Family Structure and Intrahousehold Resource Allocation: Evidence from Mali

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Family Structure, Social Norms, and Investment in Agricultural Inputs: Evidence from Mali

Abstract: One of the features of the production system in many countries of West Africa is the coexistence of both collectively-managed and individually-managed ‘private’ plots within the same. Within these households, economic activities are influenced by socio-cultural norms, which impact agricultural input decisions. This paper uses a two-year panel data on Mali to investigate intrahousehold allocation of productive resources across collective plots and ‘private’ plots. A major contribution of this paper is the clear distinction it makes between collective plots and the head’s ‘private’ plots, which is vital in understanding whether the observed yield and input differentials across collective plots and ‘private’ plots are due to headship or to the attributes of the collective plots. We find that significantly higher yields are achieved on collective plots relative to ‘private’ plots and this yield differential persists after restricting the sample to heads that control the collective plots and their own private plots. The estimations of the intensity of labor use show that collective plots are more intensively farmed with male-labor and child labor whereas the opposite is observed for female-labor. However, after isolating the gender effect by excluding female-controlled plots from the sample, we find that collective plots are more intensively farmed than male-controlled ‘private’ plots regardless of the labor source. We infer from these results the importance of taking the gender component into account when studying intrahousehold farm-labor allocation. Unlike previous similar studies that only focus on labor allocation, we also investigate chemical fertilizer application. We find that the probability of fertilizer application tends to be higher on ‘private’ plots while the intensity of its use is higher for collective plots. These contrasting findings highlight the importance to investigate not only the probability of the use of a given technology but also the intensity of its application, especially for inputs such as fertilizer that requires a certain amount in order to obtain a yield response.

1. Introduction

In many countries of West Africa, farming households are often large and encompass multiple small families. One of the features of the production system is the coexistence of both collectively-managed and individually-managed ‘private’ plots within the same household and it is common for households to simultaneously plant the same foodcrop both on the collective plot and on the ‘private’ plots in order to ensure food security, especially as land sizes per capita diminish with rising population densities. Within these households, economic activities are influenced by socio-cultural norms (Fafchamps and Quisumbing (2003), Guyer (1981), Fortes et al. (1947)), which influence agricultural input decisions.

The question of whether the allocation of productive resources across plots within the same household is efficient has been the focus of a large body of empirical literature in agricultural development (see review by Quisumbing, (1996) and Croppenstedt et al., (2013)). However, most early studies that focus this issue compared among male- and female-headed households without taking plot management into account. Exploring this issue in Uganda and Nigeria, Peterman et al. (2012) found that productivity differences depend on aggregation of gender indicator and the unit of analysis. The complexity of decision-making within farming households in the West African Sahel has long been noted. Among the most influential studies conducted in the region is the work by Udry (1996), who challenged the conceptual basis of the unitary household and tested the relationship between gender and agricultural production using plot level data from Burkina Faso. Udry (1996) found that the productivity of the same crop planted in the same year in the same household was significantly higher when planted on plots controlled by men than those controlled by women.

He argued that the yield differential is attributable to men's higher access to agricultural labor and fertilizer. Quisumbing (1996) finds that there are no intrinsic differences in productivity between male-plot managers and female-plot managers after controlling for input use. Also, Udry and Duflo (2004) find that in Cote d'Ivoire, individuals (mainly husbands and wives) within the same household fail to fully insure one another against transitory shocks in individuals' income.

More recently, using household plot level data from Burkina Faso, Kazianga and Wahhaj (2013) show that plots controlled by the head of the household present higher yields than plots controlled by the other household members. They explain these higher yields by the fact that the household head, under some social norms, has the obligation to provide the other household members with food, which in return provides incentives to the other members to voluntarily work on his farm. In a similar study carried out by Guirkinger and Platteau (2014) on Mali, the authors find contradictory results to that of Kazianga and Wahhaj –that is, they find that 'private' plots are much more intensively farmed than collective plots.

One implication of these findings is inefficiencies in the allocation of productive resources within the household, which contradicts the main assumption of the collective bargaining models of households developed by Chiappori (1988, 1992). Indeed, since there is decreasing marginal productivity to labor, reallocation of resources from plots receiving relatively more labor to those receiving less labor has the potential to increase total production within the household. For example, Udry (1996) computed the potential gain through reallocation of productive resources within the household to be on the order of 10 to 15 percent of the total output of the household.

Using a two-year panel data on Mali, this study aims to investigate intrahousehold resource allocation across collective plots and 'private' plots under the existence of social-cultural norms. The analysis presented here contributes to the literature in two major ways. First, this study builds on work by Kazianga and Wahhaj (2013) by making a clear distinction between collective plots managed by the head of household from his own 'private' plots. This was not feasible with the data used by Kazianga and Wahhaj (2013). In addition, like most of the work cited above, Kazianga and Wahhaj focused on labor allocation. An emphasis on labor reflects the fact that labor remains a binding constraint for many farming families in this region and elsewhere in Sub-Saharan Africa. However, given the low utilization rate of chemical fertilizer in Sub-Saharan Africa despites its yield-enhancing potential, an empirical investigation of intrahousehold allocation of chemical fertilizer among these households proves to be important. Such a study is also crucial due to the increasing land scarcity in sub-Saharan Africa (Mwangi (1997)). Yet, the ability to carry out such an empirical investigation is restricted due to limited availability of data that contain enough observations on chemical fertilizer use. The large sample size used in this analysis allows us to fill in the gap in the literature by not only investigating the probability of chemical fertilizer and manure use, but also the intensity of their use. For the rest of the study, we use the terms fertilizer and manure, respectively, to refer to chemical fertilizer and organic fertilizer. One of the challenges in empirical work striving to investigate intrahousehold resource allocation is omitted variable bias due to unobserved factors that may influence the household's decision in the allocation of the household intrahousehold . We exploit the panel data to address this issue by using household-year-crop fixed effect, which allows to control for unobserved time-invariant factors.

The results show that higher yields are achieved on collective plots than ‘private’ plots. This yield differential persists after restricting the sample to the heads that control both collective plots and their own ‘private’ plots, which implies that the yield different is mostly due to the attributes of the collective plots rather than headship. Regarding fertilizer application, we find that the probability of fertilizer application tends to be higher on ‘private’ plots while the intensity of its use is significantly higher for collective plots. One of the explanations we provide for the contradictory findings about the likelihood of fertilizer use and the intensity of its application is the smaller sizes of private plots, which make the managers of such plots more likely to split a relatively small quantity of fertilizer across multiple plots. The estimations of the intensity of labor use across collective plots and ‘private’ plots show that collective plots are more intensively farmed with male-labor and child labor whereas the opposite is observed for female-labor. However, after isolating the gender effect, we find that collective plots are more intensively farmed than ‘private’ plots regardless of the labor source, implying that male-managed ‘private’ plots do not receive significant amount of female labor.

The remainder of the paper is organized as follows: in section 2, we present the family structure and the agricultural production system in Mali. Section 3 presents the theoretical model where we replicate Udry’s illustration of the collective household model and then extend the model to establish how individuals’ optimization problem is altered when social pressure to contribute to the joint welfare of the family is taken into account. The econometric specification is presented in section 4 while section 5 present the descriptive statistics and the regression results. Section 6 concludes.

2. Family structure and agricultural production systems in Mali

Similar to most West African countries, household structure in Mali is commonly composed of extended family members as well as Western conceptions of the nuclear household. This leads to the adoption of two terminologies of household in this study: extended household and nuclear household. The extended household is formed with multiple nuclear households and is controlled by a senior male (patriarch or the head of household). Note that besides being the head of the extended household, the patriarch also heads his own nuclear household. The farming structure within the extended household consists of collective plots controlled by the patriarch and 'private' plots controlled by adult males and married females. The patriarch makes land allocation to the latter.

The collective plots, named "foroba" (which means "big field" in Bambara), are generally larger than the 'private' plots. The decision maker on those plots is usually called the "chef des travaux" (work team leader). The work team leader tends to be the patriarch (Becker, 1996) or one of the brothers or eldest sons of the patriarch. Because there is hierarchy in decision-making, the work team leader is perceived as the overall leader of the farming activities. Note that in addition to being the manager of the collective plots, the "chef des travaux" can also have his own 'private' plot. 'Private' plot managers are required to share their labor between the collective plots and their own plots and the proceeds from the collective plots are shared by everyone in the extended unit while those from the 'private' plots normally belong to members who control the 'private' plots and their dependents.

Finally and most strikingly, in the context of the Malian culture, there is a social pressure to contribute to the joint welfare of the whole family and failing to do so might result into being perceived as selfish. [1] Individuals who refract from following such social norms are usually subject of gossips, which can tarnish their reputation and their social status. Given the conspicuous nature of agricultural activities, the social pressure to contribute to the family joint welfare may have implications for intra-household resource allocation across collective plots and 'private' plots. The current work therefore attempts to answer the following questions. Will a junior plot manager be inclined to invest in an input on his 'private' plot when that input is not applied on the collective plots? How does the pressure to contribute to the joint welfare of the household affect investment on 'private' plots versus investment on collective plots? We hypothesize that both the probability of input use (fertilizer and manure) and the intensity of use are higher for collective plots relative to 'private' plots.

3. Method

3.1. Theoretical model

The theoretical model begins with a replica of the specifications of Udry (1996), which was inspired by the collective model of the household developed by Chiappori (1988). The model postulates that intrahousehold resource allocation is efficient. Such efficiency can be achieved through the following optimization problem:

$$Max \sum_i^n \delta^i u^i(\boldsymbol{x}^i, \boldsymbol{z}) \quad (1)$$

subject to

$$\boldsymbol{P}_z \boldsymbol{z} + \sum_i^n \boldsymbol{P}_x \boldsymbol{x}^i \leq \sum_i^n \boldsymbol{P}_{ki} F_{ki}(\boldsymbol{I}^1, \ldots, \boldsymbol{I}^n, \boldsymbol{A}^i) \quad (2)$$

where **z** and **x** are vectors of household public and 'private' goods, respectively, and $\boldsymbol{P}_x$, $\boldsymbol{P}_z$, and $\boldsymbol{P}_k$ represent a vector of prices of 'private' goods, household public goods, and market

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[1] Author's personal observation (2008-2011) and personal communication with Malian nationals among whom Alpha Kergna (July 2015), and Nouhoum Traore (December 2012).

prices for crop k, respectively. There are *n* individuals in the household and $\delta^i$is the welfare weight attributed to each individual. The physical characteristics of the plot are represented by vector $\boldsymbol{A}^i$, and $\boldsymbol{I}^i$ is a vector of input contribution from each adult member in the household.

As argued by Udry (1996), if the same production technology is used on a collective plot and a 'private' plot, then conditional on plot characteristics, total output from the collective plot should not differ from the total output from the 'private' plot for the same crop. Mathematically, the following equality must hold as long as $A^i = A^j$ and $K_i = k_{jj}$:

$$F_{ki}\left(I^i, \dots, I^n, A^i\right) = F_{kj}(I^j, \dots, I^n, A^j) \qquad (3)$$

We next extend the theoretical model to include a parameter that represents a deviation from the social norm in the utility function of the individual. The model assumes a non-cooperative two-stage equilibrium. In the first stage, household members allocate their labor and non-labor inputs across the collective plots and the 'private' plots. Consumption decisions are made in the second stage. Solving the problem by backward induction, the optimal consumption level is derived by the following optimization problem:

$$U = Max \sum_i^n \delta^i u^i\left(\boldsymbol{x}^i, \boldsymbol{z}, \boldsymbol{d}^i\right) \qquad (4)$$

subject to

$$\boldsymbol{P}_z\boldsymbol{z} + \sum_{\boldsymbol{i}}^{\boldsymbol{n}} \boldsymbol{P}_x\boldsymbol{x}^i \leq \sum_i^n \boldsymbol{P}_{ki}F_{ki}(\boldsymbol{I}^1, \dots, \boldsymbol{I}^n, \boldsymbol{A}^i) \qquad (5)$$

$$\boldsymbol{d} = \emptyset(\boldsymbol{S})$$

$$\frac{\partial \boldsymbol{U}}{\partial \boldsymbol{d}} \leq \boldsymbol{0} \quad \text{and} \quad \frac{\partial d}{\partial s} < 0.$$

Similar to the assumptions made by Kevane and Wydick (2001) in their model of women's labor allocation in Burkina Faso, the level of utility is assumed to be decreasing with deviation from the social norm (that is, failing to contribute to the joint welfare of the household) and this is represented by *d* in Equation (4). The utility loss, *d*, is decreasing with the degree to which the individual conforms to the social norm, *S*. Though conformity to the social norm might not be entirely enforceable per se, the conspicuous nature of agricultural activities constitutes somehow a strong monitoring mechanism. For example, spending more time in your own field relative to the collective field is easily visible to the other household members. In addition, given the limited market access to inputs in the rural area, and also because household members tend to live in the same concession, the purchase and the use of such inputs is easily observed by the other household members.

Finally, the fact that proceeds from the collective plots are public goods within the household may incentivize some household members to free ride on others. While we are not able to empirically rule out this possibility with the available data, we argue that it should not be a large source of concern in this context since we are dealing with households instead of a large group of community. Indeed, Olson (1971) argues that social pressure to contribute to joint welfare works well in small groups where "members can have face-to-face contact with one another".

It is important to mention that we do acknowledge that individuals may readily contribute inputs to the collective plots for reasons other than social pressure. The motivation for our argument of the presence of social pressure to contribute input to the collective plots is due to the fact that 'private' plot managers could achieve a higher level of output on their own by allocating all their productive resources on their own 'private' plots. One fact supporting this claim is that the farm work schedule is generally such that individuals work on their ‘private’ plots in the afternoons after spending their mornings working on the collective plots (Becker, 1996) when they are likely to be the most productive.

3.2. Econometric approach

As argued by Udry (1996), if input allocation across different plots owned by the same household is Pareto-efficient, then controlling for plots’ physical characteristics, plots grown to the same crop in the same year should achieve the same production (as shown in equation (3)). Following the notations of Udry (1996) and Kazianga and Wahhaj (2013), the assertion made in equation (3) can be used to specify an econometric model for multiple households as follows:

$$Q_{htci} = X_{htci}\boldsymbol{\beta} + P_{\boldsymbol{htci}}\gamma + \delta_{ht} + \epsilon_{htci} \qquad (6)$$

where $Q_{htc□}$ is the log of yield on plot *i* planted to crop *c* in year *t* by household *h*; $X_{htci}$is a set of the observable characteristics of plot i, $\delta_{ht}$is a household-year-crop fixed effect; and $P_{\boldsymbol{htci}}$ is an indicator variable for collective plots (1 if collective plot and 0 otherwise). If productive resources are allocated efficiently within the household, then $\gamma = 0$. That is, yield on a plot should not depend on who controls the plot after controlling for factors that may influence yield.

Recall that the main hypotheses to be empirically tested are: (i) collective plots are more likely to receive fertilizer and manure than ‘private’ plots and (ii) collective plots use inputs (including labor) more intensively than ‘private’ plots. These hypotheses are driven by our assertion that social pressure compels household members to contribute to inputs on the collective plots such that those plot receive disproportionately more inputs than ‘private’ plots.

To empirically investigate this, we define a demand function for each input by crop type across collective plots and 'private' plots within the same household in the same year. Such demand function is specified in the following equation:

$$D_{htci} = X_{hci}\boldsymbol{\beta} + P_{hci}\gamma + \delta_{ht} + \epsilon_{htci} \,. \tag{7}$$

Operationally, D_{htci} is specified here as either the probability of the use of a given input (fertilizer or manure) or the intensity of the input use (fertilizer, manure, male labor, female labor, or child labor) per hectare on plot i of household h planted to crop *c* in period *t*.

The specification of the demand by crop type is motivated by the fact that input needs vary across crop types. A positive sign on γ for the estimation of the probability of the use of an input (fertilizer or manure) would be evidence that collective plots are more likely to receive that input and a positive sign on γ for the estimation of the intensity of the use of an input would be evidence that collective plots receive intensively more of that inputs than 'private' plots. One potential source of concern is the possibility of non-randomness of land allocation. In fact, since land allocation is made by the patriarch, it is possible that the later will allocate land of different quality in a way that creates a correlation between land quality and the plot type (collective plots or 'private' plots). This possibility and the lack of comprehensive land quality data lead to a concern of omitted variable bias. Nonetheless, this concern is lessened by the use of the household-year-crop fixed effect, which allow to remove the omitted variable bias due to unobserved time-invariant factors that may influence crop yield (Udry 1996 and Wooldridge, 2009).

4. Data source

The study uses the Saving for Change (SfC) project data[2]. The sampling was carried out in four "cercles" (Bla, San, Segou, and Tominian) in the Segou region, the second largest region of Mali (in terms of population). The agro-ecological zone of the region is the Sudano-Sahelian zone. While the region of Segou is well known for its fishery and pottery industry, the main economic activity remains small-scale farming. The main crops are millet, sorghum and vegetables. Even though there is a trend of increasing individualization of the farming system in places with high access to irrigation the farming system with the coexistence of collective plots and 'private' plots is still widely observed.

The data collection comprised a baseline and an endline surveys implemented in 2009 and 2012, respectively. Each round covered about 6,000 households in 500 villages. The survey used two household classifications: Restricted household (RHH) defined as a person with his direct dependents. This definition corresponds to the Western conception of the nuclear household. The second classification is the extended household (EHH) formed by extended family members where multiple restricted households live and carry out economic activities together. The survey used two questionnaires: one questionnaire for the RHH and another for the EHH. Only the questionnaire for the RHH was administered to households that are exclusively nuclear while both questionnaires were administered to RHH that live and carry out economic activities with an EHH. Plots belonging to the RHH are referred to as 'private' plots while those belonging to the EHH are classified as collective plots. Since the main objective of the study is to compare input allocations across collective and 'private' plots within the same household, the sample is restricted to households in which collective and 'private' plots coexist, which constitute about 75% of the total sample.

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[2] The objective of the SfC project was to evaluate a microfinance credit among rural women in the Segou region.

5. Results

5.1. Descriptive statistics

The descriptive statistics on plot characteristics and crop choice at the plot level across 'private' plots and collective plots are presented in Table 1. The results show that collective plots are significantly larger than 'private' plots (about four times larger). Also land tenure and soil type are different across the two types of plot management. These differences in plot characteristics are reflected in the differences in crop choice since the household's crop choice may depend on plot characteristics. A higher proportion of collective plots tend to be grown to cereal crops while the opposite is observed for vegetable crops. This might be explained by the higher proportion of female 'private' plot managers in the sample (74%), who are more likely to grow vegetable crops compared to male plot managers. These tendencies are also common among households in Burkina Faso (Udry (1996) and Theriault et al. (2015)). The most predominant cereal crops are millet and sorghum and this is consistent with the nationally representative data (USAID-Mali, 2008)).

The dependent variables are presented in Table 2. They include the proportion of plots on which fertilizer (or manure) is applied, the quantity of fertilizer, the quantity of manure, total labor, male-labor, female-labor and child-labor. All the continuous dependent variables are in hectare.

The statistics show that a relatively higher proportion of collective plots receive fertilizer and manure compared to 'private' plots. The quantity of fertilizer use per hectare is also significantly higher for collective plots. The most interesting figures in Table 2 are the ones related to labor use. Total labor per hectare is significantly higher for 'private' plots.

However, when labor is disaggregated by source, we find that the most contributing source of labor to the 'private' plots is female labor. This result may be explained by the fact that a large proportion of the 'private' plots are managed by women who tend to have very small plot size. Combined with the missing labor and land markets, the finding suggests that female-controlled plots are more likely to be intensively farmed.

5.2. *Regression results*

5.2.i. *Yield differential across collective plots and private plots*

The summary statistics in Table 2 show that collective plots significantly present higher yield than 'private' plots. However, as shown in Table 1, both crop choice and plot characteristics vary across collective plots and 'private' plots. The significant mean differences of plot characteristics and crop choice may constitute possible sources of variation in yields across collective plots and 'private' plots. Thus, as in Udry (1996) and Kazianga and Wahaaj (2013) we estimate differences in yield between 'private' plots and collective plots for plots planted to the same crop and in the same year in the same household.

Table 3 presents the results of the crop-specific regression of the log of yield using household year-crop fixed effects. Crops taken into account are millet, sorghum, maize, peanut, and vegetables. Our variable of interest is *collective*, an indicator variable for collective plots. We find that significantly higher yields are produced on collective plots compared to 'private' plots for all types of crops. The crop with the highest yield differential is millet, which constitutes the most prevalent subsistence crop in the study area.

These findings on yield differential are broadly consistent with the empirical results from previous studies (Udry (1996); Kazianga and Wahhaj (2013); Goldstein and Udry

(2008)) The almost monotonically decreasing coefficients on the deciles of plot size indicate that yield decreases with increasing plot size.

5.2.ii. Yield differential across plots controlled by household heads

A remarkable feature of the data used in the current work is that it allows to distinguish the ‘private’ plots controlled by the head of household from plots that are purely collective. Since collective plots are mostly controlled by the head of the household, this ability to separate the head’s ‘private’ plots from the collective plots he controls provides a unique way to investigate whether the observed yield differential is due to the attributes of the collective plots or to household headship. If the observed yield differential is solely due to the fact that collective plots are managed by the head of household, then the coefficient on the indicator variable *collective* should be statistically non significant after restricting the sample to heads that control both the collective plots and their own ‘private’ plots.

Table 4 presents the regression results for sorghum, millet, and “other crops” after restricting the sample to household heads that both control the collective plots of the extended household and their own ‘private’ plots. The category “other crops” includes rice, maize, peanut, chickpeas, bean, okra, and sesame. These crops are put together due to the lack of enough variations within households for these crops caused by the clustering at the household level.

While the magnitude of the coefficients on the indicator variable for collective plots becomes smaller compared to those obtained with the full sample, the coefficients remain statistically different from zero at the 1% significance level. This finding suggests that the observed yield differential between collective plots and ‘private’ plots is mainly due to the attributes of the collective plots though headship seems to matter (shown by the decrease in the coefficient on the collective plots).

5.2.iii. Input differential

The yield differential observed between collective plots and ‘private’ plots does not necessarily indicate that collective plots are more productive than ‘private’ plots since yield is contingent on inputs applied to the plot. For instance, Quisumbing (1996) shows that the main source of higher yields achieved on male-controlled plots is inequality of access to productive resources. This section investigates the probability and the intensity of fertilizer and manure use as well as the intensity of labor use across collective plots and private plots.

Fertilizer and manure use

The estimation results for the probability of fertilizer use are presented in Table 5. The estimated coefficients on *collective* indicate that ‘private’ plots planted to millet, sorghum, and peanut are more likely to receive fertilizer relative to collective plots, while the opposite is observed for maize. The estimates of the coefficients on the deciles of plot size are generally positive and statistically significant. They also tend to be increasing in magnitude (especially for millet and sorghum) as the plot size increases. These results provide evidence that the decision to use fertilizer increases with plot size. The results for manure use (which are not presented here in order to conserve space) are similar except for maize, where the coefficient on collective is not statistically different from zero.

Table 6 reports the intensity of fertilizer use across collective plots and ‘private’ plots for millet, sorghum, and “other crops”. The estimated coefficients on *collective* indicate that collective plots receive significantly a higher level of fertilizer application per hectare relative to ‘private’ plots regardless of crop type. Since there are decreasing marginal returns to scale in fertilizer use, the noted differences in the amount of fertilizer use per hectare across collective plots and ‘private’ plots imply that households fail to achieve a Pareto-efficient allocation of resources across plots belonging to the same household. This lack of Pareto-efficient allocation of resources has been found among households in other West African countries (Udry et al. (1995), Udry (1996) and Kazianga and Wahhaj (2013) in Burkina Faso; Goldstein and Udry (2008) in Ghana, and Duflo and Udry (2004) in Ivory Coast)).

Similar to the relationship between yield and land size, the estimated coefficients on plot deciles indicate a monotonically decreasing relationship between the intensity of fertilizer use and increasing plot size, which is expected. The regression results for manure did not yield any significance differences across collective plots and private plots.

A noteworthy finding in this analysis is the fact that collective plots receive significantly more fertilizer than ‘private’ plots while the opposite is observed for the probability of fertilizer use. We provide the following possibilities in an attempt to explain these rather intriguing findings. The first plausible explanation is related to the smaller sizes of private plots, which make the managers of such plots more likely to split a relatively small quantity of fertilizer across multiple plots that they control. Moreover, fertilizer for collective plots is usually bought in bulky (especially where government subsidized prices exist) based on the recommended application per hectare. Consequently, there might be a remainder of fertilizer after its application to the collective plots. Some individuals might then be able to negotiate the fertilizer from the head of household for their individual plots (Alpha Kergna, pers. Comm., July 2015). As a result, ‘private’ plots managers may be more likely to apply fertilizer on their fields but at lower amounts per hectare relative to those applied on the collective plots.

While the results in Table 5 refute our prediction –that is, collective plots are more likely to receive fertilizer compared to ‘private’ plots – they provide an interesting framework for highlighting the importance of the need to investigate not only the probability of the use of a given technology but also the intensity of the application of the technology. This is especially vital for inputs such as fertilizer that requires a certain amount in order to obtain a yield response.

Intensity of labor use

The estimation of the intensity of labor use is presented in Table 7 through Table 10. To account for heterogeneity in household labor use, we present the results for male labor, female labor, and child labor. Two findings are noteworthy and deserve consideration. The first is the positive and significant estimate of the coefficient for collective plots for total labor in Table 7, which apparently refutes the results in Table 2, where the mean of total labor for ‘private’ plots is significantly higher than that of collective plots. This contrasting finding might be explained by the negative and significant effect of the deciles of plot size, which are not controlled for in the test of the simple mean-difference.

The second notable finding is the contrasting signs of the coefficient estimates on *collective* across male labor and female labor presented in Table 8 and Table 9, respectively. The results show that collective plots are more intensively farmed with male labor relative to ‘private’ plots, while the opposite results are observed for female labor. Millet, the most prevalent subsistence crop, presents the highest gender differential labor use, shown by the positive and significant sign of the coefficient on *collective* in Table 8 whereas the corresponding figure in Table 9 is negative and statistically significant at the 1% significance level.

Similar findings on gender-differential in labor use on collective plots among rural households in Mali have been reported by Becker (1996). This hints that the social norms that compel individuals to contribute to the joint welfare of the extended family are not gender neutral. Becker (1996) observes that, when they are not working in the household field, women spent part of their time collecting firewood and preparing food for field workers. In addition, women might contribute to the joint welfare of the household by using vegetables from their own production for food preparation for the entire household.

5.2.iv. Isolating the gender differential factor

The descriptive statistics presented in Table 1 show that almost all collective plots and most 'private' plots are managed by men (i.e., the patriarch) and women, respectively. As a result, the yield and the input use differential observed above might be driven by the gender differential factor, rather than the attributes of the collective plots. In order to rule out this possibility, we exclude all female-controlled plots and investigate yield and input differentials across collective plots and male controlled 'private' plots.

The regression results of yield estimation across collective plots and male-controlled 'private' plots are presented in Table 11. The estimates of the coefficients on *collective* are still positive and statistically different from zero at the 1% significance level. However, we observe a decrease in the magnitude of the estimates. This shows that part of the observed yield differential between 'private' plots and collective collective is gender based. Indeed, the yield estimation by gender (not shown here) after restricting the sample to the 'private' plots show that male-controlled 'private' plots achieve higher yields than female-controlled plots. An implication for this finding is that investigating intrahousehold resource allocation across different plots without taking into account the gender component may lead misleading findings**.**

As in section 5.2.iii, we also explore fertilizer and labor use. Only the results related to labor are presented in Table 12. In order to conserve space, we present the results by "Cereal" versus "Non-cereals". The findings (including those related to fertilizer application) are generally similar to the ones obtained in section 5.2.iii with one striking exception regarding female labor use. Specifically, female labor, which is more intensively used on 'private' plots with the full sample (Table 9), has now shifted in favor of the collective plots. This indicates that most of the difference in female labor use observed in Table 9 is directed to female-controlled plots, indicating that women tend to work less on male-controlled 'private' plots. Conversely, the results obtained with the sample restricted to female-controlled plots and collective plots (results not shown here) show that female-controlled plots do not receive significant amount of male labor. Kazianga and Wahhaj (2013) obtain similar findings in Burkina Faso.

The current results –that is, higher intensity of labor use on collective plots relative to private plots –while in line with previous empirical findings in Burkina Faso, conflict with the finding by Guirkinger and Platteau (2014) among rural households in Mali. Particularly, the authors find that 'private' plots are more intensively farmed than collective plots, especially for labor-intensive crops such as peanut and rice. One factor that might reasonably explain the opposing findings between the two studies is the regional differences. In fact, the farming system in the study zone of the current work is still dominated by the coexistence of both collectively-managed and individually-managed ‘private’ plots while there is a high emergence of individually-managed ‘private’ plots among the sampled population in the study zone of Guirkinger and Platteau. It is this individualization of land-management (which the authors attribute to enforcement problems on the collectively-managed plots and the increased land scarcity) that motivates that motivated the aforementioned study. An interesting implication is that the social norms that govern the formation of the collectively-managed plots and, consequently, establish social pressure to contribute to the joint welfare of the whole household are sensitive to the economic incentives faced by individuals and communities.

6. Conclusion

This paper investigates intrahousehold productive resource allocation across collective plots and ‘private’ plots in the context of Mali. Two predictions were made: the first was that collective plots are more likely to receive fertilizer and manure than ‘private’ plots. This prediction is based on the argument that, due to social-cultural norms that establishes a hierarchy in decision making, a junior plot manager will be less likely to use an input (such as fertilizer) on his ‘private’ plot when that input is not used on the collective plot. The second prediction is that social pressure to contribute to the joint welfare of the household leads to collective plots receiving intensively more productive resources relative to ‘private’ plots.

The empirical results partially support the first prediction. Specifically, we find that the probability of fertilizer use is higher for private plots relative to collective plots except for maize. For the intensity of fertilizer use, the results show that collective plots receive significantly more fertilizer per hectare than ‘private plots’ regardless of crop type.

The results concerning labor allocation are mitigated. We find that collective plots are more intensively farmed with male labor than ‘private’ plots while opposite results are observed for female labor. After excluding female-controlled plots from the sample, (in order to isolate the gender differential effect), the results show that both male-labor and female-labor are more intensively applied to collective plot relative to ‘private’ plots. Nevertheless, the magnitude of male labor used on the collective plots is much larger than that of female labor, implying that women are not required to work on the collective plots as much as their counterpart males do. The change of the direction of the coefficient on *collective* for female-labor following the elimination of the gender differential effect provides evidence of the importance of taking into account the gender component when trying to understand intra-household allocation of resources across collective plots and ‘private’ plots.

The disproportionate allocation of fertilizer and labor across collective plots and ‘private’ plots suggests a lack of Pareto-efficiency in intrahousehold resource allocation. These findings are in line with previous empirical findings in Burkina Faso (Udry (1996); Kazianga and Wahhaj (2013)). Udry (1996) finds that rural households in Burkina Faso could increase their production by about 10 to 15 % by reallocating inputs from men’s plots to women’s plots.

Another noteworthy finding in the current work is the conflicting results with the work by Guirkinger and Platteau (2014), where the authors find that male-controlled ‘private’ plots are more intensively farmed than collective plots. We suggest the rise in the individualization of land-management, a factor that may dissolve the socials norms that govern the existence of collective plots, as an explanation for these contradictory findings.

Despite the growing evidence against the assumption of Pareto-efficiency in intrahousehold resource allocation across different plots owned by the household, an important aspect to bear in mind is that these plots are not randomly assigned and that the household's decision to allocate its resources across these plots may be driven by factors that are not observables to the researcher. As a result, the results from empirical studies striving to investigate intrahousehold input allocation are prone to omitted variable bias despite the use of sophisticated empirical specifications.

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Table 1
Plot characteristics and crop choice across private plots and collective plots

Variables	Private plots N=11,831 Mean	Collective plots N=45,861 Mean	Difference in means and significance level
Gender (1=female)	0.74	0.0025	0.737**
	(0.44)	(0.05)	
Plot characteristics			
Plot size	0.46	1.88	-1.417**
	(0.45)	(1.97)	
Plot is own by household	0.94	0.98	0.04**
	(0.24)	(0.15)	
Plot is rented by household	0.06	0.02	0.04**
	(0.23)	(0.14)	
Sharecropping	0.006	0.003	0.003**
	(0.08)	(0.05)	
Clay	0.39	0.35	0.05**
	(0.49)		
Clay_sandy	0.35	0.37	-0.02**
	(0.48)	(0.48)	
Sandy	0.23	0.26	-0.03**
	(0.42)	(0.44)	
Gravel	0.02	0.02	0
	(0.15)	(0.15)	
Crop choice			
Rice	0.03	0.09	-0.05**
	(0.18)	(0.28)	
Millet	0.12	0.24	-0.12**
	(0.33)	(0.43)	
Sorghum	0.07	0.17	-0.103**
	(0.26)	(0.38)	
Maize	0.03	0.09	-0.0675**
	(0.16)	(0.29)	
Peanut	0.38	0.12	0.256**
	(0.49)	(0.33)	
Beans	0.02	0.03	-671
	(0.16)	(0.16)	
Chickpeas	0.03	0.05	-0.0164**
	(0.17)	(0.21)	
Other_crops	0.11	0.04	0.0629**
	(0.31)	(0.20)	

Note: ** $p<0.01$, * $p<0.05$
Observations at the plot level
Standard deviation in parentheses

Top and bottom 1% of plot size are cut

Table 2
Descriptive statistics of dependent variables by plot ownership type

Variables	Private plots N=11,831 Mean	Collective plots N=45,861 Mean	Difference in means and significance level
Fertilizer use (1=yes)	0.29	0.34	-0.06**
	(0.45)	(0.48)	
Manure use (1=yes)	0.32	0.34	-0.02**
	(0.46)	(0.47)	
Fertilizer per hectare	19	69	-49**
	(60)	(119.73)	
Manure per hectare	1,696	1,532	164
	(5,745)	(5,149)	
Male labor per hectare	44.4	65	-21**
	(118)	(89)	
Female labor per hectare	106	37	68**
	(203)	(71)	
Child labor per hectare	38	36	2
	(109)	(68)	

Standard deviation in parentheses
Note: ** $p<0.01$, * $p<0.05$
Observations at the plot level
Labor is measured in men-days

Table 3

Estimation of the log of yield differential across private plots and collective plots

	Millet	Sorghum	Maize	Vegetable crops
Collective	1.572	1.101	0.840	1.070
	(0.146)***	(0.105)***	(0.169)***	(0.112)***
Plot size (1st decile is dropped)				
2nd_decile	-0.404	-0.338	-0.490	-0.574
	(0.125)***	(0.146)**	(0.370)	(0.180)***
3rd_decile	-0.751	-0.405	-0.346	-0.983
	(0.139)***	(0.147)***	(0.330)	(0.171)***
4th_decile	-1.189	-0.720	-1.028	-1.417
	(0.143)***	(0.176)***	(0.538)*	(0.211)***
5th_decile	-1.372	-0.991	-0.381	-1.549
	(0.192)***	(0.196)***	(0.407)	(0.547)***
6th_decile	-1.551	-0.761		-2.212
	(0.199)***	(0.218)***		(0.604)***
7th_decile	-1.335	-0.765	0.164	-1.549
	(0.218)***	(0.248)***	(0.909)	(0.547)***
8th_decile	-1.396	-0.764	-2.942	-2.201
	(0.237)***	(0.257)***	(0.366)***	(0.112)***
9th_decile	-1.256	-1.368		
	(0.230)***	(0.474)***		
10th_decile	-1.687	-1.172		-3.547
	(0.204)***	(0.288)***		(0.632)***
Clay & sandy	0.037	0.020	-0.041	-0.034
	(0.028)	(0.032)	(0.025)*	(0.067)
Sandy	-0.022	-0.004	0.008	0.083
	(0.026)	(0.023)	(0.022)	(0.068)
Gravel	0.058	0.011	-0.061	-0.080
	(0.041)	(0.035)	(0.029)**	(0.147)
Tenure (own dropped)				
Rent	-0.022	-0.086	0.014	-0.061
	(0.055)	(0.085)	(0.030)	(0.207)
Sharecropping	-0.342	0.251	0.004	0.634
	(0.216)	(0.208)	(0.009)	(0.292)**
Rain	-0.091	-0.094	0.024	-0.130
	(0.042)**	(0.052)*	(0.025)	(0.175)
Constant	6.009	5.618	5.811	4.739
	(0.114)***	(0.120)***	(0.230)***	(0.203)***
N	11,479	8,784		7,236

Note: *** p<0.01 ** p<0.05, * p<0.1

Observations at the plot level

Household year-crop fixed effects are included in all regressions.

Clustered standard errors in parentheses

Vegetable crops include okra, sesame, beans, and chickpeas

Table 4
Estimation of the log of yield differential across private plots and collective plots (heads only)

	Millet	Sorghum	All crops
Collective	0.590	0.786	0.491
	(0.139)***	(0.297)***	(0.120)***
Plot size (1st decile is dropped)			
2nd_decile	0.021	-0.975	-0.250
	(0.276)	(0.622)	(0.273)
3rd_decile	-0.484	-0.667	-0.455
	(0.294)	(0.509)	(0.295)
4th_decile	-1.069	-1.075	-0.858
	(0.374)***	(0.789)	(0.370)**
5th_decile	-1.275	-1.441	-1.020
	(0.428)***	(0.812)*	(0.413)**
6th_decile	-0.665	-1.290	-0.729
	(0.300)**	(0.546)**	(0.335)**
7th_decile	-1.634	-1.446	-1.014
	(0.345)***	(0.929)	(0.418)**
8th_decile	-0.737	-1.959	-0.939
	(0.464)	(0.927)**	(0.488)*
9th_decile	-1.233		-1.121
	(0.471)***		(0.563)**
10th_decile	-1.031	-2.317	-1.044
	(0.351)***	(0.806)***	(0.430)**
Soil type (clay dropped)			
Clay & sandy	0.067	0.019	0.030
	(0.056)	(0.114)	(0.045)
Sandy	-0.025	-0.003	0.032
	(0.055)	(0.056)	(0.039)
Gravel	0.011	-0.066	-0.002
	(0.059)	(0.071)	(0.069)
Tenure (own dropped)			
Rent	-0.010	-0.083	0.082
	(0.219)	(0.071)	(0.109)
Sharecropping			0.208
			(0.168)
Water source=rain	-0.177	-0.053	-0.067
	(0.105)*	(0.062)	(0.056)
Constant	6.747	6.400	6.037
	(0.247)***	(0.565)***	(0.263)***
N	1,415	1,090	6,640

Note: *** p<0.01 ** p<0.05, * p<0.1
Observations at the plot level
Household year-crop fixed effects are included in all regressions.

Clustered standard errors in parentheses

Table 5
Estimation of the probability of fertilizer use across private plots and collective plots

	Millet	Sorghum	Maize	Peanut	Vegetables
Collective	-0.12	-0.06	0.13	-0.09	-0.03
	(0.03)***	(0.03)**	(0.06)**	(0.01)***	(0.03)
Plot size (1st decile is dropped)					
2nd_decile	0.00290	0.03624	0.09125	0.012	0.014
	(0.03179)	(0.03433)	(0.06335)	(0.013)	(0.035)
3rd_decile	0.06	0.12	0.12	0.05	0.06
	(0.03)*	(0.04)***	(0.06)*	(0.02)***	(0.04)
4th_decile	0.13	0.15	0.20	0.08	0.04
	(0.03)***	(0.04)***	(0.09)**	(0.02)***	(0.05)
5th_decile	0.23	0.20	0.24	0.18	0.10
	(0.04)***	(0.05)***	(0.15)	(0.04)***	(0.06)
6th_decile	0.20	0.18	0.26	0.15	0.04
	(0.04)***	(0.06)***	(0.23)	(0.06)***	(0.04)
7th_decile	0.29	0.24	-0.00	0.15	0.05
	(0.04)***	(0.06)***	(0.16)	(0.08)*	(0.05)
8th_decile	0.32	0.27		0.33	0.66
	(0.04)***	(0.07)***		(0.11)***	(0.30)**
9th_decile	0.33	0.21		0.19	
	(0.06)***	(0.14)		(0.06)***	
10th_decile	0.31	0.27	0.05	0.23	0.05
	(0.05)***	(0.09)***	(0.10)	(0.36)	(0.04)
Soil type (clay dropped)					
Clay_sandy	0.03	0.04	0.14	0.02	0.00
	(0.02)	(0.03)	(0.07)*	(0.02)	(0.03)
Sandy	0.03	0.06	0.14	0.01	-0.02
	(0.02)	(0.03)*	(0.08)*	(0.02)	(0.04)
Other_soil	-0.08	-0.01	-0.08	0.06	-0.05
	(0.06)	(0.08)	(0.10)	(0.04)	(0.06)
Tenure (own dropped)					
Rent	-0.04	0.02	0.14	0.02	-0.09
	(0.05)	(0.10)	(0.11)	(0.03)	(0.10)
Sharecrop	0.15	0.25		0.16	0.34
	(0.09)*	(0.27)		(0.10)	(0.62)
Constant	0.39	0.24	0.36	0.10	0.16
	(0.03)***	(0.04)***	(0.06)***	(0.01)***	(0.03)***
N	11,582	8,111	4,214	9,655	7,474

Note: *** p<0.01 ** p<0.05, * p<0.1
Observations at the plot level
Household year-crop fixed effects are included in all regressions.
Clustered standard errors in parentheses

Table 6
Estimation of fertilizer use per hectare across private plots and collective plots

	Millet	Sorghum	Other crops
Collective	27.792	35.808	49.506
	(4.976)***	(8.581)***	(9.123)***
Plot size (1st decile is dropped)			
2nd_decile	-3.349	-7.135	-8.075
	(4.670)	(10.427)	(9.657)
3rd_decile	-17.509	-25.558	-31.814
	(5.678)***	(10.975)**	(12.845)**
4th_decile	-24.985	-36.707	-49.148
	(6.282)***	(14.200)***	(19.590)**
5th_decile	-29.612	-51.279	-22.465
	(7.155)***	(13.415)***	(23.987)
6th_decile	-34.890	-81.432	-65.292
	(7.233)***	(36.256)**	(30.057)**
7th_decile	-36.484	-53.451	-60.753
	(8.441)***	(12.849)***	(19.922)***
8th_decile	-35.062	-42.592	-65.129
	(9.681)***	(15.177)***	(23.588)***
9th_decile	-33.412	-53.399	-26.103
	(6.902)***	(14.634)***	(25.351)
10th_decile	-37.522	-72.702	
	(7.648)***	(15.688)***	
Soil type (Clay dropped)			
Clay & sandy	1.624	-4.536	39.009
	(3.114)	(6.338)	(29.175)
Sandy	7.595	-1.827	-6.954
	(3.251)**	(5.293)	(24.170)
Gravel	-2.018	-19.384	1.774
	(7.496)	(14.541)	(23.511)
Tenure (own dropped)			
Rent	2.063	6.280	-3.604
	(7.470)	(9.623)	(8.589)
Sharecropping	0.275		0.390
	(9.092)		(15.338)
Constant	24.626	41.258	41.353
	(3.836)***	(9.826)***	(13.546)***
N	5,263	2,785	5,918

Note: *** p<0.01 ** p<0.05, * p<0.1
Observations at the plot level
Household year-crop fixed effects are included in all regressions.
Clustered standard errors in parentheses

Table 7
Estimation of the log of the intensity of labor use (ha) across private plots and collective plots

	Millet	Sorghum	Maize	Peanut	Vegetables
Collective	64.592	63.384	37.260	64.302	41.364
	(10.716)***	(11.158)***	(20.653)*	(7.518)***	(15.018)***
Plot size (1^{st} decile is dropped)					
2nd_decile	-80.442	-59.504	-46.644	-76.355	-48.774
	(13.994)***	(14.701)***	(25.360)*	(9.832)***	(14.466)***
3rd_decile	-109.475	-86.890	-77.251	-106.623	-90.898
	(14.309)***	(16.329)***	(22.892)***	(8.269)***	(16.864)***
4th_decile	-137.647	-112.471	-107.356	-151.820	-97.221
	(15.601)***	(17.778)***	(33.487)***	(12.705)***	(21.044)***
5th_decile	-157.820	-120.226	-177.167	-187.600	-93.695
	(17.179)***	(17.576)***	(61.522)***	(22.175)***	(21.535)***
6th_decile	-157.309	-126.075	-73.381	-205.860	-144.451
	(16.589)***	(20.008)***	(28.933)**	(20.867)***	(40.961)***
7th_decile	-162.236	-148.340	-76.667	-156.310	-124.083
	(17.464)***	(21.034)***	(46.473)*	(28.625)***	(54.816)**
8th_decile	-187.587	-169.787	-141.209	-192.880	-137.662
	(23.784)***	(24.222)***	(54.652)***	(40.819)***	(43.118)***
9th_decile	-179.155	-168.977		-93.880	
	(18.058)***	(36.837)***		(68.295)	
10th_decile	-174.361	-166.486		-210.107	-89.821
	(20.874)***	(20.613)***		(40.473)***	(50.529)*
Soil type (clay dropped)					
Clay & sandy	4.166	-2.642	43.153	2.596	58.818
	(6.899)	(8.271)	(29.928)	(14.378)	(36.935)
Sandy	0.803	9.960	35.729	-5.691	9.039
	(7.095)	(9.468)	(22.846)	(9.477)	(23.920)
Gravel	-6.165	-25.715	37.483	13.744	23.572
	(8.705)	(14.358)*	(49.584)	(18.340)	(17.743)
Tenure (own dropped)					
Rent	9.522	-13.126	-11.107	31.578	-10.514
	(11.391)	(11.998)	(34.790)	(27.301)	(26.199)
Sharecropping	54.775	12.777		-0.207	49.297
	(35.852)	(18.204)		(20.240)	(22.863)**
Constant	192.312	172.749	165.152	198.671	153.220
	(14.141)***	(12.001)***	(20.631)***	(10.193)***	(21.928)***
N	11,584	8,106	4,195	9,674	7,475

Note: *** p<0.01 ** p<0.05, * p<0.1
Observations at the plot level
Household year-crop fixed effects are included in all regressions.
Clustered standard errors in parentheses

Table 8

Estimation of the intensity of male labor use

	Millet	Sorghum	Maize	Peanut	Vegetables
Collective	57.422	45.600	38.478	50.455	40.935
	(6.155)***	(5.742)***	(8.662)***	(3.929)***	(7.910)***
Plot size (1st decile is dropped)					
2nd_decile	-13.542	-12.947	-0.288	-13.252	-4.813
	(6.718)**	(7.996)	(9.625)	(4.084)***	(6.846)
3rd_decile	-22.026	-20.616	-14.071	-24.250	-27.830
	(7.311)***	(7.974)***	(9.429)	(4.589)***	(9.274)***
4th_decile	-35.517	-32.713	-32.082	-45.099	-34.814
	(8.533)***	(8.969)***	(18.021)*	(6.015)***	(10.074)***
5th_decile	-44.907	-33.124	-59.397	-61.084	-40.918
	(9.661)***	(8.665)***	(17.071)***	(9.967)***	(10.786)***
6th_decile	-45.184	-35.110	-42.414	-69.113	-48.738
	(9.104)***	(10.035)***	(11.627)***	(8.632)***	(18.809)***
7th_decile	-41.990	-41.937	18.061	-53.154	-62.293
	(9.070)***	(9.711)***	(34.633)	(17.181)***	(27.034)**
8th_decile	-53.126	-49.373	-105.370	-46.657	-82.047
	(10.234)***	(11.207)***	(42.414)**	(18.015)***	(26.209)***
9th_decile	-52.221	-41.041		-41.658	
	(10.088)***	(10.998)***		(29.118)	
10th_decile	-49.781	-57.377		-96.525	-77.731
	(11.033)***	(11.668)***		(25.826)***	(10.474)***
Soil type (clay dropped)					
Clay & sandy	2.394	-3.943	33.600	3.065	23.500
	(3.163)	(4.771)	(13.782)**	(4.971)	(15.334)
Sandy	2.509	5.506	8.633	-4.339	5.180
	(2.822)	(4.316)	(8.887)	(4.466)	(10.889)
Gravel	-2.617	-17.320	23.163	-3.299	11.208
	(4.264)	(8.281)**	(21.289)	(8.255)	(9.448)
Tenure (own dropped)					
Rent	1.662	-4.589	-2.463	1.180	-0.216
	(8.194)	(8.592)	(12.176)	(6.211)	(16.169)
Sharecropping	0.229	11.714		-11.972	-4.493
	(7.725)	(6.004)*		(9.547)	(4.812)
Constant	34.747	45.132	35.699	47.869	30.606
	(5.463)***	(6.619)***	(9.361)***	(3.963)***	(9.398)***
N	11,584	8,105	4,195	9,671	7,475

Note: *** p<0.01 ** p<0.05, * p<0.1
Observations at the plot level
Household year-crop fixed effects are included in all regressions.
Clustered standard errors in parentheses

Table 9

Estimation of the intensity of female labor use

	Millet	Sorghum	Maize	Peanut	Vegetables
Collective	-16.681	-7.604	-4.165	-6.759	-15.794
	(3.782)***	(4.202)*	(11.867)	(3.767)*	(6.471)**
Plot size (1st decile is dropped)					
2nd_decile	-47.296	-38.810	-52.784	-54.277	-38.283
	(7.170)***	(6.790)***	(15.566)***	(6.241)***	(6.611)***
3rd_decile	-63.551	-50.118	-50.062	-60.764	-42.354
	(7.140)***	(6.779)***	(14.202)***	(4.343)***	(7.790)***
4th_decile	-70.544	-53.672	-53.559	-75.845	-40.374
	(7.182)***	(7.168)***	(17.180)***	(6.694)***	(9.200)***
5th_decile	-75.756	-57.585	-85.256	-95.180	-28.753
	(7.255)***	(7.212)***	(31.533)***	(14.833)***	(10.477)***
6th_decile	-75.023	-59.245	-47.369	-98.699	-57.454
	(7.359)***	(8.157)***	(18.867)**	(13.538)***	(13.540)***
7th_decile	-79.307	-69.364	-73.559	-66.146	-38.454
	(7.823)***	(9.762)***	(25.706)***	(8.611)***	(19.815)*
8th_decile	-92.615	-69.680	-39.216	-84.083	-33.296
	(13.174)***	(12.148)***	(20.186)*	(23.053)***	(15.903)**
9th_decile	-85.222	-91.896		-39.099	
	(8.414)***	(28.056)***		(20.453)*	
10th_decile	-82.769	-66.617		-61.809	-2.824
	(8.496)***	(9.298)***		(19.047)***	(42.949)
Soil type (clay dropped)					
Clay & sandy	0.463	0.947	-0.165	-6.593	30.396
	(3.042)	(3.727)	(14.963)	(10.818)	(19.442)
Sandy	-2.952	4.275	13.712	-0.600	5.652
	(4.075)	(3.188)	(12.679)	(6.221)	(11.101)
Gravel	-3.615	-1.071	-10.652	13.915	7.663
	(4.393)	(5.422)	(24.589)	(10.299)	(8.709)
Tenure (own dropped)					
Rent	8.638	-8.624	7.452	32.599	-7.011
	(6.665)	(5.695)	(17.246)	(23.630)	(15.575)
Sharecropping	30.788	-11.599		1.960	23.683
	(20.710)	(13.713)		(11.899)	(5.794)***
Constant	118.340	94.317	89.432	113.589	88.360
	(8.418)***	(6.633)***	(13.754)***	(7.052)***	(10.585)***
N	11,583	8,105	4,195	9,673	7,475

Note: *** $p<0.01$ ** $p<0.05$, * $p<0.1$

Observations at the plot level

Household year-crop fixed effects are included in all regressions.

Clustered standard errors in parentheses

Table 10

Estimation of the intensity of child labor use

	Millet	Sorghum	Maize	Peanut	Vegetables
Collective	23.856	23.940	2.946	20.695	16.223
	(3.476)***	(5.608)***	(7.556)	(2.580)***	(4.553)***
Plot size (1st decile is dropped)					
2nd_decile	-19.606	-9.760	6.427	-8.897	-5.679
	(4.957)***	(4.901)**	(7.809)	(3.126)***	(5.190)
3rd_decile	-23.905	-18.884	-13.118	-21.646	-20.714
	(4.881)***	(5.453)***	(7.310)*	(2.902)***	(5.406)***
4th_decile	-31.590	-27.637	-21.714	-30.977	-22.032
	(5.077)***	(6.187)***	(10.396)**	(5.019)***	(7.007)***
5th_decile	-37.161	-30.805	-32.515	-31.456	-24.024
	(5.686)***	(5.947)***	(20.481)	(4.889)***	(8.652)***
6th_decile	-37.106	-32.901	16.402	-38.169	-38.259
	(5.446)***	(6.632)***	(8.500)*	(6.965)***	(19.237)**
7th_decile	-40.944	-37.770	-21.169	-37.145	-23.336
	(6.147)***	(7.684)***	(13.781)	(8.719)***	(12.960)*
8th_decile	-41.850	-51.428	3.377	-62.285	-22.320
	(6.183)***	(14.565)***	(19.622)	(30.801)**	(11.370)**
9th_decile	-41.715	-36.424		-13.239	
	(6.216)***	(8.637)***		(22.410)	
10th_decile	-41.794	-43.296		-51.916	-9.267
	(6.602)***	(7.371)***		(9.721)***	(7.232)
Soil type (clay dropped)					
Clay & sandy	1.308	-2.508	9.718	6.131	4.922
	(2.669)	(3.160)	(11.812)	(3.575)*	(8.326)
Sandy	1.246	-0.495	13.384	-0.873	-1.792
	(2.043)	(3.491)	(7.986)*	(2.874)	(7.662)
Gravel	0.066	-7.911	24.972	3.079	4.701
	(2.808)	(3.502)**	(12.435)**	(4.369)	(9.839)
Tenure (own dropped)					
Rent	-0.775	-1.053	-16.096	-2.172	-3.487
	(4.558)	(3.275)	(16.148)	(3.517)	(6.494)
Sharecropping	23.760	12.377		9.821	30.107
	(13.436)*	(7.598)		(7.910)	(23.534)
Constant	39.231	37.484	40.043	37.288	34.254
	(4.888)***	(5.160)***	(7.772)***	(2.897)***	(6.370)***
N	11,582	8,103	4,193	9,669	7,475

Note: *** p<0.01 ** p<0.05, * p<0.1
Observations at the plot level
Household year-crop fixed effects are included in all regressions.
Clustered standard errors in parentheses

Table 11
Estimation of the log yield differential across male-controlled plots and collective plots

	Millet	Sorghum	Maize	Vegetables
Collective	0.749	0.704	0.635	0.690
	(0.160)***	(0.157)***	(0.183)***	(0.077)***
Plot size (1st decile is dropped)				
2nd_decile	-0.099	-0.335	-0.925	-0.350
	(0.356)	(0.287)	(0.526)*	(0.176)**
3rd_decile	-0.242	-0.505	-0.612	-0.464
	(0.415)	(0.285)*	(0.663)	(0.191)**
4th_decile	-0.811	-0.822	-1.630	-0.946
	(0.321)**	(0.354)**	(0.939)*	(0.204)***
5th_decile	-0.837	-0.790	-0.787	-0.822
	(0.362)**	(0.398)**	(0.632)	(0.221)***
6th_decile	-0.857	-0.751		-1.063
	(0.340)**	(0.340)**		(0.218)***
7th_decile	-0.828	-0.822	-1.147	-0.902
	(0.412)**	(0.510)	(0.843)	(0.286)***
8th_decile	-0.942	-1.080	-3.297	-1.274
	(0.352)***	(0.380)***	(0.667)***	(0.249)***
9th_decile	-0.969	-1.351		-1.123
	(0.422)**	(0.809)*		(0.329)***
10th_decile	-0.976	-1.323		-1.158
	(0.329)***	(0.459)***		(0.245)***
Soil type (clay dropped)				
Clay & sandy	0.011	-0.012	-0.019	-0.001
	(0.018)	(0.020)	(0.016)	(0.013)
Sandy	-0.032	-0.000	-0.000	0.004
	(0.018)*	(0.012)	(0.013)	(0.014)
Gravel	0.033	-0.046	-0.014	-0.002
	(0.029)	(0.035)	(0.009)	(0.033)
Tenure (own dropped)				
Rent (own_plot dropped	-0.008	0.007	0.014	0.008
	(0.029)	(0.034)	(0.015)	(0.034)
Sharecropping	-0.190	-0.006	0.002	0.049
	(0.116)	(0.010)	(0.004)	(0.092)
Water source=rain	-0.029	-0.037	0.012	-0.030
	(0.023)	(0.032)	(0.012)	(0.025)
Constant	6.232	6.012	6.336	5.895
	(0.343)***	(0.264)***	(0.406)***	(0.162)***
N	10,400	8,205	4,982	38,825

Note: *** p<0.01 ** p<0.05, * p<0.1
Observations at the plot level
Household year-crop fixed effects are included in all regressions.
Clustered standard errors in parentheses

Table 12
Estimation of fertilizer use per hectare across male-controlled plots and collective plots

	Cereals	Vegetables
Collective	38.893	21.583
	(6.512)***	(7.845)***
Plot size (1st decile is dropped)		
2nd decile	-22.073	-4.456
	(9.322)**	(12.577)
3rd decile	-44.575	-35.704
	(9.504)***	(17.043)**
4th decile	-55.610	-37.234
	(10.477)***	(20.869)*
5th decile	-57.260	-31.102
	(10.855)***	(25.211)
6th decile	-74.476	-31.562
	(13.774)***	(16.457)*
7th decile	-68.023	-75.423
	(11.301)***	(53.335)
8th decile	-69.895	
	(12.594)***	
9th decile	-70.162	
	(11.091)***	
10th decile	-69.840	
	(11.285)***	
Soil type (clay dropped)		
Clay & sandy	1.690	0.352
	(5.757)	(15.147)
Sandy	-2.841	-19.239
	(5.452)	(21.434)
Gravel	-11.322	
	(8.517)	
Tenure (own dropped)		
Rent	4.440	34.141
	(7.484)	(21.597)
Sharecropping	21.145	
	(15.219)	
Constant	63.109	49.490
	(8.153)***	(13.676)***
N	11,200	1,022

Note: *** p<0.01 ** p<0.05, * p<0.1
Observations at the plot level
Household year-crop fixed effects are included in all regressions.
Clustered standard errors in parentheses

Table 13
Estimation of male, female and child labor (ha) across male-controlled plots and collective plots

	Cereal	Vegetables	Cereal	Vegetables
Collective	18.847	22.404	14.830	7.333
	(4.802)***	(5.944)***	(2.616)***	(4.015)*
Plot size (1st decile is dropped)				
2nd decile	-31.044	-46.910	-12.972	-18.856
	(7.417)***	(11.757)***	(3.684)***	(7.404)**
3rd decile	-41.291	-62.829	-19.937	-23.058
	(7.728)***	(10.552)***	(3.879)***	(6.793)***
4th decile	-54.634	-71.528	-27.130	-31.616
	(8.478)***	(12.628)***	(4.103)***	(7.949)***
5th decile	-60.573	-78.555	-31.179	-35.676
	(9.108)***	(12.662)***	(4.139)***	(8.013)***
6th decile	-59.985	-93.580	-31.328	-52.554
	(8.695)***	(13.731)***	(4.354)***	(13.023)***
7th decile	-60.006	-77.442	-33.753	-26.485
	(8.627)***	(15.103)***	(4.365)***	(10.325)**
8th decile	-65.999	-85.859	-36.192	-33.088
	(8.676)***	(15.485)***	(5.243)***	(8.660)***
9th decile	-65.387	-115.430	-33.739	-20.301
	(9.391)***	(27.467)***	(4.236)***	(12.218)*
10th decile	-68.668	-87.471	-36.675	-29.327
	(9.121)***	(15.200)***	(4.713)***	(18.649)
Soil type (clay dropped)				
Clay & sandy	2.802	-0.263	2.517	7.124
	(2.580)	(8.793)	(1.569)	(5.222)
Sandy	5.760	-10.221	3.150	-7.341
	(2.370)**	(7.680)	(1.442)**	(5.757)
Gravel	-2.846	4.902	-2.859	9.635
	(5.083)	(14.106)	(3.319)	(11.776)
Tenure (own dropped)				
Rent	3.707	14.585	1.442	10.528
	(3.887)	(11.664)	(1.685)	(8.879)
Sharecropping	-4.722		-3.161	
	(4.975)		(3.330)	
Constant	87.693	103.676	40.853	58.430
	(7.550)***	(9.279)***	(3.976)***	(6.972)***
N	25,814	11,366	25,812	11,367

Note: *** p<0.01 ** p<0.05, * p<0.1
Observations at the plot level
Household year-crop fixed effects are included in all regressions.
Clustered standard errors in parentheses