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Review

Productive inefficiency in extended agricultural households: Evidence from Mali

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ABSTRACT

In Sub-Saharan African farm households, two types of plot management often coexist: collective fields are farmed jointly by household members under the authority of the head while individual plots are autonomously managed by members. In this paper we explore the productivity differentials between collective and individual plots in the context of extended family farms. We find that land yields are significantly larger on male private plots than on common plots after all appropriate controls have been included. Yet, the disadvantage of common plots exists only for care intensive crops and for cash crops. We provide evidence that the yield differentials stem from labor incentive problems. They may arise from the prevailing reward function and/or from preference heterogeneity over the use of the proceeds from the collective field.

1. Introduction

There has been a recent surge of interest in African family farms where collective plots that are collectively managed and worked coexist with private plots held and cultivated by individual members. On the one hand, economists have tried to understand the rationale behind the existence of various forms of farm-cum-family structures. Their theories aim at explaining either the shift from a pure collective farm to a mixed structure in which private and collective plots coexist, or the split of the collective farm into individual units (see Fafchamps, 2001, for an explanation of the former, Foster and Rosenzweig, 2002, for an explanation of the latter, and Guirkinger and Platteau, 2014, for an explanation of both). On the other hand, many studies have compared the productivity of plots (with similar characteristics) controlled by different types of farmers across households or more frequently within the same household. A large number of these studies have identified systematic gender productivity differentials and conclude to a non optimal land allocation: ceteris paribus, men tend to be more productive than women (Udry et al., 1995; Udry, 1996; Bindlish, Evenson, Gbetibouo, 1992, all dealing with Burkina Faso; Goldstein and Udry, 2008, for Ghana; Sirdhar, 2008 for Nepal; Holden et al., 2001, for Ethiopia; Jacoby, 1992, for Peru).[1]

To our knowledge, and with the exception of Kanzianga and Wahhaj (2013), hardly any study dealing with sub-Saharan Africa has assessed land yields based on a distinction between collective and individual fields, despite their oft-observed coexistence. By collective fields, we mean plots that are jointly cultivated by the family workforce under the responsibility of the head who makes decisions regarding both production and output allocation. Conversely, individual plots are independently managed, for their own use, by members of the household.[2] Kanzianga and Wahhaj compare productivity of senior male plots (assumed to be collectively farmed) with junior male private plots and female private plots in Burkina Faso. We follow up on their effort by investigating the same issue in the context of neighboring Mali, and come up with a completely different conclusion. While Kanzianga and Wahhaj find that collective plots are farmed more intensively and achieve higher yields than plots with similar characteristics farmed by individual members, we reach the opposite conclusion. In our investigation, we focus on the situation of private plots farmed by male members. This is because female plots obey a different logic compared to male plots with the result that, on their private plots, women are much more constrained than men in terms of both crop choice and use of the proceeds (Guirkinger and Platteau 2015). Because of their numerous duties inside the household, they are also more constrained in terms of sheer labor availability. Of course, in studying the differences between male private plots and collective field, we need to systematically control for female private plots. The smaller yields obtained on the female plots will be shortly commented within the general framework of our interpretative discussion.

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[1] Note that in these studies, male plots include both collective and private holdings since the authors are usually not able to distinguish between them. In contrast, female plots are private, except for the rare cases of female-headed households.

[2] Our questionnaire was specifically designed to track all collective and individual plots. First, for each household member, the household head was asked whether she/he has been granted a plot for personal cultivation. All the members thus identified were then selected to participate in the individual holders' survey. In the next step, a complete list of all collective and individual fields was drawn. The consistency between the head's reporting of individual plots and the information obtained from the members was dutifully checked.

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Our investigation of productivity differentials across plot types proceeds in three steps. First, we perform a descriptive analysis of the differences in yields between collective and male individual plots. It shows that male individual plots are significantly more productive than collective plots. Second, we use econometric analysis to determine whether the difference remains when we control for household and crop fixed effects along with individual farmer and plot characteristics. We still find important productivity differentials between individual and collective plots. Third, we explore whether the productivity differential holds for all crops or mainly characterizes certain categories of crops, namely care-intensive versus care-saving crops, and cash versus subsistence crops. What comes out is that care-intensive and cash crops largely account for the yield differential.

We hypothesize that yield differences between collective and male private plots can be ascribed to variations in labor effort that can themselves be explained in terms of incentives. Such a claim is strongly supported by qualitative evidence gathered in the course of the fieldwork. We then proceed by discussing the exact nature of the incentive problems at stake. A distinction is thus made between incentive problems caused by the prevailing remuneration system and those arising from heterogeneous preferences. These two explanations, which are not mutually exclusive, are compatible with our results.

The two aforementioned lines of explanation have been advanced by several authors to account for the individualization of farm units. Incentive problems caused by remuneration rules are at the heart of the theory of agricultural cooperatives proposed by Putterman and DiGiorgio (1985) and Carter (1987). When output is shared equally among members, a moral-hazard-in-team problem arises that leads to efficiency losses increasing in the number of co-workers. This disadvantage of collective production is to be set against its insurance advantage, giving rise to a trade-off between efficiency and risk-pooling considerations. A similar analysis has been recently extended to large family farms (Delpierre, Guirkinger, Platteau, 2012). A different trade-off underlies the analysis proposed by Guirkinger and Platteau (2014) in which it is rent-seeking instead of risk considerations that must be balanced against efficiency considerations. Their setup is that of a patriarchal farm-cum-family structure where the patriarch maximizes the surplus he extracts from the collective field by allocating family land between private plots and the collective field under the participation constraint of the individual members.

Note that the argument stressing the superiority of privately managed plots in terms of productivity has been formulated slightly differently by economists inspired by the work of Boserup (1965). More precisely, if farmers adopt relatively land-saving and labor-using techniques for which quality of labor matters, significant management diseconomies exist: since labor is costly to monitor, the advantage of private farming on individual plots increases as agriculture becomes more intensive (see, for example, Binswanger and Rosenzweig, 1986).

Incentive problems caused by heterogeneous preferences are central to the argument put forward by Foster and Rosenzweig (2002) to explain farm household splits in rural India. According to them, preferences of members work against efficiency in collective production: when preferences regarding the use of output diverge among members, their incentive to work on a collective field is undermined.

The explanation advanced by Kanzianga and Wahhaj (2013) differs from the above two strands of the literature. Indeed, they emphasize the public character of the good produced on the family field: social norms exist that require the head to use all the proceeds of this field for the collective good so that every member benefits from it. Moreover, junior partners are assumed to have a particularly strong preference for the public good thus generated. As a consequence, they are more willing to work on the collective field than on their private plots. It bears emphasis that the households surveyed in their study are relatively small and largely nuclear.

The remainder of the paper is organized as follows. Section 2 presents the setting of the study and some key background information regarding the organization of family farms in Mali. Sections 3 and 4 are devoted to the empirical analysis of yield differentials between collective and private plots. Section 5 provides a detailed discussion of the mechanisms that may drive the comparative advantage of private plots. Section 6 concludes.

2. The setting

2.1. The survey

The data used in this paper is first hand data collected in the south-eastern region of Mali in 2008. An interesting feature of this region is that various types of farm organization coexist. Traditional collective farms headed by a patriarch are still widespread although there is an increasing tendency toward more individualized forms of cultivation. We randomly sampled 17 villages in the three districts of Koutiala, Sikasso and San, which belong to the old cotton growing region. Within each village, we randomly selected 12 households from a complete listing of the local household population. A questionnaire was administered to each household head. In addition to detailed information on the composition of the household, we collected information on the size and structure of the associated farm, including the listing of all fields jointly cultivated by the family or individually held and worked by members, whether male or female. Another questionnaire was then addressed to a random sample of private plot holders.[3] The selection of the sampled individual farmers was made randomly.[4] We obtained very detailed information on agricultural production, plot characteristics and access to agricultural equipment. Furthermore, in order to have a more complete view of the household's *modus operandi*, precise qualitative questions were asked about the different rights and duties of the household members, and about the pros and cons of collective versus mixed farm structures.

2.2. Farm and family structures

As defined in Matlon (1988), cited in Udry (1996: 1016), a household is a group of individuals who "work jointly on at least one collective field under the management of a single decision-maker and draw an important share of their staple foodstuffs from one or more granaries which are under the control of that same decision-maker." In West Africa, many rural households extend both vertically (in the sense that married sons continue to live with their father) and horizontally (brothers of the head, their wives and children are part of the household). In our sample about 40% of household heads live with their brothers while, at the other extreme, only around 20% have neither brothers nor married sons around (strictly speaking, they are nuclear households). Moreover, more than half of the household heads are polygamous. On average, the sample households count 11 individuals above 12 years old with a maximum family size of 30.

In these large households, the incidence of mixed farm structures has increased over the last decades especially because of the growing number of male individual plots. On collective plots, members continue to work as a team and output is shared among all the co-workers after

[3] We initially intended to cover all the individual farmers listed by the head, yet due to time and budget constraints only two-thirds of them (68%) could be interviewed. On an average, the interview of a household comprising only collective family fields lasted half a day while the interview of a household with a mixed farm structure lasted a whole day, the second half being devoted to the interviews of private plot holders.

[4] The field supervisors got a complete list of the private plot holders in the sample households from the survey of the household heads, and they randomly drew the sample of holders to be interviewed. We believe that we do not have any biased sample of private plot holders since we do not find any systematic differences between interviewed individual farmers and those who have not been selected (as assessed from the questionnaire addressed to the household head).

[5] Only 6% of individual plot holders made transfers to the head in cash or in-kind during the 12 months preceding the survey and, when they took place, these transfers were small.

the head has retained his own portion. Conversely, male individual plot holders freely allocate the incomes that they have individually obtained and transfers to the patriarch are very rare.[5] In contrast, female individual plot holders are typically granted individual plots (also called “garden plots”) under the understanding that they must provide certain ingredients of collective meals (condiments for the “sauce”, in particular). Furthermore, when women have individual plots they are often freed from the duty to work on collective fields, which is not the case for men with individual plots.[6] Also, while the distribution of individual plots to male is a relatively recent practice in the study area, female individual plots are considered part of the traditional family farm. Male and female individual plots thus respond to different organizational principles. The main focus of the present paper is on male individual plots.

Of the 204 households of our sample, 58 belong to purely collective farms: all their fields are jointly managed. Out of the remaining 146 households, 69 have distributed individual plots to female members only, while 63 have awarded such plots to both male and female members. In another paper (Guirkinger and Platteau, 2015), we analyze a household head's decision to grant individual plots to male members. We show that male individual plots are more likely to be distributed in households where land pressure is more acute and the structure is more complex.[7]

2.3. Plots and crop allocation within households

In households where male individual plots exist, a rule prevails that assigns them to all male members above a certain age. In other words, the head does not earmark private plots for members with special characteristics, relatively skilled and hard-working members, for example. It is thus revealing that, in the few cases where the head's brothers have an individual plot while sons do not, the latter tends to be very young. Moreover, in 85% of the cases, the youngest man with a private plot turns out to be older than the oldest man with no such plot. In most cases, the man who appears excluded is either studying, sick, specializing in livestock breading or in a small business. In short, he does not actually participate in cultivation. Eventually, it is only in 5% of the cases that the age hierarchy is not respected in the sense that one holder of a private plot is younger than a man who participates in cultivation but has no such plot. Note, moreover, that in households were several men have an individual field, differences in size tend to be small: in three-fourth of the cases, the difference between the average size of all these fields and the individual observation is less than 20%.[8] Finally, it bears emphasis that the egalitarian principle rules out systematic variations between private plots not only in terms of quantity but also in terms of quality. We thus find that, in 60% of the sample households where several men possess a private plot, private plots all belong to the same larger field whose quality is rather uniform.[9] [10]

The crop pattern adopted by the sample farms is complex. Over a particular season (rainy or dry), our data show that a farmer can plant as many as eight different crops by subdividing a plot. In subsequent analysis, the land unit will therefore be the subplot assigned to a particular crop, and we refer to it as plot.[11] Table 1 provides information about the plot data set. From column (1), we see that our sample includes 1784 plots, of which 1049 are collectively cultivated and are 735 private plots. A total of 530 private plots belong to female household members and 205 to male members.[12] On an average, an individual farmer holds 1.6 plots in the mixed farms. In contrast, there is an average of 5.1 collective plots per household. Table 2 provides a detailed account of the frequency of crops grown across types of plots (more details about this later).

Table 1
Description of the plot sample.

	(1) Total number of plots	(2) Dryland plots	(3) Plots in care-intensive crops	(4) Nr of interviewed farmers
Collective plot	1049	990	504	201
Individual plot	735	406	619	387
Male plot	205	118	171	115
Female plot	530	288	448	272
Total	1784	1396	1123	587

Any study dealing with land productivity has to give great attention to quality variations between plots. We will come back to this important point later. For the moment, we simply focus on the critical distinction between dry and bottom lands. Dryland can be farmed only during the rainy season because cultivation entirely depends on rainfall. Bottom lands, by contrast, correspond to plots located in a flood-recession area or irrigable with a well, so that they can be possibly cultivated beyond the rainy season and allow the growing of more water-demanding crops, such as vegetables. Column (2) of Table 1 reveals that collective plots are more likely to be on dryland than individual plots. Column (3) reports the number of plots planted to care-intensive crops (the remainder are in care-saving plots). This critical distinction will be used in the econometric analysis.

Our measure of productivity is plot yield, measured as the value of a plot output divided by plot area. Since the practical difficulties in computing these yields are considerable, they deserve a special discussion that the interested reader will find in Appendix A.

3. Difference in productivity between collective plots and male individual plots

Table 3 presents descriptive statistics for yields at the plot level. It breaks the sample into collective and individual plots, and it distinguishes between male and female individual plots. The first column (top half) indicates that male individual plots (MIP) are more than twice as productive as collective plots (CP). Columns (2) and (3) distinguish between dry and bottom plots. As expected, yields on the higher quality land (bottom land) are considerably higher than on dryland, and this is true for collective fields as well as for private plots. The differences in land productivity across collective and male individual plots are of similar relative magnitude on both types of land, and they are always statistically significant.

At this stage it is important to stress that efficient input allocation does not require that yields are identical across different plots, only that marginal productivities are equalized. For example, with a production function concave in plot size, we expect smaller plots to exhibit higher yields (quality being constant). By the same logic, two identical

[5] Only 6% of individual plot holders made transfers to the head in cash or in-kind during the 12 months preceding the survey and, when they took place, these transfers were small.

[6] 41% of women who have an individual plots are not required to work on collective fields. In contrast, only 9% of male individual plot holders are in this situation.

[7] In Guirkinger and Platteau (2015), we show that, assuming that family members have a given outside opportunity, individualization is predicted to occur as land pressure becomes strong enough, and that the size of private plots should then increase with the same pressure. The intuition is that in face of land pressure, the head has to pay greater attention to efficiency considerations even if he cannot extract rent from private plots. When put to the data, the two predictions stand neatly confirmed. Note that in the present paper we are not using exactly the same sample as in Guirkinger and Platteau (2015): it is only for the 204 households surveyed in 2008 that we have the detailed production information needed for the present analysis.

[8] In computing this statistic, we have added up the areas of all plots possessed by a given individual.

[9] To obtain this statistic we use information on plot name as detailed in Section 3.

[10] Note also that we find no correlation between plot characteristics (area, bottom, distance) and the characteristics of the plot holder (age, number of children, number of wives and the fact that he is a brother of the head).

[11] In case of intercropping, we compute the per ha yield for each of the associated crops (without adjusting the area because we do not have the required information). Intercropping only occurs on 12.8% of the cultivated plots, and this frequency does not significantly differ between collective and individual plots. When we add a dummy variable indicating the presence of inter-cropping in our regressions, all our results hold and the coefficient of this new variable is never significantly different from zero.

[12] Bear in mind that the sample of collective fields is complete whereas we have a randomly selected subsample of individual plots.

Table 2
Distribution of crops for each type of plot (columns sum to 100%).

	Collective plots	Male individual plots	Female individual plots	All plots
Care-saving crops				
Sorghum	25.07	10.24	11.13	19.23
Millet	19.26	2.44	2.08	12.22
Niebe	4.39	3.9	2.26	3.7
Fonio	3.24	0	0	1.91
Care-intensive crops				
Cotton	10.77	3.41	0.19	6.78
Rice	2.67	6.34	19.81	8.18
Groundnut	9.15	19.51	23.02	14.46
Maiz	17.25	7.32	1.32	11.38
Pepper	0.57	15.61	11.32	5.49
onion	0.57	12.68	9.81	4.71
Tomato	0.57	6.34	3.77	2.19
Sweet potato	0.29	2.93	3.02	1.4
Gombo	0.19	0.98	7.36	2.41
Pois de terre	2.67	0	2.08	2.19
Cabbage	0.29	2.44	0.38	0.56
Sesame	1.62	1.46	0.38	1.23
Ginger	1.05	3.9	2.08	1.68
Potato	0.38	0.49	0	0.28

plots of the same size should have the same productivity in the efficient equilibrium (for a formal treatment, see Udry, 1996).

Other factors than plot size may explain average differences in yields. First, crop choice may systematically differ between male individual plots and collective fields. If groundnut is more productive than sorghum and if the former is cultivated on individual plots while the latter is cultivated on collective plots, average yields would be higher on individual plots than on collective fields. Second, the observed differences may reflect differences in plot-specific characteristics. Individual plots may be located on land of better average quality than collective plots. Finally, households where male individual plots are present may be on average more productive (for example, because the household head is more educated) in which case the yield premium of individual plots would reflect a household characteristic.

Tables 2 and 4 indicate that the first and last concerns are partly justified. To begin with, the distribution of crops is different on collective and male individual plots. However, Table 2 also reveals that there is no complete crop specialization according to the type of plot: groundnuts and sorghum, in particular, but also rice, maize, and millet to a lesser extent, are cultivated on both collective fields and private plots (within mixed structure). Regarding the last concern, Table 4 reports average differences across households with and without male individual plots and shows that households with male individual plots are larger in terms of both household size and total landholding. Furthermore they are more likely to own bottom land. Household heads who have distributed individual plots to male members are also older by three years on an average yet this difference is not statistically significant.

In order to check whether yield differences between collective and individual plots are driven by crop choices and household characteristics, the bottom portion of Table 3 reports the results of regressions of yield on plot type, controlling for crop and household fixed effects. Since the average yield on collective plots is 71,000 FCFA, the reported coefficient indicates that on an average male individual plots remain more than twice as productive as collective plots. This implies that only about 35% of the raw difference in yields between plot types can be attributed to systematic differences across crops and households (column (1)).

Even if crop and household fixed effects absorb many systematic differences across individual and collective plots, the remaining yield differential may still reflect differences in intrinsic characteristics of the plots within households (our second concern above). Table 5 shows that individual plots undeniably differ from collective plots in several dimensions that are correlated with yields. For example, individual plots are more likely to be on bottom land and they are significantly closer to the household dwelling. These two characteristics tend to be positively correlated with yield and may thus explain part of the raw differences between plot types observed above. In contrast, collective fields appear advantaged in terms of input application: chemical input expenditures tend to be positively correlated with yield and are larger on collective than on individual plots. Importantly, the average size of individual plots represents only 25% of the average size of collective plots. Given this stark contrast in plot size, we need to verify that there is actually a sufficient overlap in the support of the distribution of plot sizes by type of plot before turning to a multivariate framework. Fig. 1 indicates that this is the case at least for plots of less than 3 ha. It deserves to be emphasized that all the results presented in the paper are robust to dropping plots larger than 3 ha. This overall lack of balance across plot types not only points to the need to turn to a multivariate framework to examine yield differentials, but also raises the concern that endogenous allocation is biasing our results. In other words, we may worry that individual plots are superior to collective plots along some unobserved dimension that we wrongly confound with the effect of the mode of cultivation (individual vs collective). In an effort to address this concern, we perform various robustness checks that raise confidence in our main result, still given the nature of our data, we cannot definitely rule out the influence of unobserved plot or farmer characteristics.

Table 6 presents regression results where we control for observable differences in plot type in addition to crop and household fixed effects. Specifically we include plot area, its square, and their interaction with a binary variable indicating whether the plot is on bottom land, to allow for a non-linear effect of area that differs by land type. We also control for the farmer's age and education and for the distance of the plot to the dwelling. Column (1) display the results for the full sample

Table 3
Descriptive yield statistics.

	All plots	Dry plots	Bottom plots
Mean yield men individual plots (MIP)[a] (std dev)	206.10 (242.25)	124.73 (148.40)	316.47 (296.37)
Mean yield collective plots (CP) (std dev)	71.14 (76.55)	67.21 (70.92)	137.05 (124.26)
Mean yield female individual plots (FIP) (std dev)	129.17 (152.72)	89.57 (117.05)	176.28 (175.44)
Δ yield CP-MIP (std err)	−134.96*** (9.18)	−57.52*** (8.05)	−179.41*** (40.85)
Δ yield FIP-MIP (std err)	−76.94*** (14.98)	−35.16*** (13.87)	−140.18*** (26.75)
Δ yield CP-MIP w/ fixed effects[b] (std err)	−83.11*** (16.39)	−48.43*** (15.47)	−88.80* (52.46)
Δ yield FIP-MIP w/ fixed effects[b] (std err)	−54.53*** (18.51)	29.86* (17.21)	−64.10 (47.46)

[a] Yields are reported in thousands of FCFA per hectare. 1000 FCFA is 1.52 euros.
[b] These rows report the estimated coefficients of OLS regression of yield on CP and FIP, controlling for crop fixed effects and household fixed effects, and the corresponding standard errors clustered at the respondent level.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 4
Characteristics of households with and without individual plots.

	Households with male IP (sd)	Households without male IP (sd)	Is difference statistically significant? (10%)
Collective field area	11.9 (6.7)	11.2 (9.2)	No
Total land holding	14.2 (8.4)	11.7 (9.4)	Yes
Average distance of plots to house (min)	23 (17)	21 (16)	No
Presence of bottom land	0.6 (0.4)	0.4 (0.5)	Yes
Total household size (>12 years)	13.7 (6.6)	9.4 (5.4)	Yes
Total number of adults (>18 years)	10.2 (5.5)	7.2 (4.4)	yes
Percent of male members speaking French	0.15 (0.24)	0.11 (0.22)	No
Head's education (=1 if has at least 1 year of education)	0.14	0.14	No
Age of head	59 (13)	56 (13)	No

of plots with household and crop fixed effects. What comes out is that the difference between collective and male individual plots is only slightly reduced by the introduction of the above control variables. It is thus striking that male individual plots remain about twice as productive as collective plots once all control variables are introduced.

We may still be worried that the results presented in Column (1) of Table 6 are driven by unobservable plot or intra-household characteristics that we imperfectly control for. The most obvious objection concerns land quality: differences in unobserved land quality could explain productivity differentials between plot types. Our use of crop fixed effects partly addresses this concern. The idea is that there exists a strong relationship between the type of crop grown and land quality, so that controlling for the former is about equivalent to controlling for the latter. In Burkina Faso, a country very similar to Mali (both are Sahelian, neighboring countries), Udry (1996) has thus shown that "the primary impact of the soil type and location variables runs through the choice of which crop to plant on a given plot. […] There is a very strong correlation between both the location and the soil type of a plot and the crop planted on that plot" (p. 1025). It might nevertheless be argued that relative differences in (unobserved) land quality within households drive crop and plot choices simultaneously. Ideally we would like to introduce interactions between crop and household fixed effects. Unfortunately, we do not have enough degrees of freedom to do so. However, two alternative, second-best strategies are available to us. First, we include interactions of household fixed effects and crop fixed effects for the four main crops separately (sorghum, millet, maize and groundnut), and interactions of household fixed effects with the remaining crops regrouped in two categories: "other care saving" and "other care intensive". The results are presented in column (2). Second, we add village ∗ crop fixed effects to the list of regressors, in column (3). In both cases, it is easily verified that the results are robust to the introduction of these interacted fixed effects.[13]

In order to further probe into the issue of land quality, we conduct the analysis on a sub-sample of plots for which we are confident that quality is relatively homogeneous across collective and private plots. More precisely, we restrict our attention to private plots that are located on the same field as the collective plots, implying that the former are just portions of the latter. To identify these plots, we have used information about plot names, which we have collected with great care. The underlying idea, supported by field evidence, is that private and collective plots bearing the same name are adjacent to each other and part of the same field. We are then left with 1358 observations, 103 of which are male individual plots. The results, which are reported in column (4), stands. While we cannot firmly rule out that higher quality land goes to males more likely to use it well, on the subsample of adjacent plots, the issue is certainly less important and it is comforting that our parameter estimates have barely changed.

An additional cause of concern is that some unobservable characteristics are correlated with a head's overall decision to grant male individual plots.[14] Our use of household fixed effects partially account for this selection effect by absorbing the effect of household-level characteristics. There may still exist unobserved plot characteristics that are correlated with this decision and introduce bias in the estimated coefficients. To evaluate this possibility, in column (5), we restrict the sample to households where male individual plots actually exist. The sample size is roughly halved. Reassuringly, the estimated coefficient on "collective" is only slightly smaller when estimated on this sample. Column (6) combines the last two types of restrictions by focusing on the subsample of plots of homogenous quality located in households with male individual plots. The sample size further drops to 648 units, but the results again stand unaffected.

Finally, in column (7) we examine to what extent our coefficient of interest changes when we remove several control variables from the estimation. The idea is to evaluate whether male individual plots appear superior to collective plots along the observed dimensions of plot characteristics.[15] From Table 1, we learned that the inclusion of household and crop fixed effects reduced the raw difference in average yields by about one third, implying that male individual plots are twice as productive as collective plots. Table 6 indicates that whether we add only plot size to the regression (column (7)) or the full set of covariates (column (1)), the estimated yield differential remains very similar. These results tend to indicate that along the *observable* dimensions of plot characteristics, male individual plots are *not* superior to collective plots planted to the same crop. As pointed out by Udry (1996), this does not rule out the possibility that *unobserved* plot characteristics drive the productivity differential, but it does make it less plausible.

Note carefully that in all the above estimations, we have avoided including as repressors three inputs described in Table 5: chemical input use, land rights and access to a plow. This is because we suspect endogeneity biases. To nevertheless investigate the role of these input variables in explaining the observed yield differential, we check whether their level systematically differs by plot type (using the same specification as in Column 1 of Table 6). The results are presented in Table 8. We see that use of chemicals and land rights do not systematically differ between collective and male individual plots. The coefficient of collective plot is significant for the third input, use of a plow. Yet, the sign is positive, pointing to an advantage of collective rather than individual plots. In other words, the yield differentials between the two types of

[13] Crop fixed effects are necessary to address concerns of unobserved land quality dimensions. If we had a fully reliable measure of land quality, it would not be clear that we need to control for crop fixed effects. Indeed, better incentives on private plots could drive members to choose more labor-intensive crops in the same way as they would drive them to apply more effort given the chosen crop.

[14] For example, an exogenous shock could perhaps affect the way the household allocates the family land.

[15] A formal treatment of the procedure is proposed by Altonji et al. (2011). They provide conditions under which it is legitimate to infer about selection on the unobservables from selection on the observables. In particular, they distinguish between "dominant characteristics" that are always observed (like plot size in our case) and other observables that are a random subset of relevant additional determinants. Their procedure requires a large number of the latter type of explanatory variables and that they have sufficient power. We do not think that our data meet these requirements.

Table 5
Plot characteristics and correlation with yield, by type of plot.

		Collective plots		Male IP		Female IP		Test CP = MIP
Variable name	Variable definition	Mean (st dev)	Corr w/yield[a]	Mean (st dev)	Corr w/yield	Mean (st dev)	Corr w/yield	p value
Area	Surface in hectare	2.20 (2.37)	−0.04	0.51 (0.81)	−0.24*	0.27 (0.30)	−0.20*	0.00
Bottom	=1 if bottom land	0.06 (0.23)	0.21*	0.42 (0.50)	0.39*	0.46 (0.50)	0.28*	0.00
Distance	# min from plot to dwelling	21.04 (22.47)	−0.01	15.93 (20.64)	−0.16*	26.61 (31.29)	−0.08***	0.03
Age	Farmer's age[b]	56.60 (12.99)	0.03	43.53 (14.82)	−0.19*	39.37 (13.49)	0.04	0.00
Education	=1 if farmer had at least 1 year[b]	0.04 (0.19)	−0.06*	0.04 (0.21)	0.05	0.01 (0.11)	−0.02	0.04
Chemical inputs	Fertilizer, herbicides and pesticides in 1000 CFA	43.81 (3.46)	0.25*	10.72 (2.43)	0.01	1.25 (0.43)	0.01	0.00
Land right	=1 if farmer can plant a tree[b]	0.84 (0.36)	0.04	0.77 (0.42)	−0.24*	0.37 (0.48)	0.07	0.01
Plow access	=1 if farmer has access to plow[b]	0.80 (0.40)	0.06*	0.77 (0.42)	0.03	0.74 (0.44)	−0.02	0.29

[a] The correlation coefficients are followed by a star if they are different from zero at 5% or lower.
[b] The farmer corresponds to the person in charge of the plot.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

plots would be even larger than what we observe had we taken input use into account.

While our main focus is on the difference between collective and male individual plots, our regression framework also allows a comparison between male and female individual plots. In Table 6, for all specifications and samples (except subsample 3), the coefficient on female individual plots turns out to be negative and of a magnitude slightly smaller than the coefficient on collective plots. These results suggest that female individual plots are less productive than male individual plots.

4. Heterogeneous effect by crop type

We have established that in family farms yields are higher on private plots than on the collective fields when we control for crop, household, plot and farmer characteristics. A key unobservable is the input of labor effort. In this section we follow an indirect procedure to examine whether labor effort can be a driver of the observed productivity difference. This procedure consists of comparing crops which presumably have different labor effort requirements. Specifically we distinguish care-intensive and care-saving crops. We thereby follow the work of Boserup (1965) who first stressed the varying importance of incentive problems depending on the level of care required by the crop considered. She thus contrasted care-saving crops grown under extensive forms of agriculture with care-intensive crops grown under intensive forms. In contrast to the former crops, the latter necessitates special care at some stage of the cycle: soil preparation, weeding, application of fertilizers, transplanting, and water control, in particular. Regarding crops found in our sample area, soil preparation and intensive weeding are required for groundnuts and rice (and to a lesser extent Bambara beans and sesame), application of fertilizers and treatments are necessary for cotton and maize, and water control for rice and vegetables. Hence our selection of these crops as care-intensive. By contrast, sorghum and millet, as well as fonio and to a lesser extent niebe, necessitate almost none of these operations: the broadcasting technique is used, fertilizer is hardly applied, and cultivation typically consists of dryland farming. A few crops (Bambara beans, sesame and niebe) are intermediary in terms of their care requirements. In order to test the sensitivity of our results to our classification, we therefore resort to two alternative classifications (variables care0 and care2) whose only difference lies in whether these "intermediary" crops are regarded as care-intensive or care-saving.[16]

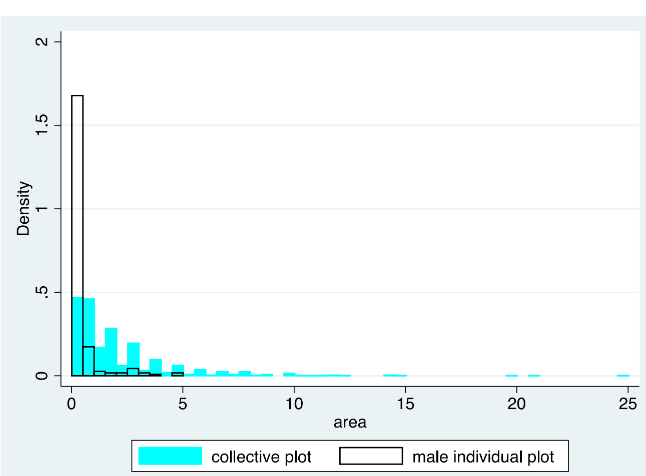

Fig. 1. Plot size distribution for collective plots and male individual plots.

We also use a third classification defined in terms of the marketability of the crops. Specifically, we refer to a crop as a "cash crop" when it has been sold (at least partly) by more than half of the farmers in the sample, otherwise a crop is considered to be a "subsistence" crop. Strikingly, the list of crops entering the subsistence category (millet, sorghum, maize, Bambara bean, fonio) is very similar to the list of care-saving crops pointing to the need to be careful in the interpretation of our results.

Table 7 presents descriptive statistics for yields at the plot level for collective and individual plots, distinguishing between care-saving and care-intensive crops. The bottom half of the table shows yield differentials when household and crop fixed effects are introduced. Clearly, both the average yield and the yield differential between collective and private plots are much larger for care-intensive crops. Once we control for crop and household fixed effects, the *relative* advantage of individual plots is of similar magnitude for care-saving and care-intensive crops: male individual plots appear about twice as productive as collective plots. However, while the difference between male individual plots and collective plots is significant at the 1% level for care-intensive crops, it is only significant at the 10% for care-saving crops.

Table 8 reports average plot characteristics by plot type and their correlations with yields separately for care-saving and care-intensive crops. Plots planted to care-intensive crops are notably smaller than plots planted to care-saving crops and they are more likely to be on

[16] The variables care0, care and care2 are increasingly exclusive. Specifically care0 includes niebe in the care-intensive category while care2 excludes sesame and Bambara beans from the care-intensive category. These alternative classifications were suggested by Luc Kafando, a well-informed agronomist actively involved in the evaluation of crop productivity at the village level in the sub-region.

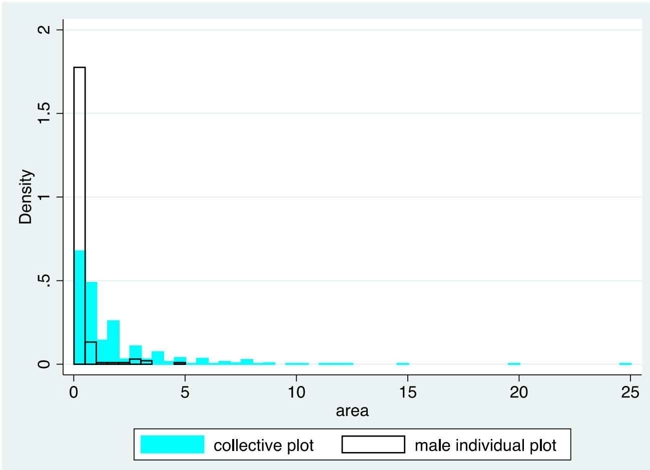

Fig. 2. Plot size distribution for care-intensive crops for collective plots and male individual plots.

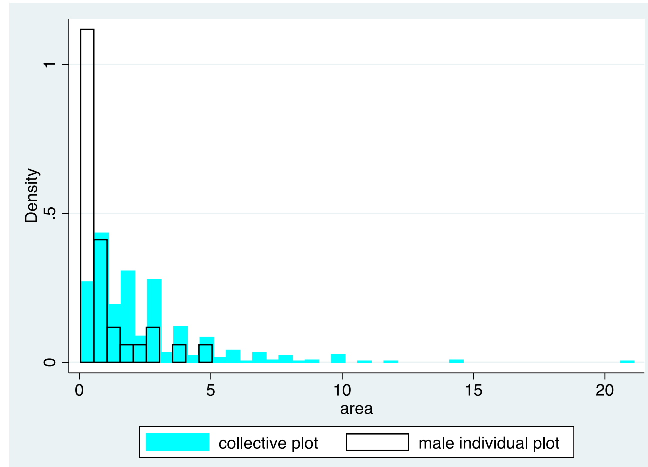

Fig. 3. Plot size distribution for care-saving crops for collective plots and male individual plots.

bottom land. These differences hold for both collective and male individual plots. As noted above, plot characteristics are systematically different between collective and male individual plots, for both types of crop.[17] While we control for observed differences in our econometric analysis, the lack of balance along observed dimensions again raises the lingering concern that endogenous allocation is biasing our results.

Column (1) of Table 9 reports the result of an OLS estimation that includes an interaction term between care-intensive crop and collective plot. A strong contrast between the types of crops emerges: the productivity disadvantage of collective plots nearly doubles when the crop is care-intensive.[18] Columns (2) and (3) reproduce the estimation with alternative classifications of crops, as detailed above. The results are robust to these alternative definitions: the productivity differential between collective and male individual plots is significantly larger for relatively care-intensive crops. When we use the more exclusive definition of care-intensity, the disadvantage of collective plots appears nearly entirely driven by care-intensive crops, the coefficient on collective plot is smaller and less significant. The same conclusion holds when we compare cash and subsistence crops: as is evident from column (5), the disadvantage of collective plots is driven by cash crops (the coefficient on collective plot is then not significantly different from zero).[19]

Here again, we may worry about unobservable plot or farmer characteristics that simultaneously influence crop choice (in terms of care-intensity, in particular) and productivity. As argued earlier, we take comfort from the fact that the estimated yield differential is not strongly affected by the addition of control variables. In fact, once we control for household and crop fixed effects (bottom half of Table 7), the addition of plot-specific variables barely affects the estimated productivity differential. Observable plot and farmer characteristics do not appear to favor male individual plots, and we can only hope that unobservable characteristics behave similarly.

Regarding the disadvantage of female individual plots with respect to male individual plots, Table 10 indicates that there is no compounding effect of the care-intensity (or marketability) of the crop: the interaction between female individual plot and care-intensive crop is never significantly different from zero.

5. Discussion

We have learned that, controlling for crop, household, plot and farmer characteristics, the differential in farm yields between private and collective plots is especially marked for care-intensive crops. Although caution is needed in this matter, the whole of the evidence brought out in Sections 3 and 4 strongly suggests that productivity differences cannot be attributed to land quality variations, or other intrinsic characteristics of land plots and farmers. We are also quite confident that these differences do not arise from variations in material inputs. Indeed, when we estimate how expenditures on chemical inputs, access to farm equipment and land rights vary between collective and individual plots (Table 7), we find that they cannot explain our yield differential. We infer that this differential must be largely caused by variations in the residual factor and main input, labor effort. Admittedly, it would have been better to establish this result directly but, because of considerable practical measurement problems, we could not observe labor inputs in a reliable manner.[20]

This conclusion is consonant with qualitative statements made repeatedly by household heads. When queried about the major constraints limiting farm production, many of them complained that members do not do their best when they work on the collective fields. Labor-shirking is attributed to the higher priority that members give to cultivation of their own individual plots. For example, one head said that "more effort is applied to the individual plots and when members work on the collective plot, they are tired". Another one complained that when they work on the collective field, his sons "are prone to keep energy in reserve for their individual plots" ("*ils se réservent*"). Many heads also mentioned that higher quality of labor, in the sense of more intensive labor efforts, would be the best manner (together with greater application of fertilizers and better access to water) to increase collective output. Finally, it is revealing that, in local language, the term *barakebaliya* explicitly refers to the idea of free riding on others' efforts, and is distinct from the idea of laziness depicted by another word, *saliya*.

There is an interesting parallel to draw here with observations made in Gambia (another country of West Africa) by von Braun and Webb

[17] Figs. 2 and 3 plot the distribution of plot sizes for individual and collective plots, separately for care-intensive and care-saving crops. Again, while individual plots are much smaller on average, there is significant overlap in the distributions.

[18] The same conclusion holds if we estimate a fully saturated model by interacting all explanatory variables with the care-intensive variable.

[19] When we add crop group ∗ household fixed effects to the estimation, the results stand in the sense that the signs and magnitudes of the coefficients remain largely unchanged. However some of the interaction terms become non-significant, which we explain by the small number of observations used to effectively identify the coefficient on the interaction.

[20] In a context where labor requirements are highly crop-specific and vary a lot across the season, recall data for the entire season are unreliable. The only way to measure labor inputs adequately in such conditions consists of frequent field visits, which entails huge costs. In addition, there remains the awkward problem that even frequent visits only allow the observation of nominal labor inputs, not effective effort units.

Table 6
Plot yield estimations.

	(1) Full sample	(2) Full sample	(3) Full sample	(4) Subsample 1	(5) Subsample 2	(6) Subsample 3	(7) Full sample
Collective plot	−67.03*** (19.16)	−56.61** (22.72)	−50.85*** (19.14)	−66.71*** (20.94)	−48.26** (20.64)	−54.28** (25.52)	−74.78*** (19.19)
Female plot	−53.57** (20.93)	−66.00*** (24.78)	−52.44** (21.59)	−39.38* (22.30)	−40.44* (20.53)	−9.17 (25.16)	−55.24*** (20.96)
Area	−6.40** (2.92)	−5.15 (4.21)	−8.06*** (2.95)	−5.99** (2.89)	−18.46** (8.17)	−17.01* (8.84)	−6.99** (2.94)
Area^2	0.28* (0.16)	0.39* (0.22)	0.30* (0.17)	0.22 (0.14)	1.96** (0.83)	1.74** (0.85)	0.33* (0.17)
Bottom * area	−143.59*** (51.55)	−223.74*** (51.14)	−197.30*** (50.74)	67.68** (32.47)	−207.42*** (70.20)	−218.87** (98.97)	
Bottom * area^2	15.61*** (5.53)	23.47*** (5.69)	22.40*** (5.49)	−117.29** (58.30)	21.80*** (7.61)	22.53** (10.46)	
Bottom	78.83*** (25.98)	134.95*** (30.94)	88.90*** (27.33)	12.38** (6.10)	120.91*** (32.05)	118.32*** (39.25)	
Distance	0.14 (0.18)	0.10 (0.18)	0.18 (0.19)	0.33** (0.16)	0.09 (0.17)	0.34* (0.18)	
Age	0.18 (0.47)	0.02 (0.61)	0.31 (0.49)	0.13 (0.70)	0.35 (0.65)	0.57 (0.81)	
Education	25.05 (29.00)	28.50 (46.58)	22.76 (23.87)	16.04 (34.74)	43.67 (37.22)	−20.08 (38.37)	
Fixed effects	Crop household	Crop group household hhld * crop group	Crop household crop * village	Crop household	Crop household	Crop household	Crop household
Mean yield	103.89	103.89	103.89	88.21	121.36	100.75	103.89
N	1784	1784	1784	1358	914	648	1784

Standard errors in parentheses.
In subsample 1 we drop individual plots that are not adjacent to a collective field, to ensure greater homogeneity in land quality. In subsample 2, we consider only households where male individual plots are present. In subsample 3, we consider only households where male individual plots are present and we drop individual plots that are not adjacent to a collective field. In column 2 we include interactions of household fixed effects and crop fixed effects for the four main crops separately (sorghum, millet, maize and groundnut), and interactions of household fixed effects with the remaining crops regrouped in two categories: "other care saving" and "other care intensive". The crop fixed effects are defined accordingly.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

(1989: 515-6). These authors, indeed, stressed that competition unavoidably arises between personal interest and cooperation with the rest of the household when effort has to be allocated between collective and private production.[21]

The question therefore arises as to why work incentives are stronger on private plots than on collective fields and why the difference is especially marked for care-intensive crops. Two explanations come to mind here, one based on moral-hazard-in-team (Holmström, 1982), and the other on preference heterogeneity (as in Foster and Rosenzweig, 2002).

The first explanation has received a lot of attention in the literature of agricultural cooperatives, in particular (Carter, 1987; and Putterman and DiGiorgio, 1985). It can be formulated simply: when effort is not contractible, output sharing creates incentives to shirk and free-ride on co-workers' effort. While on private plots members have optimal incentives to work and first-best efficiency is therefore achieved, efficiency losses arise in collective cultivation, and these losses are all the more important as the number of co-workers is higher (due to the incentive dilution 0 effect).[22] Following Boserup (1965), the argument stressing the superiority of privately managed plots may be stated thus: if farmers adopt relatively land-saving and labor-using techniques for which quality of labor matters and monitoring of labor is therefore costly, the advantage of private farming on individual plots increases as agriculture becomes more intensive. Since quality of effort has greater incidence on yields for care-intensive crops, these crops are more vulnerable to incentive problems.[23]

One may, of course, wonder why family heads do not choose to make payments according to individual effort contributions to collective production. The most immediate answer is that they are unable to observe individual efforts in a sufficiently precise manner. That such an explanation seems incomplete is attested by the following fact: when we queried the heads about the rationale of the egalitarian reward scheme, the answer we typically received is that differential rewards are not feasible in the local culture. The reason is that such rewards would be deeply resented as unfair by disfavored members, and therefore seriously contested. What needs to be emphasized is that the family is a special social group if only because internal relationships are highly emotional so that feelings of injustice easily arise and have particularly dramatic consequences. In such a context, equal treatment often appears to the head as the best way of avoiding poisonous inter-personal conflicts that would undermine his authority and threaten the unity and persistence of the family. Williamson's argument that metering may create a "calculative atmosphere" that destroys trust and cooperation applies especially well to the family setting with which we are dealing in this paper (Williamson, 1985, 1996: chap. 10; Platteau and Nugent, 1992).[24]

Other solutions are theoretically available to overcome the moral-hazard-in-team problem (Bolton and Dewatripont, 2004). In particular, if aggregate output is observable by the head, he could punish the working team collectively for excessive shirking. For example, if it turns out that first-best effort levels were not applied, the head could refuse any labor payment. Again, we believe that this sort of solution is not feasible in the family context. Collective punishment is hardly conceivable in a poor economy where farm members critically depend on collective production for their livelihood, and where guaranteeing subsistence to all members is considered a customary duty of the head.

Production incentives on the collective field are dampened not only because workers share a joint output on an egalitarian basis, but also because the head of the household retains a portion of it for his own use. This constitutes a second reason why the worker cannot obtain the full marginal product of his effort. Losses of efficiency resulting from under-application of labor to the collective field are aggravated if workers consider the distribution rules as unfair and thereby feel exploited. When frustrations of this kind have been clearly expressed

[21] Here again, the existence of the problem is reflected in expressions collectively used by local people. The word *badingya* indicates harmony, cooperation, and shared progress (or shared decline), ideals that are stressed in the local culture and contrasted to selfish ambitions and competitiveness captured by the word *fadingya*. In the context of farm production, *badingya* refers to altruistic behavior resulting in restrained free riding while operating in the collective sector of the family. On the contrary, *fadingya* points to types of behavior exclusively driven by the relentless pursuit of self-interest.

[22] Why would collective and private plots coexist in such a context? One interesting answer is that there exists a trade-off between rent capture and efficiency considerations: acting as a patriarch, the head aims at extracting a rent from collective production since he is unable to enforce transfers from the private plots managed individually by the male members (for a formal argument, see Guirkinger and Platteau, 2014).

[23] Interestingly, in Hungarian cooperatives before the collapse of communism, care-intensive activities were conducted on households private plots, whereas activities easy to standardize and monitor remained the province of collective work on the cooperative fields (Swain, 1985; Guillaume, 1987; see also Chayanov, 1991: Chap. 13).

[24] Note that it is precisely the same logic of egalitarian fairness that explains why no differentiation is observed in the distribution of private plots.

Table 7
Estimations of input use.

	(1) Chemical inputs	(2) Land right	(3) Plow access
Collective plot	−0.46 (4.81)	0.05 (0.05)	0.08*** (0.02)
Female individual plot	0.67 (3.01)	−0.28*** (0.05)	−0.02 (0.02)
Area	4.52(3.85)	0.01*(0.01)	0.00(0.00)
Area^2	1.21** (0.51)	−0.00* (0.00)	−0.00 (0.00)
Bottom * area	−5.74 (7.96)	−0.14* (0.08)	−0.06 (0.03)
Bottom * area^2	−0.97 (0.86)	0.02* (0.01)	0.01* (0.00)
Bottom	−13.94** (5.91)	0.02 (0.06)	0.04 (0.03)
Distance	−0.03 (0.05)	−0.00 (0.00)	−0.00 (0.00)
Age	0.05 (0.07)	0.01*** (0.00)	0.00 (0.00)
Education	−7.08** (3.43)	0.00 (0.11)	−0.00 (0.05)
N	1784	1782	1784

Standard errors in parentheses.
The three dependent variables are defined in Table 5.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

in the course of our interviews, their cause was typically the excessive share appropriated by the head.

The second explanation has been suggested by Foster and Rosenzweig (2002) for whom efficiency in collective production is impaired when workers and the head have heterogeneous preferences regarding the best uses of agricultural incomes. They predict that, as incomes rise and consumption possibilities expand, collective farms will disappear because the advantage of scale economies will be eventually outweighed by the disadvantage of preference heterogeneity. In our context of mixed farms, the contrast is between the collective field where the allocation decision is essentially made by the household head and the private plots where this decision entirely belongs to the individual holders. Individual male members of the family have a special incentive to put hard work on their private plots because they freely dispose of the entire output obtained, while the head has a major role in determining the level and content of collective consumption financed by the joint income of the collective field. The marginal utility of the income earned is therefore higher for efforts applied to private plots than for those applied to the collective field.

For subsistence crops, which constitute the main ingredients of collective meals, we do not expect preferences to be widely heterogeneous inside the family. This holds particularly in contexts where basic food choices are extremely limited. In this instance, the above argument is unlikely to apply. On the contrary, non-subsistence goods are typically purchased in cash, and, given the variety of such goods, preferences may easily diverge causing potential conflicts among family members. We thus expect the importance of the second mechanism to increase with the monetization of the family economy, that is, when cash crops are being cultivated or growing portions of traditional crops are destined for market sale, including on collective plots. If the preference-based mechanism is at work, the theory predicts that the comparative advantage of private plots in terms of land productivity will exist mainly for cash crops.[25]

[25] There are two additional possible explanations that may account for the cash crop effect on collective fields. The first one relies on the idea that, unlike staple crops, which are jointly consumed, cash proceeds from the collective field can be somehow concealed by the head. As a result the head cannot commit to redistribute fairly these proceeds and work incentives are dampened. In our context, however, information regarding prices and quantities of collective cash crops appears to be well shared within the family. The second one is based on the assumption of incomplete markets. The argument runs as follows: in imperfect market conditions, harvest failure in subsistence crops may be more risky and more costly than harvest failure in other crops, with the result that work incentives on collective plots planted with staples are higher than incentives on collective plots planted with other crops. Although we have no evidence for such a mechanism, we cannot rule it out. But it is worth noting that it cannot explain why work incentives are higher on individual plots compared to collective plots.

Table 8
Descriptive yield statistics by type of crop.

	Care-saving crops[a]	Care-intensive crops[a]
Mean yield men individual plots (MIP)[b] (std dev)	78.21 (79.33)	231.53 (255.49)
Mean yield collective plots (CP) (std dev)	49.39 (58.16)	94.67 (86.51)
Mean yield female individual plots (FIP) (std dev)	50.13 (116.80)	143.63 (154.19)
Δ yield CP-MIP (std err)	−28.82*** (10.53)	−136.86*** (13.15)
Δ yield FIP-MIP (std err)	28.08 (21.89)	87.90*** (16.87)
Δ yield CP-MIP w/ fixed effects[c] (std err)	−48.61*** (17.97)	−89.82*** (19.90)
Δ yield FIP-MIP w/ fixed effects[c] (std err)	−55.92*** (21.05)	−53.79** (21.25)

[a] The complete list of care-saving and care-intensive crops is provided in Table 2.
[b] Yields are reported in thousands of FCFA per hectare. 1000 FCFA is 1.52 euros.
[c] These rows report the estimated coefficients of OLS regression of yield on CP and FIP, controlling for crop fixed effects and household fixed effects, and the corresponding standard errors clustered at the respondent level
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

With the data at hand, it is obviously impossible to differentiate between the different strands of the first argument. Regarding differentiation between the first and the second mechanisms, a plausible approach consists of testing whether the productivity differential is driven by the care-intensity of the crops or by their marketability. Unfortunately, we have seen that a strong correlation exists between these two characteristics: care-intensive crops tend to correspond to cash crops whereas care-saving crops tend to be subsistence crops. Therefore, it is impossible to disentangle the aforementioned two sources from which incentive problems arise on collective fields. This said, it is important to stress that the associated mechanisms are not mutually exclusive and may actually reinforce each other.

We nevertheless have a result that may be cautiously interpreted as pointing toward the presence of the second mechanism, and this result concerns female private plots.[26] As a matter of fact, as was found by Udry (Udry, 1996; Udry et al., 1995) but not by Kanzianga and Wahhaj (2013) for Burkina Faso, productivity is higher on male than on female private plots. Our result continues to hold even if we control for weaker women's land rights (measured by the right to plant trees), hence our inclination to attribute the smaller productivity of women to weaker effort incentives. Since a significant difference between male and female plots lies in the fact that unlike men who can freely dispose of the entire income obtained, women are mainly expected to use their private plots to produce ingredients for the collective meals, we may infer that the preference-based incentive problem is probably plaguing efficiency on the women's plots.

6. Conclusion

There exists an abundant literature dealing with the efficiency of collective production as it takes place in rural cooperatives or labor-managed firms (see the seminal works of Sen (1966) and Putterman (1989), in particular). The focus is placed on the moral-hazard-in-team problem that plagues collective endeavors involving horizontal relationships between co-workers, and one way to surmount it is by devising remuneration systems based on work points. One central result is that, when such systems are applied, members may over-apply rather than under-apply effort, and there is thus a need to mitigate effort incentives by introducing need-based considerations into the remuneration formula. Another way to solve the free riding problem in

[26] Caution is needed because we do not control for the fact that, owing to the numerous duties befalling them inside the household (see Section 1), women are likely to be much more time constrained than men.

Table 9
Plot characteristics and correlation with yield, by type of plot, for care-saving crops and care intensive crops.

	Collective plots		Male IP		Female IP		Test CP = MIP
	Mean (st dev)	Corr w/ yield[a]	Mean (st dev)	Corr w/ yield	Mean (st dev)	Corr w/ yield	p value
Care-saving crops							
Area	2.49 (2.27)	−0.13*	0.99 (1.18)	−0.41*	0.33 (0.45)	0.00	0.00
Bottom	0.01 (0.10)	0.00	0.06 (0.24)	0.58*	0.02 (0.16)	0.18	0.02
Distance	20.28 (20.02)	−0.06	19.03 (24.99)	−0.18	28.90 (31.48)	0.01	0.73
Age	56.09 (12.68)	0.01	45.82 (16.17)	−0.43*	40.83 (15.32)	0.08	0.00
Education	0.05 (0.21)	−0.07	0.03 (0.17)	−0.14	0.01 (0.11)	−0.02	0.65
Chemical inputs	9.58 (1.21)	−0.00	5.28 (1.81)	−0.17	0.82 (0.24)	−0.03	0.38
Land right	0.84 (0.36)	0.03	0.91 (0.29)	0.09	0.38 (0.49)	0.24*	0.29
Plow access	0.82 (0.38)	0.10*	0.76 (0.43)	0.32	0.77 (0.42)	0.10	0.38
Care-intensive crops							
Area	1.89 (2.43)	0.07	0.42 (0.68)	−0.20*	0.26 (0.26)	−0.24*	0.00
Bottom	0.11 (0.31)	0.21*	0.50 (0.50)	0.34*	0.54 (0.50)	0.23*	0.00
Distance	21.87 (24.84)	−0.00	15.32 (19.68)	−0.15*	26.19 (31.27)	−0.08	0.00
Age	57.15 (13.32)	0.03	43.08 (14.55)	−0.18*	39.10 (13.13)	0.05	0.00
Education	0.03 (0.16)	−0.03	0.05 (0.21)	0.05	0.01 (0.11)	−0.02	0.23
Inputs	80.83 (6.71)	0.22*	11.80 (2.90)	−0.01	1.32 (0.50)	0.01	0.00
Land right	0.84 (0.37)	0.04	0.74 (0.44)	−0.23*	0.37 (0.48)	0.05	0.00
Plow	0.77 (0.42)	0.08	0.77 (0.42)	0.01	0.73 (0.44)	−0.03	0.88

[a] The correlation coefficients are followed by a star if they are different from zero at 5%.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

teamwork is by meting out collective punishment in case the joint output falls below a certain threshold. The message is that collective production can be efficient even in the absence of strong moral or ideological incentives, provided that the right reward or punishment system is devised.

A fascinating question, clearly under-researched, is the extent to which such conclusions can be extended to family farms (and businesses). As a matter of fact, the family is a special type of social organization in the sense that members tend to be particularly sensitive to the fairness dimension of any rule adopted. This makes the adoption of reward systems based on individual productivity performances or collective punishment especially difficult in family contexts, and it is therefore no coincidence that they are found in neither the study area of Kanzianga and Wahhaj (in Burkina Faso) nor in the region on which the present study is based (in Mali). Contrary to expectations derived from economic theory, Kanzianga and Wahhaj (2013) have reached the conclusion that collective plots are farmed more intensively and achieve higher yields than plots with similar characteristics farmed by individual members. To explain their results, they invoke the role of strong social norms and moral prescriptions guiding contributions to collective effort. By contrast, our own study shows that the prediction of economic theory is confirmed: yields are higher on private male

Table 10
Plot yield estimations, care-intensive versus care-saving crops.

	(1)	(2)	(3)	(4)
Collective plot (CP)	−41.08** (16.08)	−26.30* (15.90)	−40.82*** (15.09)	−18.47 (18.10)
CP * care	−34.41** (17.12)			
CP * care0		−51.34*** (16.93)		
CP * care2			−36.18** (17.22)	
CP * cash crop				−69.66*** (22.61)
Female IP	−42.55** (20.98)	−40.39** (17.23)	−39.26** (18.83)	−33.64* (19.10)
FIP * care	−12.41 (24.35)			
FIP * care0		−13.69 (21.73)		
FIP * care2			−16.51 (22.88)	
FIP * cash crop				−23.02 (26.15)
Area	−7.58*** (2.76)	−8.14*** (2.81)	−7.43*** (2.75)	−8.65*** (2.84)
$Area^2$	0.33** (0.16)	0.35** (0.16)	0.32** (0.15)	0.38** (0.16)
Bottom	78.51*** (23.20)	78.15*** (23.13)	78.36*** (23.23)	79.80*** (22.92)
Bottom * area	−143.23*** (49.00)	−142.43*** (48.90)	−143.23*** (48.99)	−141.96*** (48.47)
Bottom * area2	15.72*** (5.28)	15.70*** (5.27)	15.72*** (5.27)	15.74*** (5.23)
Distance	0.15 (0.15)	0.15 (0.15)	0.15 (0.15)	0.14 (0.15)
Age	0.20 (0.42)	0.21 (0.42)	0.19 (0.42)	0.24 (0.41)
Education	24.75 (24.84)	25.65 (24.74)	24.46 (24.85)	25.23 (24.70)
hh fixed effects	Yes	Yes	Yes	Yes
Crop fixed effects	Yes	Yes	Yes	Yes
N	1784	1784	1784	1784

The list of care-intensive crops for which care = 1 is provided in Table 2. The variable care0 is less exclusive as it includes niebe, while care2 is more exclusive as it excludes sesame and Bambara beans.
The variable cash is equal to 0 for millet, sorghum, maize, Bambara beans and fonio as these crops are sold by less than half of farmers in the sample.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

plots than on the collective fields when we control for crops, households, plot and farmer characteristics. Moreover, the superiority of private plots is largely driven by care-intensive crops which happen to largely correspond to cash crops.

The latter side-result is especially interesting because it suggests that the disadvantage of collective farming compared to individual farming may arise from two sorts of incentive problems. On the one hand, there is the incentive problem caused by free riding in teamwork in the context of egalitarian distribution of the proceeds among co-workers, to which we must add the problem of erosion of incentives when a share system governs distribution of output between the household head and the members. On the other hand, there is the incentive problem arising from preference heterogeneity when proceeds from private production can be freely used whereas use of the proceeds from collective production is partly decided by the head to the extent that he sets the level and content of collective consumption. Because there is a strong correlation between care-intensity and marketability of crops, we are unable to differentiate between these two mechanisms which are likely to operate simultaneously. What deserves to be stressed is that the second mechanism is not relevant in the context of rural cooperatives if the entire income from collective cultivation is distributed among the co-workers.

How can we account for the difference between our results and those obtained by Kanzianga and Wahhaj? A plausible explanation rests on the fact that whereas the households in our sample are large and complex, the opposite is true of the households surveyed by them. On the one hand, problems of moral-hazard-in-team are less important in a restricted family (there is little incentive dilution). Moreover, identification of members with the family is stronger in simple, essentially nuclear, households, thereby making enforcement of social norms of solidarity easier. On the other hand, preferences are likely to be less divergent in small and simple families.

Appendix A

Below, we set out to detail the computation of our input and output variables. Due to heterogeneity of the measurement units used in each village (sometimes in each household), the first task was to express in kilograms the various reported measures of crop quantities (such as the cartload, the tin, the box, the plate, the handful, etc.). In the case of some minor crops, we could not find a proper way to convert the harvested amount into a single measurement unit. We therefore decided to keep them out of the analysis.

Price data are likewise complex since the harvest of a given plot may have been disposed of at different points in time and a portion may have been retained for self-consumption purposes. Our preferred strategy is to use the median price reported by farmers in the village. We can do so for seven of the main crops (cotton, millet, sorghum, maize, rice, onion and groundnut). However for the other crops this option did not turn out to be feasible. Owing to the great heterogeneity of physical measurement units, we could not derive homogenous unit prices (prices per kilogram) for the other crops. Evaluating the entire production in monetary terms was nevertheless possible since most respondents provided homogeneous quantity and price information (quantity and price per tin, for example).

Measuring inputs used in agricultural production proved to be as complex as measuring outputs. Data about chemical fertilizers were collected on a plot basis. We had to add up quantities of various fertilizers applied at several points of time and to value them at the reported prices. When fertilizers were acquired from the CMDT ("*Compagnie Malienne pour le Développement des Textiles*"), a public agency in charge of marketing cotton and cereal fertilizers, prices were uniform over our study area. When, on the other hand, they were purchased from private traders, we chose to apply the median price calculated over the whole sample in order to minimize measurement noise. Data about organic fertilizers are unfortunately unavailable. Yet, we know that this input has a significant impact on production only if it can be applied in sufficient quantity and quality. Our field observations have suggested that this condition remains typically non-satisfied.[27] Nowhere did we notice the presence of manure pits on farm sites. At best, farmers use animal dung to fertilize their fields.

Regarding seeds, the main point is that, except for cotton, sample farmers do not buy improved seed varieties and use instead self-reproduced seeds. We have ignored cotton seeds altogether because quantities applied are standardized and actually fixed by the CMDT on a per hectare basis. Finally, we have detailed information on agricultural equipment, oxen and plow in particular (nobody has mechanical equipment).

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[27] It is estimated that in order to restore soil fertility in the area a minimum of ten tons of organic fertilizers per hectare should be applied (personal communication of field agronomists working in the area).