and agroecological zones. These results support the growing R&D prioritization and policy interests towards scaling sustainable intensification among farmers, with a particular focus on nutrition domain.

Keywords: Agricultural intensification, choice experiments, farmer preferences, Mali, sorghum

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Introduction

Agriculture plays an important role in poverty alleviation and food security in sub-Saharan Africa, especially given its subsistence nature. However, agricultural development is constrained by limited adoption of agricultural intensification technologies that could be explained among others by the fact that the technology development process fails to incorporate the traits valued by farmers (Lunduka et al. 2012). This issue has not received much attention in the technology adoption literature. There are some concerns that technology adoption is associated with unintended adverse effects on the farming system and livelihoods of farmers, as experienced in the Asian Green Revolution, where the use of productivity-enhancing inputs such as mineral fertilizer was intensified. To address these challenges, Godfray et al. (2010) argue that more food needs to be produced in sustainable ways. Sustainable intensification is an approach of agricultural production whereby desired outputs are increased without adversely affecting the environment (Giller et al. 2015). Musumba et al. (2017) developed a framework to assess sustainable intensification, which encompasses five dimensions of sustainable intensification, including productivity, economic, environment, human, and social dimensions. Each of the domains has specific indicators that are used as a metric across different spatial scales. While several studies have recently examined farmers' preferences for technology attributes (Lunduka et al. 2012; Ortega et al. 2016; Kassie et al. 2017; Waldman et al. 2017; Jourdain et al. 2020; Silberg et al. 2020), most of them did not consider attributes associated with all sustainability domains.

Moreover, most studies on sustainable intensification in smallholder agriculture did not explicitly assess sustainability from farmers' perspectives (Pretty et al. 2011; Peterson and Snapp 2015; Smith et al. 2017). Our study fills this gap by analyzing farmers' preferences for technology attributes reflecting different domains of sustainable intensification. Specifically, we identified important attributes associated with sorghum-based cropping system technologies as perceived by farmers using the recent framework for assessing sustainability in smallholder agriculture. In addition, we assessed heterogeneity in the technology preferences across farmers and by social network and agroecology of farmers while examining the trade-offs between technology attributes.

Material and Methods

The study area covers three districts in Sikasso region in Mali, namely Bougouni, Yanfolila, and Koutiala, and is divided into two climatic zones including Sudanian and Guinea zones. Our sampling framework is based on the list of 576 arm-households from 20 villages interviewed in February 2020. The survey followed a quasi-experimental design. The research was designed within the discrete choice experiment (DCE) survey-based approach. We followed three steps to design and implement the DCE. First, we identified six relevant attributes through focus groups with farmers and expert consultations: sorghum yield, yield stability, soil fertility, nutrition, labor requirement, and forage yield. These attributes cover four of the five sustainable intensification domains. The social domain was captured indirectly through a disaggregated analysis of the data based on the social network of farmers. Then, we combined various attributes and attribute levels into different pairs of mutually exclusive hypothetical options (i.e., choice sets) that would be evaluated by farmers. We constructed 12 laminated choice cards from the choice sets, of which each card consists of two unlabelled hypothetical options of sorghum-based intensification systems (options A and B) and an opt-out (option C). The opt-out option represents the current sorghum-based cropping practice of farmers – i.e., the status quo or business-as-usual option. The farmers evaluated the attribute levels of each option on the choice cards and freely made a choice on each of the six choice occasions. The data are analyzed with a mixed logit (MXL) model. We estimated MXL models with subsamples of farmers to explore heterogeneity in preferences and tradeoffs, with respect to two policy-relevant variables for intensification social network and agroecology.

Results and Discussion

The ASC coefficient estimate is negative and significantly different from zero, which indicates that on average, the farmers have positive preferences for sustainable sorghum-based cropping systems intensification options over their current cropping practice. The farmers in southern Mali are strongly interested in transitioning from their existing sorghum-based cropping systems to those that closely align with the domains of sustainable intensification. However, there are considerable heterogeneous preferences across the entire distribution of the farmers and between distinct sub-groups of farmers characterized by their social networks and agroecological zones. With respect to the productivity domain of sustainable intensification, the farmers are open to sorghum-based cropping systems that are associated with a larger grain yield and fodder yield. This is expected given the crucial roles of sorghum grain for household food security and fodder for livestock production in crop-livestock farming systems, which makes the crop a dual-purpose crop in the research area (Waldman and Richardson, 2018). The policy implication of this finding is that sorghum varietal improvement and dissemination efforts should be strengthened towards scaling up dual-purpose sorghum seeds. There is limited evidence to show that farmers are strongly averse to yield instability. That suggests that smallholder farmers are generally averse to yield variability or crop failure. However, there is substantial preference heterogeneity for yield instability across the farmers and between households with strong and weak networks, and households Sudanian and Guinea agroecological zones. The farmers attached more value to increased nutrition outcome relative to grain yield and other attributes. This suggests that farmers are interested in options that can enhance nutrition security beyond the traditional focus on food security, and thus the human domain of sustainable intensification is much more appealing to farmers. This implies that nutrition-enhancing technologies and management practices can

easily diffuse among smallholders. The policy implication is that breeding programs for the biofortification of sorghum with different micronutrients in Mali should be strengthened to increase varietal turnovers. With respect to the environmental domain, the farmers placed more value on increased soil fertility outcome over the weight placed on grain yield. Except for households with weak social networks, this finding is consistent for all the sub-groups of farmers. This result implies that farmers value natural resource management and extension interventions should strongly promote the integration of legumes in sorghum-based cropping system, as an entry point for resource-poor farmers to maintain their soil fertility (Silberg et al. 2020). With respect to the economic domain, the farmers are averse to labor-intensive options. This suggests that complementary labor-saving technologies may play a role in incentivizing farmers adoption of sustainable intensification. However, this finding is partially in line with the findings for the sub-groups of farmers, i.e., households with strong and weak networks, and households in Sudanian and Guinea agroecological zones.

Table 1: Results of MNL and MXL models showing farmers' preferences

	MXL	
	Mean	Std. Dev.
ASC	-3.388*** (0.583)	
Grain yield	0.053*** (0.006)	0.055*** (0.006)
Yield instability	-0.014 (0.009)	0.020*** (0.008)
Soil fertility outcome: increase	1.133*** (0.172)	0.040 (0.075)
Soil fertility outcome: neutral	0.355*** (0.077)	-0.130 (0.285)
Nutrition outcome: increase	1.349*** (0.227)	-0.852*** (0.156)
Nutrition outcome: neutral	0.842*** (0.097)	0.539*** (0.202)
Labor requirement	-0.005* (0.003)	-0.017*** (0.007)
Fodder yield	0.007*** (0.001)	-0.016*** (0.003)
N	10,206	

Table 2: Results of MXL models showing heterogeneity in farmers' preferences by social network

	Strong social network		Weak social network	
	Mean	Std. Dev.	Mean	Std. Dev.
ASC	-3.449*** (0.618)		-3.574*** (1.279)	
Grain yield	0.052*** (0.007)	0.054*** (0.008)	0.070***(0.013)	0.070*** (0.012)
Yield instability	-0.021** (0.010)	-0.020** (0.008)	0.003 (0.018)	0.010 (0.014)
Soil fertility outcome: increase	1.238*** (0.215)	0.209 (0.277)	0.901** (0.372)	-0.006 (0.103)
Soil fertility outcome: neutral	0.440*** (0.096)	0.337 (0.261)	0.135 (0.148)	0.096 (0.242)
Nutrition outcome: increase	1.175*** (0.270)	0.886*** (0.209)	2.014*** (0.481)	0.779** (0.344)
Nutrition outcome: neutral	0.900*** (0.122)	0.534** (0.214)	0.818*** (0.198)	0.501 (0.510)
Labor requirement	-0.006 (0.004)	-0.020*** (0.007)	-0.008 (0.007)	-0.011 (0.010)
Fodder yield	0.006*** (0.002)	-0.017*** (0.004)	0.009*** (0.004)	-0.023*** (0.006)
N	7326		2880	

Table 3: Results of MXL models showing heterogeneity in farmers' preferences by agroecology

	Guinea agroecological zone		Sudanian agroecological zone	
	Mean	Std. Dev.	Mean	Std. Dev.
ASC	-2.622*** (0.717)		-3.989*** (0.813)	
Grain yield	0.054*** (0.010)	0.060*** (0.010)	0.059*** (0.008)	0.060*** (0.008)
Yield instability	-0.002 (0.014)	-0.018 (0.029)	-0.021* (0.012)	-0.023*** (0.005)
Soil fertility outcome: increase	1.166*** (0.339)	0.025 (0.042)	1.227*** (0.252)	0.334 (0.325)
Soil fertility outcome: neutral	0.178 (0.145)	0.021 (0.058)	0.451*** (0.103)	0.481** (0.222)
Nutrition outcome: increase	1.940*** (0.383)	-0.736** (0.311)	1.218*** (0.324)	1.026*** (0.229)
Nutrition outcome: neutral	0.773*** (0.169)	-0.788*** (0.250)	0.939*** (0.126)	-0.495** (0.231)
Labor requirement	-0.013** (0.006)	-0.021* (0.012)	-0.003 (0.004)	0.018** (0.009)
Fodder yield	0.006** (0.002)	0.005 (0.007)	0.008*** (0.002)	-0.022*** (0.004)
N	3096		7110	

Conclusions and Outlook

The findings reveal that farmers have strong preferences for sustainable sorghum-based cropping systems intensification over their current cropping practice. This supports the ongoing R&D interventions as well as policy efforts to scale up sustainable intensification. Farmers prefer intensification options associated with a larger grain yield, a neutral or an increased soil fertility outcome, a neutral or an increased nutrition outcome, and a larger fodder yield. Surprisingly, the farmers are indifferent to yield instability, which suggests that the farmers do not attach much weight to yield instability. More importantly, the farmers placed more value on nutrition outcome, which calls for more R&D interventions along the nutrition domain, including biofortification of sorghum. Thus, development partners should strongly invest in interventions around nutrition outcomes, as they are likely to gain widespread adoption among smallholder farmers.

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