



How Does Gender Affect Sustainable Intensification of Cereal Production in the West African Sahel? Evidence from Burkina Faso

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Summary. — Better understanding of gender differences in the adoption of agricultural intensification strategies is crucial for designing effective policies to close the gender gap while sustainably enhancing farm productivity. We examine gender differences in adoption rates, likelihood and determinants of adopting strategy sets that enhance yields, protect crops, and restore soils in the West African Sahel, based on analysis of cereal production in Burkina Faso. Applying a multivariate probit model to a nationally representative household panel, we exploit the individual plot as unit of analysis and control for plot manager characteristics along with other covariates. Reflecting the socio-cultural context of farming combined with the economic attributes of inputs, we find that female managers of individual cereal fields are less likely than their male counterparts to adopt yield-enhancing and soil-restoring strategies, although no differential is apparent for yield-protecting strategies. More broadly, gender-disaggregated regressions demonstrate that adoption determinants differ by gender. Plot manager characteristics, including age, marital status, and access to credit or extension services do influence adoption decisions. Furthermore, household resources influence the probability of adopting intensification strategy sets differently by gender of the plot manager. Variables expressing the availability of household labor strongly influence the adoption of soil-restoring strategies by female plot managers. By contrast, household resources such as extent of livestock owned, value of non-farm income, and area planted to cotton affect the adoption choices of male plot managers. Rectifying the male bias in extension services along with improving access to credit, income, and equipment to female plot managers could contribute to sustainable agricultural intensification.

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1. INTRODUCTION

With uncertain rainfall and degraded soils, farmers in the West African Sahel have devised techniques for managing their land and water intensively in order to feed their families (e.g., Reij, Tappan, & Smale, 2009). Donors and governments have also invested in agricultural research to raise productivity since the great droughts of the 1970s and 1980s. Nonetheless, farm families in this region remain vulnerable to chronic food insecurity. Increasing food supply on smallholder farms will depend on sustainable agricultural intensification. Given the key role that women play in food security on smallholder farms (e.g., Quisumbing *et al.*, 2014), better understanding of gender differences in the adoption of intensification strategies is crucial for designing effective policies to close the gender gap while sustainably enhancing farm productivity.

Developing agricultural technologies to improve women's well-being poses a "much more difficult challenge" than merely "taking women into account" (Doss, 2001, p. 2057). Indeed, gender roles in farming and farm household structures vary widely across cultural contexts. In the West African Sahel, extended farm households headed by a patriarch continue to prevail (Guiringer & Platteau, 2014; West, 2010). Extended farm households are composed of members who are vertically (e.g., married sons and their wives) and horizontally (e.g., brothers and multiple wives) linked to the household head, who is responsible for managing collectively farmed plots and allocating individually managed plots among household members.

In conducting gender research, the selection of the appropriate unit of analysis matters. A large body of case studies conducted in Africa controls for the sex of the household head

when estimating the determinants of technology adoption and productivity. In their seminal work, Doss and Morris (2001) found no gender difference in the adoption of improved seed and fertilizer on maize in Ghana, but major differences when they accounted for the sex of the household head; females in female-headed households were systematically disadvantaged and adopted less frequently than those in male-headed households. Subsequent analyses have shown that it is not whether the head is female but rather the lack of access to resources that explains gender productivity differentials (e.g., Alene *et al.*, 2008; Quisumbing & Pandolfelli, 2010).

Similarly, Peterman, Quisumbing, Behrman, and Nkonya (2011) demonstrated the sensitivity of productivity differentials to whether comparisons were made at the level of the household head or between male and female plot managers using datasets from Nigeria and Uganda. In Burkina Faso, Udry (1996) found productivity differentials between plots managed by men and women. With the same dataset and a comparable modeling framework, Kazianga and Wahhaj (2013) later attributed the differential to headship management of collective fields, finding no differential between plots managed individually by males and females. In neither of these

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studies, however, were researchers able to control for whether individual plots were managed by the household head.

Several recent studies have examined the determinants of adoption of multiple yield-enhancing, protective, and/or conserving strategies, especially in Eastern and Southern Africa (Kamau, Smale, & Mutua, 2014; Kassie, Jaleta, Shiferaw, Mmbando, & Mekuria, 2013; Lambrecht, Vanlauwe, & Maertens, 2016; Ndiritu, Kassie, & Shiferaw, 2014; Teklewold, Kassie, Shiferaw, & Köhlin, 2013; Wainaina, Tongruksawattana, & Qaim, 2016), and to a lesser extent in the West African Sahel (Asfaw, Di Battista, & Lipper, 2016). Although most of those studies have controlled for gender of the farmer or household head, better understanding of gender differences in technology adoption has not been their main focus, with the exception of Ndiritu *et al.* (2014)'s work in Kenya and the study by Lambrecht *et al.* (2016) in DR Congo.

Ndiritu *et al.* (2014) found that female plot managers were less likely to adopt minimum tillage and use manure, suggesting that socioeconomic inequalities and barriers in access to resources still exist for women. The authors underscored the need to conduct more analysis on the adoption of multiple intensification strategies at the individual decision-making level, but no plot manager characteristic other than the sex of the plot manager was included in their analysis. The effect of participation in agricultural extension programs by male and female farmers on technology adoption was at the core of the study by Lambrecht *et al.* (2016), who found that joint male and female participation led to highest adoption rates of improved seed, fertilizer, and row planting.

In this analysis, we examine three fundamental questions regarding gender and technology adoption in cereal production. We apply multivariate probit models to test for gender differentials in (1) adoption rates; (2) the likelihood of adoption; and (3) determinants of adoption in the farming context of the West African Sahel, using Burkina Faso as an example. We consider the adoption of yield-enhancing, yield-protecting, and soil restorative strategy sets on individually managed plots of maize, sorghum, and millet.

Our analysis contributes to the literature on gender roles and technology adoption in several ways. First, we add to the ongoing discussion on the gender gap in technology adoption by exploring jointly the determinants of a wide range of intensification strategy sets in a different farming context—the West African Sahel. Second, reflecting the cultural specificity of gender roles and farm decision-making in this region, we control not only for the sex of the plot manager but whether or not the manager is the household head. Third, we use a nationally representative household panel to exploit the individual plot as a unit of analysis and control for additional plot manager characteristics along with other covariates.

2. GENDER AND FARM STRUCTURE IN THE WEST AFRICAN SAHEL

Historical, ethnographic research (e.g., Hammond, 1966; Lallemand, 1977) and more recent research by Udry (1996), West (2010), and Kazianga and Wahhaj (2013) notes the defining features of Burkinabe farm households, also depicted by Van den Broek (2009) and Guiringer and Platteau (2014) for cereals production systems in Mali. Farm work is conducted across numerous plots with well-defined boundaries, for which the management has been assigned to a specific adult member, under the titular authority of the household

head who is almost always an elder patriarch. Some plots are worked collectively by household members. According to existing social norms, these are managed by the household head and all proceeds are destined to meet the needs of the extended family. Other plots are managed by individual male or female members who make decisions over input use, including the choice of crops and techniques. Proceeds from production on individual plots are retained by the household member to meet his or her food or budgetary needs. This individualization of decision-making power differs from parts of Eastern and Southern Africa, where jointly managed plots are common (see Ndiritu *et al.*, 2014 for Kenya; Marennya, Kassie, & Tostao, 2015 for Mozambique; Slavchevska, 2015 for Tanzania).

The allocation of individual plots is associated with the status of household members in relation to the patriarch (Kazianga & Wahhaj, 2013; Kevane & Gray, 1999). For example, married sons of the patriarch and some unmarried sons are often allocated their own fields. Upon marriage to sons of the patriarch, wives are allocated small plots to meet the specific needs of their own children and to contribute ingredients used in preparation of meals. In some instances, an elderly widow of a male family member may be allocated fields to ensure her subsistence. Even when land has been allocated, the extent to which major factors of production such as labor and draught power are shared is the outcome of a complex intrahousehold negotiation (De Vreyer, Lambert, Safir, & Sylla, 2008; Kevane & Gray, 1999; Smith & Chavas, 2007). Ethnographic studies (Becker, 1990, 1996; Kevane & Wydick, 2001) have long reported that, as a reflection of the priority placed on overall household welfare, household labor is allocated first to the collective fields. Household members can work on their individual fields after completing all their tasks on the collective fields.

Another important feature of the Burkinabe farming structure is the interplay between customary norms and formal tenure rights. Konaté (2006) explains that in patrilineal systems such as that of Burkina Faso, land rights are transmitted via male family members. Because of the principle of exogamy (marriage outside the family), women are generally awarded no more than usufruct rights at marriage. The possibility of divorce, and thus alienation of lineage lands outside the family, poses an inherent threat. Thus, despite that all Burkinabe are equal in the rights according to the Constitution, and that the Agrarian Reform of 1996 declares no discrimination, customary norms, which are inherently unequal, prevail in practice. For instance, in some regions of Burkina Faso, women have no access to plots except for the off-season (Konaté, 2006). Another example of gender inequality is the allocation of irrigated plots to male farmers only in Dakiri, eastern Burkina Faso (Zwarteveen, 1997).

In recent years, socio-cultural norms and incentives guiding resource use have evolved in response to food insecurity, spurred in part by the land fragmentation that accompanies high rates of population growth (Kazianga & Wahhaj, 2013). Guiringer and Platteau (2014) document the individualization of agricultural production within extended farm households, as more plots are allocated by the patriarch to both male and female household members. Micro-studies also suggest that more women are planting sorghum—a crop traditionally cultivated on the collective fields and managed by the elder—on their individual plots, in order to contribute to family food security, and also because sorghum prices have risen relative to other crops they grew before (Dabiré, Theriault, Smale, & Traoré, 2016; Van den Broek, 2009). Hence the importance of examining the determinants of adoption of mul-

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