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Two Heads Are Better Than One

Agricultural Production and Investment in Côte d'Ivoire

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Abstract

Low levels of agricultural productivity and investment hinder economic growth in developing countries. This paper presents results from a field experiment in Côte d'Ivoire, which randomized wives' participation in an agricultural extension training for rubber, a male-dominated export crop that takes six years to start producing latex but requires upfront care. The training included a planning portion, consisting of filling out an action plan for rubber farming over the next two years, and a skills portion. In the without-wife group, households witnessed a 26.4 percent drop in the value of the crop harvested and a 18.4 percent drop in productivity, with labor going to planting rubber seedlings. In the group with wife participation, households had higher levels of investment (planting 20 percent more rubber seedlings) and were able to maintain pre-program levels of agricultural production on older trees and other crops. These households increased their labor hours and agricultural input use, resulting in no drop in overall production or productivity. This outcome did not come through increased skills or incentives. Rather, underlying these results are increases in planned agricultural management by wives, increased retention of the action plan, and a reduction in gendered task division. The results show how including women in economic planning can improve the efficiency of household farm production and promote higher levels of investment.

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Two Heads Are Better Than One:
Agricultural Production and Investment in Côte d'Ivoire

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1 Introduction

Agriculture employs the majority of the labor force in developing countries, and plays a critical role in economic development (Gollin et al. 2014, Herrendorf et al. 2014). Most of the global poor live in Sub-Saharan Africa, where agriculture is the dominant income-generating activity, with nearly nine in ten rural households generating income from crop production (Davis et al. 2017, World Bank 2018). Agricultural productivity in the region remains low. Increasing it will be critical to making a meaningful dent in global poverty.[1] Bolstering rates of investment and adoption of improved technology are crucial to this endeavor. Indeed, poverty-reducing agricultural growth in the region is expected to come largely from expanded use of technology, including improved seeds and agro-chemicals (Sheahan and Barrett 2017).

Yet, investment is often costly, particularly for poor households. In the face of imperfections in credit and labor markets, households can face steep trade-offs between current and future production. Low returns to saving and high costs of borrowing make smoothing from one harvest to the next more costly and raise the relative price of consumption at times of the year most distant from the previous harvest (Kaminski et al. 2014). This cost is magnified for investments that take relatively longer to yield returns, such as crops with long maturation periods. In this paper, we focus on one potential way to decrease the relative cost of investment: improving the efficiency of farm household production.

A growing number of empirical studies within economics have found evidence against the assumption that family members pool their resources and allocate them to their most efficient use, maximizing a single utility function under a common budget constraint. Moreover, research shows that even the minimal assumption of intra-household efficiency may be unwarranted in parts of West Africa (Von Braun and Webb 1989, Udry 1996, Duflo and Udry 2004). In this context, decisions made by one individual in a household are influenced not only by the economic environment which confronts the household, but also by intra-household dynamics undergirded by asymmetries in how rights, resources, and responsibilities are distributed. These asymmetries, including those that are rooted in gender, can lead to lower investment in less observable inputs into production, including agricultural labor, and inefficient input allocation decisions.

One potential way to improve household efficiency is by facilitating communication and coordination of production decisions within the family. We test this hypothesis among couples in rural Côte d'Ivoire. We randomly selected 1,491 (male) lead farmers to receive ~600 (2 ha worth) subsidized high-yield variety rubber seedlings. Rubber cultivation is a high stakes setting in which to analyze household investment decisions: rubber trees require upfront care, especially in the first two years, but take up to six years to start producing latex. Once they start producing, they are a highly profitable crop, which farmers in Côte d'Ivoire refer to as their 'pension' (Ruf 2008). Selected lead farmers were required to attend a 3-day agricultural extension training to receive their seedlings, where they were taught rubber maintenance skills and planned out the management of the first two years of cultivation. Out of the 1,491 couples, approximately half (741) were further randomized into a couples' training group, which called for the participation of the wife in both the skills and management portion. Lastly, to hold gender attitudes constant when comparing couples' training outcomes to individual training outcomes—netting out any unintended signaling effects of the importance of gender equality not operating though the skills or planning channel— we additionally administer a short gender awareness training to both groups.

[1] For example, NEPAD (2014) notes that productivity per agricultural worker has improved by a factor of only 1.6 in Africa over the past 30 years, compared to 2.5 in Asia.

The wife's presence and participation in the creation of an action plan for rubber cultivation increases her visibility and planned responsibility in rubber production, with a more than three-fold increase in agricultural tasks assigned to her management in the action plan compared to in the individual training. These tasks include tasks that had previously been male-dominated in the household, where we see a four-fold increase for wives compared to the individual training group. While we observe these substantial shifts in the planning exercise, we do not find evidence of increased wives' agricultural knowledge through the skills channel. The lead farmer's perception of her knowledge increases during the training in one of two measures used, but the effect disappears by the endline survey. However, the change in planning translates into a meaningful shift in economic outcomes two years later.

Households in the individual training group planted the improved rubber seedlings, but due to the influx of young (and thus non-producing) trees that require significant upfront care, they witness a 26% drop in total harvest and 18% drop in yield. In this group, we also observe an increase in male engagement in domestic work and an increase in the planter's income from self-employment as they shift some of their work off-farm. Meanwhile, the couples' group plants 20% more rubber seedlings, with current production and yield staying constant. Total hours per week per rubber plot hectare increase by 31% in the couples training group compared to the control group, with increases in labor hours for both husbands and wives. Households also increase the proportion of plots with phytosanitary products by 16% and the proportion with fertilizer by 36%. The increase in fertilizer also applies to cocoa plots, indicating how couples' training households take more of a portfolio approach to their agricultural management. The planter's engagement in non-agricultural self-employment decreases but overall self-employment income stays the same, perhaps indicating increased efficiency off the farm as well.

Households assigned to the couples' training are also 19% more likely to still have their action plan at endline compared to households assigned to the individual training, suggesting increased longevity of planning intentions. Moreover, our evidence suggests a close match between what households planned for during the training and what happened in the field. Households where spouses are empowered as co-managers in the action plan are the ones increasing their use of productive inputs two years later, and we also observe a higher share of women completing input-related tasks (such as the application of fertilizer) in couples' training households. We find modest increases in the wife's productive incentives: the amount of rubber harvest revenue and the proportion of household savings she controls increase by approximately 50% over the individual training group, though given that the base value is close to zero, women's economic control does not meaningfully improve. Overall, our results are consistent with the idea that frictions in household communication and management impede household efficiency, and that this inefficiency can be overcome by including spouses in a simple and low-cost household planning exercise. However, a different approach is needed when the objective is to transform gendered power relations in the household (see for example Ambler et al. 2021).

Our study relates to the literature on production in teams. While early models of team-based production highlighted the risk of moral hazard and free riding (Alchian and Demsetz 1972, Holmström 1982), later literature finds that team members can effectively monitor and sanction their peers to mitigate this risk (e.g., Babcock et al. 2015, Corgnet et al. 2013 and Kandel and Lazear 1992). An action plan such as the one tested in our study could serve as a tool for such monitoring. To the best of our knowledge, previous work has only shown that action plans can increase individual accountability (e.g., Abel et al. 2019, Rogers et al. 2015). Our finding that increased wife's responsibility in the action plan leads to changes in behavior by the husband, including increases in his labor supply, suggests that action plans can also enhance accountability within teams.

Our paper also contributes to the evidence base on *why* team-based production can lead to efficiency gains. In our context, increased enjoyment of work or mutual learning do not emerge as the underlying mechanism. Rather, our results support the theory that teamwork may unlock additional worker abilities (collaborative skills like communication, problem-solving, flexibility) that expand production possibilities (Hamilton et al. 2003, Boning, Ichniowski and Shaw 2007). Moreover, while our identification strategy does not vary the diversity of team composition, our findings contribute to the literature on the functioning of mixed-gender teams (Dutcher and Order 2018, Marx et al. 2021).

Our paper is closely related to an extensive literature on household investment decisions, focused on uncovering why households underinvest or do not reach the efficiency frontier (e.g., Bensch et al. 2015, Bryan et al. 2014, Lambrecht et al. 2014). Since rubber is a male-dominated crop and bringing women into its management reduces agricultural gender inequality, our paper builds on a subset of this literature that focuses on gender norms as a source of market failure, and describes how overcoming such frictions can increase economic efficiency (e.g., Croppenstedt et al. 2013).

Specifically, our results add to a small but growing body of work on the potential to improve household functioning by training husbands and wives together. Existing studies on the effects of such couples' trainings are descriptive in nature (Bishop-Sambrook and Wonani 2009, Farnworth et al. 2018), focus on reproductive health and intimate partner violence (e.g., Doyle et al. 2018, McCarthy 2019, Raj et al. 2016) or target information asymmetry within the couple (Abate et al. 2019; Lecoutere et al. 2019). To the best of our knowledge, the only experimental evidence on the impact of a couples' training that emphasizes economic co-management is Lecoutere and Van Campenhout (2018). The authors use random encouragement to test a couples' intervention intended to stimulate cooperation, finding positive effects on household income per capita and food security among smallholder coffee farming households in Uganda and Tanzania. However, they detect limited gains in cooperation, the main channel through which the program was intended to work, leaving open the question of mechanisms through which these economic impacts are occurring.

Our study is unique in its use of random assignment to study the short-term and medium-term impacts of wives' participation in economic planning on households' investment and production. We leverage detailed text analysis of action plans completed during the training to examine immediate impacts, and then trace these impacts to field and couple functioning outcomes two years later. From a policy perspective, our findings suggest large potential welfare gains from increasing women's participation in economic production through increasing their role in management.

The remainder of the paper proceeds as follows. Section 2 introduces the experimental design, data and presents summary statistics. Section 3 covers our estimation strategy and describes balance. Our results, on household-level outcomes and mechanisms respectively, are covered in Section 4 and Section 5. Section 6 concludes.

2 Setting and Experimental Design

As in most of Sub-Saharan Africa, large heterogeneity in agricultural labor productivity within Côte d'Ivoire points to important opportunities for earnings gains (Christiansen and Premand 2017). The main export crops in the country play a key role in the agriculture sector's growth and in poverty alleviation: they are smallholders' main income providers as well as the engines of the country's major farming systems.

Rubber is particularly important, as Côte d'Ivoire is Africa's top rubber exporter, though productivity is dampened by the old age of current plantations and the use of non-improved seedling varieties.

Gender is a fundamental determinant of an individual's opportunities and constraints in the country. Research has found that household allocation of crop income is gender-specific in Côte d'Ivoire (Duflo and Udry 2003) and that income from cash crops is usually controlled by men (Maertens and Swinnen 2010); occupational segregation is a key driver of gender gaps in the country (Donald, Lawin and Rouanet 2020). Rubber is no exception, with women making up only a small share of rubber producers nationally. Working together with the Ivorian rubber professional association APROMAC, we innovated on their standard agricultural extension training to address the twin problems of low agricultural productivity and low participation of women in rubber production.

The training was developed in the context of an intervention delivering improved planting material to eligible farmers through the Côte d'Ivoire Agricultural Support Program (PSAC), financed by the World Bank, which mandated the 3-day agricultural training before receiving inputs from the program. The setting for this study spans four regions in the south (Gboklé, Grand Ponts, La Mé and Sud-Comoé) and four regions in the center of Côte d'Ivoire (Haut-Sassandra, Iffou, Moronou and N'Zi). To be eligible, farmers needed to have less than two hectares of rubber cultivated pre-program and be willing to increase cultivation.

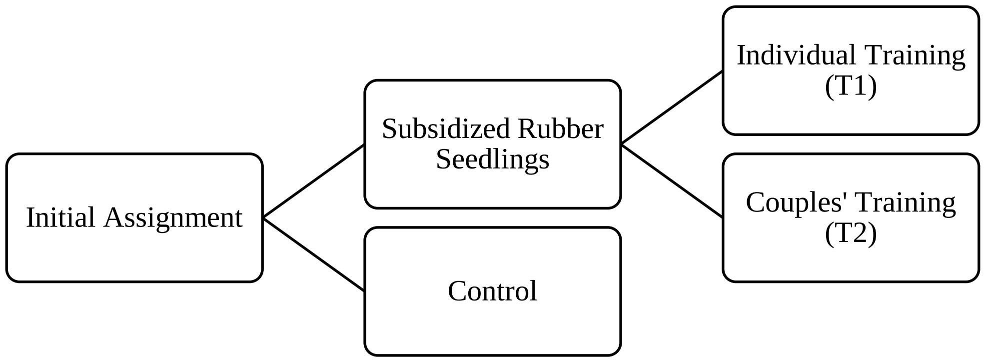
2.1 Experimental Design and Implementation

Our sampling frame is the APROMAC database of farmers who applied to receive high-yield variety rubber seedlings from the program. While a small number of female producers also applied to receive rubber seedlings, here we focus on the male producers only.[2] We randomly assigned these male farmers to two variants of the agricultural extension training. The randomization was done at the village-level to ease training implementation and minimize non-compliance with treatment status. Once a village had been randomly labelled as an individual training (T1) or couples' training (T2) village, we randomly selected a fixed number of male lead farmer applicants to receive that village's training (T1 or T2) or be in the control group.[3] APROMAC extension agents were given the list of farmers who reported a given village on their application form, along with the treatment status for each village (and consequently for each farmer). They then contacted the farmers around a week prior to the training to invite them, using the phone number provided on the application form.

Figure 1 shows the experimental design. Of the 2,502 male lead farmers in a couple who applied, 30 percent were randomized into receiving the training by themselves, while another 30 percent were randomized into receiving the training with their spouse.

[2] Our original sampling frame included a small share of female lead farmers: 307 women, or 17.6% of the sample. Treatment assignment is unbalanced (and underpowered) within the female lead farmer group, precluding a standalone analysis.
[3] We generated quartiles of the number of applicants, and the number of applicants randomized into treatment was a discontinuous function of this number, based on an agreement with APROMAC given the available supply of seedlings. For example, the number of beneficiaries was 2 in the first quartile if the number of new beneficiaries was below 10, and 8 otherwise. The number of beneficiaries was 13 in the second quartile, 25 in the third quartile and 50 in the fourth quartile.

Figure 1: Experimental Design



The training curriculum consisted of three main blocks, pictured in Appendix Figure 1. The first ("gender reflection"), administered to both the individual and couples' group, prompted couples to reflect on division of labor, asset ownership and sharing of decision-making and income within the household. The material for this part of the training was adapted from the Gender Balance Tree portion of Oxfam's Gender Action Learning System (Oxfam 2014).

The second block ("knowledge") consisted of a standard agricultural extension training related to rubber cultivation, where farmers were taught how to choose the right plot, prepare the land, space trees at planting, apply inputs, weed and intercrop.

The last block ("action plan") consisted of the creation of an action plan, where farmers had to write down the activities to do to take care of their rubber tree in the first two years, when they would do them, who would manage the task, what resources would be necessary, and where the money would come from. Moreover, before starting to fill out the action plan, farmers had to reflect on how to split decision-making on rubber and income earned from rubber with their spouses. In the couples' training group, attendance was mandatory for both the lead farmer and his spouse or cohabitating partner (henceforth 'spouse') throughout the 3-day training. In the individual training group, the farmer attended the training by himself: attendance of the spouse was only permitted for the gender reflection portion.

2.2 Data

We collected data on study participants through in-person interviews and self-administered assessments throughout the training. Specifically, the data used for this study consists of three primary sources: (i) a household baseline survey administered approximately a month before the training, (ii) data provided by the farmers themselves during the training, which we collected and transcribed and (iii) an endline survey administered approximately two years after the training.

Source (ii) includes farmers' responses to questions on decision- and income-sharing, the content of the filled-out action plans, and a quiz capturing gender attitudes and agricultural knowledge. This quiz was administered to farmers during the training after the gender sensitization but before the action plan creation activity. We also asked farmers to assess their spouse's agricultural knowledge, after the knowledge portion of the intervention had been completed.

The baseline and endline surveys both contain detailed plot and crop rosters, allowing us to compute number of plots, surface cultivated, production and yields separately by crop. For each plot, we also collect detailed information about the use of labor inputs (number of workers from inside and outside the household by gender, which tasks they did, as well as the intensity of this work – allowing us to observe effort) and non-labor inputs (phytosanitary products, fertilizer and hybrid seeds). We also collected information on the farmers' agricultural knowledge, their perception of their spouse's knowledge, and several variables capturing women's decision making in agricultural production and control over crop revenue and household savings.

We also collected information on other income sources, household composition and other aspects related to the couple, such as relationship quality, and whether they still have the action plan two years later. The baseline survey was administered in June-July 2016, while the endline was administered in June-July 2018.

3 Empirical Strategy and Sample

3.1 Empirical Strategy

Our primary results specification in this paper is ANCOVA. Our results using survey data are estimated as follows:

$$Y_{ijs} = \alpha + \beta SeedlingSubsidy_{ijs} + \delta\, CouplesTraining_{ijs} + \mu Y_{ijs}^{0} + \theta X_{ijs} + \varphi_s + e_{ijs} \qquad (1)$$

Where

- $\mathrm{Y_{ijs}}$ is the outcome of interest for farmer i in village j in strata s, at follow-up.
- $\mathrm{Y_{ijs}^{0}}$ is the outcome of interest for farmer i in village j in strata s, at baseline.
- $\mathrm{SeedlingSubsidy_{ijs}}$ equals one if farmer i in village j in strata s is assigned to receive a seedling subsidy and zero otherwise.
- $\mathrm{CouplesTraining_{ijs}}$ equals one if farmer i in village j in strata s is assigned to couple's training and zero otherwise.
- $\mathrm{X_{ijs}}$ is a vector of covariates, containing all socio-demographic variables, such as age, education, marital status, household size, and farm characteristics (discussed further in Section 3.2). For agricultural outcomes (harvest and yield) we additionally control for whether rubber and cocoa were intercropped on that field.
- φ_s is a full set of strata dummies, indicating whether farmer *i* is located in a particular APROMAC extension zone, whether village j had an above-median number of female applicants, which quartile of the number of beneficiaries that had never received rubber seedlings from APROMAC before are present in village j, and which age tercile corresponds to farmer i.

Standard errors are clustered at the village level to account for any geographic correlation and heteroscedasticity. The coefficient on SeedlingSubsidy shows the effect of being assigned to receive the seedling subsidy and the single farmer training, while SeedlingSubsidy+CouplesTraining provides the total impact of being assigned to receive the seedling subsidy and the couples training. Additionally, the coefficient on CouplesTraining provides the additional impact of inviting the producer's spouse to the extension training.

For the action plan results, our primary objective is to assess the effects of the treatment (receiving the couples' training versus the individual training) on the salience of women in the action plan and women's economic power over rubber cultivation in the couple (measured through decision making and income-sharing intentions in the action plan).

Thus, for outcomes from administrative data collected during the training, we restrict to farmers for whom SeedlingSubsidy equals one, and we estimate the following equation:

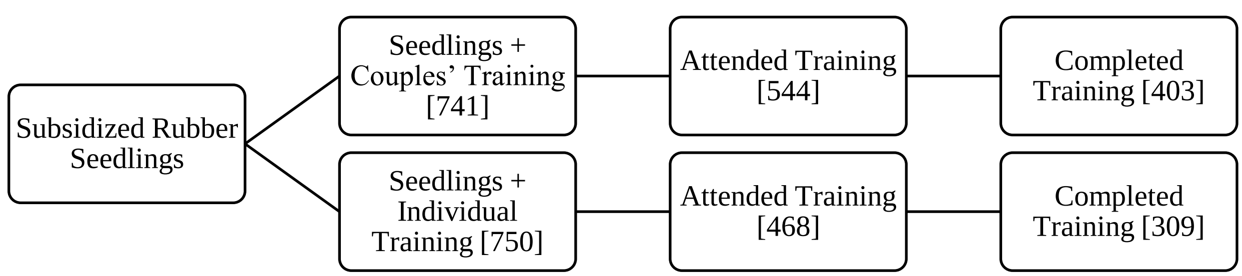
$$Y_{ijs} = \alpha + \beta CouplesTraining_{ijs} + \theta X_{ijs} + \varphi_s + e_{ijs} \quad (2)$$

where all variables are defined as in (1).

3.2 Balance and Final Sample

Figure 2 shows take-up rates by treatment arm. 73% of the couples' training group ever attended the training, while 62% of the individual group attended the training. Among the attendees, 74% completed the couples' training, while 66% completed the individual training. While these take-up rates might appear modest, the invitation to the training program came several months after they (costlessly) expressed interest in receiving the seedlings and are not uncommon for agricultural extension programs (e.g., Casaburi et al 2014). Non-compliance with training assignment is almost entirely driven by lack of take-up rather than participation in the wrong experimental arm: 99.1% of farmers who participated, participated in the training to which they were assigned.

Figure 2: Take-up Rates



Appendix Table 1 shows the characteristics of farmers across our three groups among the sample used for analysis (those farmers for which we have both baseline and endline data). Overall, characteristics are balanced. In our key comparison of interest between the individual and couples' group, we note that the couples' group is likelier to have someone in the household earning off-farm income and has a slightly higher number of plots, though they are further away compared to the individual training group. We include all 15 covariates shown in Appendix Table 1 in our vector of covariates X_{ijs}.

Second, we test whether farmers who completed the training differ from those in the overall sampling frame at the time of randomized assignment. Appendix Table 2 shows that the farmers who completed the training have 0.3 more household members on average, are 7 percentage points more likely to be married (rather than just cohabitating), own 0.5 fewer assets and have a 0.3 ha larger plot size on average. However, all these differences go in the same direction for *both* farmers randomized into the individual training group and those randomized into the couples' training group, indicating comparability between compilers when analyzing the action plan data comparing couples' training attendees and individual training attendees.

Table 1 shows summary statistics for the final sample of farmers included in our study. On average, households have six members, evenly split between adults and children. 90 percent of the lead farmers are married (versus merely cohabitating with their partner), while 24 percent of households have a traditionally matrilineal ethnicity (in Côte d'Ivoire, matrilineal ethnicity mainly determines through which channel men inherit assets).

Table 1: Descriptive Statistics

VARIABLES	Observations	Mean	SD
Age of household head	1,435	45.63	11.21
Household size	1,435	6.23	3.44
Number of adults	1,435	2.98	1.70
Number of children	1,435	3.07	2.35
Dependency ratio	1,435	1.18	0.88
Married planter	1,435	0.90	0.30
Polygamous relationship	1,435	0.12	0.36
Matrilineal ethnicity	1,435	0.24	0.42
Has off-farm income	1,435	0.66	0.48
Asset index	1,435	9.84	2.09
Credit constrained	1,435	0.13	0.34
Share of plots owned	1,435	0.94	0.21
Average distance to plots (minutes)	1,435	66.67	52.52
Number of plots	1,435	2.37	1.38
Average plot size	1,435	3.68	3.45
Planter age	1,435	45.13	11.15
Planter years of education	1,435	6.37	4.85
Planter weekly hours of agr. Work	1,435	26.17	15.01
Spouse age	1,254	37.53	10.42
Spouse years of education	1,254	3.05	3.59
Spouse weekly hours of agr. Work	1,254	13.06	13.36

Thirteen percent of households report that they were credit constrained (i.e., were refused credit in the last year) and 66 percent of households had an income-generating activity. The average plot size used or held by the household over the past 12 months was 3.7 hectares, with a large majority of plots being (customarily) owned. However, the plots are located far from the household, over an hour's walk away. Women, defined as the spouses of male planters, are on average younger, less educated and spend less time on agricultural activities.

4 Results

4.1 Treatment Adoption

Following Equation (1), Table 2 shows the impact of being assigned to receive the subsidized seedlings (first row) and the additional impact of living in a village assigned to couples' training (second row) on households' investment in planting. The subsequent rows show the cumulative impact of being assigned to receive the seedling subsidy with the couples' training, and its associated p-value. The first four columns show the total number of rubber trees planted by the household in the years 2016, 2017, 2018, and across the three years, while the last three columns of the table show the number of rubber trees received through the Côte d'Ivoire Agricultural Support Program ('PSAC trees') that were planted in 2016, 2017 and across these two years.

Looking at control means, farmers who were not assigned to receive subsidized seedlings planted around 608 trees from 2016 to 2018 (mean for control group, column 4), with the vast majority being planted in 2016 (432 trees). Among those, an average of 212 were identified by the respondents as PSAC trees, which indicates some spillover from the treatment. In 2016, farmers who were randomized to receive a subsidy for rubber seedlings and were invited to an individual training that year planted 171 more PSAC trees, and a total of 200 more rubber trees—a 46% increase relative to the control mean.[4]

Turning to the impact of the couples' training, we find that being assigned to the couples' training does not have an additional impact on planting behavior in 2016, but it does in later years. While the individual training group planted significantly fewer rubber trees than the control group both in 2017 and 2018 (post-intervention), the couples' training group kept planting more trees (all rubber trees as well as PSAC rubber trees) in 2017, and did not plant less in 2018. As a result, over the 2016-18 period, the impact on the number of rubber trees planted is more than double for the couples' training group compared to the individual training group: they planted 47.7% more trees than the control group. Recall that the subsidy received by farmers was supposed to cover 2 ha worth of rubber, or around 600 rubber seedlings. Couples' training farmers were thus better at converting received trees into planted trees: they planted around 233 more PSAC trees during 2016-17, compared to a significantly lower number for the individual training group farmers (160 trees). This is also shown in the last column of the table where the proportion of PSAC trees received that were planted in 2016-17 is significantly higher in the couples' training group compared to the individual group.

[4] This provides suggestive evidence that subsidizing PSAC trees does not lead to a crowding out of other trees, in which case we would find a lower impact on all rubber trees planted than on PSAC trees planted.

Table 2: Investment in planting

	All rubber trees planted in 2016	All rubber trees planted in 2017	All rubber trees planted in 2018	All rubber trees planted in 2016-18	PSAC trees planted in 2016	PSAC trees planted in 2017	PSAC trees planted in 2016-17	PSAC trees planted in 2016-17 as % of received in 2016
Seedling Subsidy	200.01***	-39.59*	-13.53*	140.69**	171.04***	-12.31*	160.25***	-0.01
	(46.98)	(20.89)	(7.68)	(63.41)	(24.22)	(7.30)	(25.61)	(0.01)
Couples' Training	64.64	80.01***	7.90	149.53**	31.87	42.16***	72.86**	0.03**
	(53.18)	(22.64)	(8.45)	(68.99)	(28.35)	(8.92)	(31.06)	(0.01)
Seedling Subsidy + Couples' Training (beta)	264.65***	40.42*	-5.63	290.22***	202.91***	29.85***	233.12***	0.02
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.00	0.08	0.48	0.00	0.00	0.00	0.00	0.14
Observations	1424	1424	1424	1424	1424	1424	1424	1424
Mean for control group	432.42	123.84	38.06	607.91	212.09	30.46	242.54	0.34
Mean for individual training	624.88	90.67	25.54	748.13	390.08	26.14	417.71	0.63

Robust and clustered standard errors in parentheses. All values are winsorized at 99%.

* p<0.1 ** p<0.05 *** p<0.01

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

4.2 Production Outcomes

Moving to the land under cultivation, Table 3 shows the impact of being assigned to receive a seedling subsidy and either individual or couples' training on the household's number of plots (five first columns) and plot area in hectares (five last columns). These outcomes are shown for all plots, rubber plots, cocoa plots, other crops plots (excluding rubber and cocoa) and fallow plots. Throughout this study, we pay close attention to cocoa production because it is the most prevalent crop on farmers' plots (see Appendix Table 3). This makes sense: Côte d'Ivoire is the world's largest cocoa producer (World Bank 2019).

Receiving the seedling subsidy with individual training leads to a significant decrease of 0.36 ha in cocoa plot area (a 10.8% decrease over the control mean). The couples' training offsets this decrease, so that couples' training farmers see no change in cocoa plots area. Being assigned to the couples' training also leads to a significant increase in rubber plot area (14.4% increase in area compared to the control group), driven by an increase in their number of rubber plots. The area increase of 0.63 ha is the expected area needed to plant 200 additional rubber trees, so this increase in area is consistent with Table 2's results.[5] The couples' training farmers also intensify their farming, decreasing their fallow area by 0.16 ha (a 35.5% decrease compared to control group). These results confirm the higher level of investment in rubber in the couples' training group, and that it does not come at the expense of cocoa farming.

[5] It should be noted that due to intercropping, the increase in the total cultivated area is lower than the sum of the increases in the cultivated areas of each crop type.

Table 3: Plots and land area

	Number of plots	Rubber plots	Cocoa plots	Other crops plots	Fallow plots	Total plots area (ha)	Rubber plots area (ha)	Cocoa plots area (ha)	Other crops plots area (ha)	Fallow plots area (ha)
Seedling Subsidy	0.01	0.04	-0.03	0.03	0.00	-0.34	0.20	-0.36*	-0.15	-0.03
	(0.03)	(0.05)	(0.05)	(0.04)	(0.03)	(0.22)	(0.22)	(0.20)	(0.24)	(0.08)
Couples' Training	0.02	0.06	-0.01	-0.07	-0.04	0.53**	0.44*	0.36	0.35	-0.13
	(0.03)	(0.05)	(0.05)	(0.04)	(0.03)	(0.23)	(0.23)	(0.22)	(0.26)	(0.08)
Seedling Subsidy + Couples' Training (beta)	0.03	0.10**	-0.04	-0.04	-0.04	0.19	0.63***	-0.00	0.20	-0.16**
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.14	0.03	0.36	0.36	0.25	0.41	0.01	1.00	0.44	0.04
Observations	1435	1435	1435	1435	1435	1435	1435	1435	1435	1435
Mean for control group	2.34	1.00	0.73	0.85	0.16	8.42	4.36	3.33	3.45	0.45
Mean for individual training	2.16	0.99	0.61	0.82	0.14	7.25	4.10	2.55	2.91	0.36

Robust and clustered standard errors in parentheses. Area values are winsorized at 99%.
* p<0.1 ** p<0.05 *** p<0.01
Note: Area variables are in hectares. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size. Contemporaneous control variables in all regressions: Rubber-cocoa intercrop, Any other intercrop.

Table 4 examines the program’s impact on households’ harvest (first four columns) and yield (last four columns). These outcomes are shown for all crops, rubber, cocoa and other crops (excluding rubber and cocoa). The seedling subsidy causes a 26.4% drop in total harvest, with almost half of it coming from a drop in rubber harvest. The individual training group harvested an equivalent of $166.56 less rubber compared to the $443.34 rubber harvest value in the control group. At the same time, there is a 18.4% drop in total yield for the individual training group, and an even larger 38% decrease in rubber productivity. This group of farmers compensates for the effort of planting and caring for new rubber seedlings by decreasing farm production elsewhere, on older rubber trees that are already being harvested. The couples’ training offsets these drops in harvest and productivity. Their outcomes are not significantly different between the couples’ training group and the control group in aggregate and for specific crops.

Comparing rubber yields between treatment and control groups at the household level can however be misleading: treated farmers recently planted new rubber trees that cannot be harvested yet, given that rubber trees have a maturation period of six years. In order to better understand the impact of the program on production and productivity on crops that are agronomically able to produce, in Appendix Table 4 we focus on plots where farmers already reported at baseline that rubber trees were planted before aggregating results at the household level. Appendix Table 5 focuses on plots where cocoa trees were planted at baseline.

On the subset of rubber plots at baseline (Appendix Table 4), we find an even greater drop in rubber harvest and productivity for households in the individual training group. In contrast, households assigned to the couples’ training get relatively more out of their mature rubber trees: they harvest more rubber and have significantly greater rubber yields than the individual training group. However, as in Table 4, the net effect for the couples’ group is not significantly higher than the control group. On the subset of cocoa plots at baseline (Appendix Table 5), we see a similar pattern: the individual group experiences a significant decline in both rubber and cocoa harvests, as well as rubber yields. The couples’ group does not experience these declines.

Taken together, these findings suggest that being trained as a couple cushions the fall in current production and productivity that the work on investing in new trees causes for the individual training group. In addition, couples' training households take a portfolio approach to their agricultural management and keep taking care of other crops while maintaining rubber yields. We now turn to differences in production choices to better understand how this cushioning of current output and yields came about for the couples' training group.

Table 4: Harvests and productivity

	Total harvest ($)	Rubber harvest ($)	Cocoa harvest ($)	Other crops harvest ($)	Total yield ($/ha)	Rubber yield ($/ha)	Cocoa yield ($/ha)	Other crops yield ($/ha)
Seedling Subsidy	-356.68***	-166.56**	-73.26	-41.87	-32.10*	-29.83**	8.55	-10.63
	(110.58)	(72.79)	(48.23)	(52.28)	(17.76)	(12.09)	(14.68)	(16.75)
Couples' Training	346.05***	180.02**	49.73	54.29	16.74	18.69	-17.65	0.17
	(132.46)	(85.32)	(61.86)	(57.78)	(19.12)	(15.11)	(17.10)	(15.71)
Seedling Subsidy + Couples' Training (beta)	-10.63	13.46	-23.53	12.41	-15.36	-11.14	-9.10	-10.47
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.93	0.88	0.64	0.79	0.36	0.50	0.52	0.44
Observations	1435	1435	1435	1435	1435	1435	1435	1435
Mean for control group	1353.01	443.34	480.27	310.55	174.55	78.52	105.88	83.57
Mean for individual training	840.80	242.01	351.54	241.06	137.54	51.08	104.98	69.09

Robust and clustered standard errors in parentheses. All values are winsorized at 99%. Household-level regressions.

* $p<0.1$ ** $p<0.05$ *** $p<0.01$

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size. Contemporaneous control variables in all regressions: Rubber-cocoa intercrop, Any other intercrop.

4.3 Production Choices

Table 5 examines the impact of the seedling subsidy and couples' training on non-labor factors of production. The first three columns indicate that households assigned to the couples' training significantly increase the proportion of plots with phytosanitary products (herbicides and pesticides) and chemical fertilizer relative to both the individual training group and the control group (the latter at 10 percent significance).[6] These increases are particularly pronounced on 'producing' rubber plots (columns 4 and 6) with older trees, where an additional 9 percentage points of fields now have phytosanitary applied in the couples' training group compared to the control group. In addition, the couples' group increases the use of chemical fertilizer on cocoa fields (although this is only significant at the 10 percent level). Compared to the control group, trained couples have a higher proportion of producing rubber plots where phytosanitary products are used, but not a higher proportion of producing rubber plots where chemical fertilizer are used. While chemical fertilizer is used most intensively in the first years of rubber trees, phytosanitary inputs are essential both for younger trees and older trees.

Table 6 displays the impact of being assigned to the seedling subsidy and couples' training on labor inputs. The significant result here is an increase of close to 2 hours per week per plot supplied by the planters (i.e., male lead farmers) in the couples' group. This is about a 14 percent increase relative to the control group. Table 7 focuses specifically on labor outcomes for rubber plots. Here, we see a more broad-based increase in labor hours. Total hours per week per rubber plot hectare increase by 31% in the couples' training group compared to the control group. When looking by labor category type, we notice significant changes for both the planter (who increases weekly hours per rubber hectare by 38%) and the spouse (for whom the increase is 45%). Interestingly, and suggestive of our mechanism, only spouse labor hours are significantly higher in the couples training group farmers compared to the individual training ones. We do not detect a significant increase in rubber hours for other household members.

We also note that drops in planter and spouse hours for cocoa in the individual training group are somewhat cushioned in the couples' training group, but that other household members reduce their cocoa hours (Appendix Table 6). Reassuringly for the food security of these households, we find that the increase in spouse hours on rubber plots does not come at the expense of her labor participation on non-rubber or non-cocoa plots (see Appendix Table 7). Overall, we see an increase across factors of production, for both labor and non-labor inputs, in the couples' training group, concentrated in rubber production.

[6] The extension training delivered to planters in both groups stressed the importance of applying these inputs to rubber trees.

Table 5: Factors of production

	Proportion of plots with phyto-sanitary	Proportion of plots with org fert.	Proportion of plots with chem. fert.	Proportion of rubber plots with phyto-sanitary	Proportion of rubber plots with org fert.	Proportion of rubber plots with chem. fert.	Proportion of cocoa plots with phyto-sanitary	Proportion of cocoa plots with org fert.	Proportion of cocoa plots with chem. fert.
Seedling Subsidy	-0.08***	-0.02	-0.01	-0.03	-0.02	-0.01	-0.02	-0.02	0.02
	(0.03)	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)
Couples' Training	0.14***	0.03	0.05**	0.12***	0.02	0.04**	0.05	0.02	0.02
	(0.04)	(0.02)	(0.02)	(0.04)	(0.02)	(0.02)	(0.03)	(0.01)	(0.02)
Seedling Subsidy + Couples' Training (beta)	0.06*	0.01	0.04*	0.09**	0.01	0.03	0.02	-0.00	0.04*
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.07	0.52	0.07	0.02	0.73	0.20	0.47	1.00	0.07
Observations	1435	1435	1435	1435	1435	1435	1435	1435	1435
Mean for control group	0.37	0.08	0.11	0.31	0.07	0.10	0.26	0.06	0.06
Mean for individual training	0.30	0.07	0.10	0.28	0.06	0.10	0.24	0.05	0.08

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Table 6: Labor hours per plot

	Total hrs per week per plot	Planter hrs per week per plot	Spouse hrs per week per plot	HH hrs per week per plot	Hired labor hrs per week per plot	Total hrs per week per hectare	Planter hrs per week per hectare	Spouse hrs per week per hectare	HH hrs per week per hectare	Hired labor hrs per week per hectare
Seedling Subsidy	-0.72	0.61	-0.07	-0.90	-0.44	-0.26	0.47	-0.05	-0.15	0.08
	(4.49)	(1.01)	(0.49)	(0.98)	(3.34)	(1.93)	(0.57)	(0.29)	(0.39)	(1.11)
Couples' Training	2.44	1.29	0.55	-0.71	1.34	0.35	0.23	0.28	-0.39	-0.06
	(5.16)	(1.13)	(0.58)	(0.98)	(4.09)	(2.38)	(0.63)	(0.35)	(0.45)	(1.52)
Seedling Subsidy + Couples' Training (beta)	1.71	1.91**	0.47	-1.61	0.91	0.09	0.70	0.23	-0.53	0.02
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.72	0.02	0.36	0.14	0.82	0.96	0.12	0.43	0.22	0.99
Observations	1435	1435	1435	1435	1435	1435	1435	1435	1435	1435
Mean for control group	56.17	13.53	6.77	7.90	27.53	20.86	5.56	2.78	2.93	8.74
Mean for individual training	53.10	13.87	6.56	6.25	25.90	20.72	6.16	2.77	2.61	8.92

Robust and clustered standard errors in parentheses. All values are winsorized at 99%.

* p<0.1 ** p<0.05 *** p<0.01

Note: Household (HH) hours exclude planter and spouse work hours. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Table 7: Labor hours per rubber plot

	Total hrs per week per rubber plot hectare	Planter hrs per week per rubber plot hectare	Spouse hrs per week per rubber plot hectare	HH hrs per week per rubber plot hectare	Hired labor hrs per week per rubber plot hectare
Seedling Subsidy	1.81	1.02	0.11	-0.33	0.85
	(2.35)	(0.74)	(0.35)	(0.53)	(1.11)
Couples' Training	3.28	0.74	0.82**	0.19	1.32
	(2.70)	(0.83)	(0.41)	(0.52)	(1.63)
Seedling Subsidy + Couples' Training (beta)	5.09**	1.76***	0.93**	-0.14	2.18
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.04	0.01	0.04	0.78	0.14
Observations	1435	1435	1435	1435	1435
Mean for control group	16.63	4.64	2.07	2.59	6.72
Mean for individual training	18.90	5.79	2.28	2.21	7.90

Robust and clustered standard errors in parentheses. All values are winsorized at 99%.

* p<0.1 ** p<0.05 *** p<0.01

Note: Household (HH) hours exclude planter and spouse work hours. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Table 8 examines whether this increased investment in agriculture comes at a cost in terms of non-agricultural employment. Compared to the individual training group, both the planter and the spouse in the couples' group are less likely to engage in off-farm self-employment, though this does not translate into a significant change in non-agricultural income. The second and third columns of Table 8 show no significant changes in income from processing, livestock or poultry rearing in either of the treatment groups. The last four columns of the table report how much income is earned in the past month from off-farm work. We find no significant difference in off-farm income (self-employment or wage income) between the individual training group and the couples' group. Interestingly, we see a significant increase in monthly self-employment income for planters in the individual training group, but this is not significant for couples' planters. Overall, the magnitude of any changes to this monthly income is very small compared to the impact on total harvest (Table 8, first column).

Table 8: Sources of household income

	Total harvest ($)	Income from process-sing ($)	Income from poultry/ livestock ($)	Monthly income self-employ. (planter) ($)	Monthly income self-employ. (spouse) ($)	Monthly income wage employ. (planter) ($)	Monthly income wage employ. (spouse) ($)
Seedling Subsidy	-356.68***	-4.48	2.63	10.01**	-1.89	-0.60	0.03
	(110.58)	(6.47)	(3.24)	(4.74)	(1.75)	(3.14)	(0.20)
Couples' Training	346.05***	3.16	-2.23	-5.04	1.71	0.17	-0.21
	(132.46)	(7.92)	(3.19)	(5.60)	(1.89)	(3.11)	(0.21)
Seedling Subsidy + Couples' Training (beta)	-10.63	-1.32	0.40	4.96	-0.18	-0.43	-0.18
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.93	0.85	0.91	0.26	0.92	0.87	0.41
Observations	1435	1435	1435	1435	1435	1435	1435
Mean for control group	1353.01	26.57	6.34	15.70	10.06	11.07	0.41
Mean for individual training	840.80	18.36	9.80	26.49	10.33	13.10	0.37

Robust and clustered standard errors in parentheses. All values winsorized at 99%.

* p<0.1 ** p<0.05 *** p<0.01

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

5 Underlying Mechanisms

Focusing on the aggregate farming impacts in Section 4, we can see that individual training households experienced a 25% fall in total harvest value as they planted new rubber trees. Those in the couples' training avoided this drop while achieving a 20% higher level of overall investment (looking at total trees planted between 2016 and 2018). Part of how they achieved this was through using more chemical inputs (a 16% increase in plots using phytosanitary and 36% increase in plots using chemical fertilizer – both significant at the 10 percent level) and perhaps a modest increase in total labor (not significant at conventional levels). While we do not know the shape of the production function(s), these sizable investment and productivity outcomes do not seem to be mainly driven by quantities of input use. We now turn to potential explanations around efficiency focusing on three potential channels: skills, management and incentives.

5.1 Skills

A first potential explanation is an increase in skills. In the couples' training, two members of the household attend the training rather than one. This could result in additional knowledge acquisition and/or the reinforcement of the planter's knowledge as the couple discusses what they were taught.

Table 9: Quiz and knowledge scores

	Planter rubber quiz score (4Qs - PT)	Planter rubber knowledge score (5Qs - ANCOVA)	Planter perception of spouse knowledge (PT)	Planter perception of spouse knowledge (EL)	Planter perception of spouse knowledge with PT obs. (EL)
Seedling Subsidy		0.05		0.08	
		(0.07)		(0.10)	
Couples' Training	-0.07	-0.02	0.52***	0.07	-0.12
	(0.10)	(0.08)	(0.17)	(0.11)	(0.13)
Seedling Subsidy + Couples' Training (beta)		0.03		0.15	
H0: Seedling Subsidy + Couples' Training = 0 (p-val)		0.72		0.13	
Observations	597	1408	578	1187	502
Mean for control group		1.87		2.42	
Mean for individual training	2.85	1.92	3.10	2.47	2.67

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01

Note: PT stands for post-treatment, EL stands for endline. Post-treatment regressions (PT) exclude individuals who did not take part in the training. Planter perception of spouse knowledge is measured on a scale [1;5], 5 meaning the highest perceived knowledge. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Table 9 provides some insight, showing the results of agricultural knowledge quizzes administered to producers. These quizzes covered key concepts taught in the training and important for rubber cultivation and productivity.[7] While we are not powered to report changes in the spouse's knowledge directly (only 220 spouses took the agricultural knowledge quiz during the training, and even fewer at endline) we examine whether the planter himself increased his knowledge by learning together with his spouse, or whether he perceived his spouse as having increased her agricultural knowledge.[8] Note that the planter's perception is significantly associated with spouse's actual knowledge: the correlation between the two is 0.28, with a p-value of 0.0001, in the sample of 220 spouses who did take the knowledge quiz (results available upon request).

In column 1 we can see that planters in the couples' group do not show higher knowledge than the individual group immediately following the training. Column 2 shows that neither individual planters nor couples' group planters show significantly higher knowledge than the control group. Couples' planters perceive their spouse to have higher knowledge immediately following the training (column 3) but this fades completely by endline (column 4). Taken together, these results suggest that increased knowledge is not a mechanism for the production changes we observe.

[7] Questions included the ideal spacing between rubber trees during planting, where to apply fertilizer to trees after the first three years and which crops are suitable for intercropping with rubber.
[8] The question asked the planter to assess his spouse's knowledge of best practices for rubber cultivation from 1 ('Very poor') to 5 ('Very good').

5.2 Planning and Management

We next turn to the second component that we exogenously varied in the couples' training: the planning and management portion.

5.2.1 Planning for co-management

One possible explanation for the improved productivity of the couples' group could be that their farms are better managed. To start examining this, we focus on the action plans that they developed as part of the intervention. The first column of Table 10 shows that lead farmers who completed the action plan with their wives were 19 percent, or 7 percentage points, more likely to still have an action plan at endline compared to the individual training group.[9] This suggests that the action plans remained more salient for this group over time.

Recall from Section 2, that we digitized farmers' action plans and conducted text-based analysis to examine mechanisms. In the remainder of the table, we examine differences in how farmers assigned to the couples' training filled out their action plans. In column 3, we can see a substantial increase in the number of tasks that farmers filled out in the action plan, indicating a more detailed planning process. When we turn to who was responsible for managing the listed tasks, we notice a more than three-fold increase in tasks managed by the wife, and a more than seven-fold increase in tasks managed *solely* by the wife (i.e., when we do not allow for joint management). We also see significant increases in tasks managed by other family members beside the spouse or planter, and by hired labor (more than two-fold increase). We detect no significant change in the number of tasks managed by the planter: while planters assign themselves 3.3 times as many tasks to manage as their spouse in the individual training's action plans, they are only assigned 22% more tasks to manage in the couples' action plans. Finally, the last column indicates that a significantly higher percent of tasks in the couple's training action plans have anyone assigned to them, indicating a higher level of accountability or responsibility. These are very substantial changes in the planned management of rubber cultivation that are in line with our results on labor hours on rubber plots (Table 7).

[9] We note in the second column that some pure control individuals also report having an action plan, meaning that there was either some non-compliance or spillover in the use of such plans within the community.

Table 10: Action plan tasks

	Have an action plan (EL)	Have an action plan with pure control (EL)	All tasks in AP (PT)	Family tasks in AP (PT)	Planter tasks in AP (PT)	Planter tasks in AP with sole responsibility (PT)	Spouse tasks in AP (PT)	Spouse tasks in AP with sole responsibility (PT)	Hired labor tasks in AP (PT)	Fraction of tasks with assigned person in AP (PT)
Seedling Subsidy		0.15***								
		(0.04)								
Couples' Training	0.07*	0.07*	1.99**	0.21**	0.41	0.43	1.27***	1.30***	0.35**	0.12**
	(0.04)	(0.04)	(0.95)	(0.08)	(0.47)	(0.41)	(0.40)	(0.37)	(0.16)	(0.06)
Seedling Subsidy + Couples' Training (beta)		0.22***								
H0: Seedling Subsidy + Couples' Training = 0 (p-val)		0.00								
Observations	919	1420	927	927	927	927	927	927	927	927
Mean for control group		0.19								
Mean for individual training	0.37	0.37	4.32	0.06	1.82	1.36	0.55	0.20	0.25	0.30

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01

Note: PT stands for post-treatment, EL stands for endline. Individuals who did not take part in the training and did not create action plans are recoded as zeros in post-treatment regressions (PT). Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

In Appendix Table 9, we re-run the same analysis restricting the sample only to famers who participated in the training (i.e., excluding farmers who were assigned to the training but did not complete it, rather than setting their observations to zero as in Table 10). In this specification, we do not detect an overall increase in tasks in the action plan as a result of the couples' training, indicating that results in Table 10 were driven by couples' training households being more likely to fill out an action plan at all. However, the allocation of tasks is not driven by this extensive margin effect. In this restricted sample, the impact of the couples' training group on the number of tasks managed by the spouse is even larger: a four-fold increase. We do not detect a change in the number of tasks managed by the planter or hired labor. But we do see a significant increase in the number of family tasks, as well as a significantly higher fraction of tasks with assigned individuals. Taken together, these results indicate more complete and durable planning as a result of the couples' training. Moreover, these households show a marked increase in the wife's role in taking responsibility for and managing tasks.

To better understand the shift in management that is happening within couples' training households, we turn to examining which categories of tasks become assigned to spouses. As increases in the use of phytosanitary products and chemical fertilizer were most pronounced on rubber plots, we are particularly interested to see whether changes in planned management concern tasks related to input use. In Appendix Table 10 and Appendix Table 11 we report the number of tasks listed in the action plans that mentioned phytosanitary products and fertilizer, respectively. Overall, we find non-significant increases in tasks mentioning phytosanitary products and fertilizer in the action plan, but significant increases in the number of these tasks managed *solely* by the spouse. This result highlights that including the wife in economic planning (the completion of the action plan) is an important mechanism underlying the increase in phytosanitary and fertilizer application we observe.

Next, we examine whether the couples' training led to a breakdown in traditional gendered divisions of labor in the action plan, which may have more to do with persistent stereotypes surrounding appropriate tasks rather than economic efficiency.[10] We aggregate tasks completed across all household plots in the twelve months preceding the baseline by gender, thus identifying tasks that are more frequently done by women ('female-dominant') or men ('male-dominant') in each household.[11] Table 11 shows that when we allow for joint management, the couples' training leads to an increased recognition of the wife's tasks in the action plan, as well as a 62% increase in the number of "opposite sex" tasks. We find an even larger breakdown in gendered task allocation when restricting to solely managed tasks in the seventh column: a three-fold increase compared to the individual training group. This shift is caused both by a greater recognition of women's tasks in the action plan (an increase of 0.075 tasks) as well as women crossing over into tasks that at baseline were male-dominant in the household (an increase of 0.258 tasks). Thus, the increase in spouse-managed action plan tasks we saw in Table 10 is working in two ways: (i) a smaller increase in women's sole responsibility for managing traditionally female tasks and (ii) a substantial increase in women's sole responsibility for managing traditionally male tasks.

[10] On the persistence of gender norms, see for example Alesina et al. (2013).
[11] Comparing the individual group means to the overall number of tasks recorded in Table 10, this exercise can explain 20% of all tasks as well as 68% of all tasks with an assigned manager in the action plan.

Table 11: Action plan gendered task division

	Planter/ spouse in opposite sex dominant tasks	Planter/ spouse in same sex dominant tasks	Planter in female-dominant tasks	Planter in male-dominant tasks	Spouse in male-dominant tasks	Spouse in female-dominant tasks	Planter/ spouse in opposite sex dominant tasks	Planter/ spouse in same sex dominant tasks	Planter in female dominant-tasks	Planter in male dominant-tasks	Spouse in male dominant-tasks	Spouse in female dominant-tasks
							With sole responsibility					
Couples' Training	0.215*	0.087	0.045	0.015	0.170	0.072*	0.303***	0.149	0.044	0.075	0.258**	0.075***
	(0.127)	(0.153)	(0.056)	(0.143)	(0.116)	(0.041)	(0.115)	(0.126)	(0.037)	(0.122)	(0.111)	(0.027)
Observations	927	927	927	927	927	927	927	927	927	927	927	927
Mean for individual training	0.345	0.535	0.116	0.486	0.229	0.049	0.151	0.339	0.069	0.327	0.082	0.011

Robust and clustered standard errors in parentheses

* p<0.1 ** p<0.05 *** p<0.01

Note: All tasks variables are action plan tasks. Individuals who did not take part in the training and did not create action plans are recoded as zeros. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

5.2.2 Co-management on the field

We now turn to exploring how action plan features translated into behavior on the farm two years down the line, and how the relationship between these features and field outcomes differs between the couples' and individual training groups. Given the increase in sole responsibility of the wife for tasks, we want to examine how this might be associated with the changes we see in input use.

To this end, Table 12 regresses input use at endline on three dimensions of the action plan that allow us to capture key features of management arrangements within couples: 1) the number of tasks for which the wife is solely responsible in the action plan, 2) whether the planter reports that he can let his wife take decisions and manage rubber cultivation (his perceived ability to delegate and 3) the planter's response to who should control future rubber revenue (measured on a scale from 1= the husband to 9=the wife). We examine this relationship separately for the couples' groups versus those that attended training alone in order to facilitate comparison.

Table 12 shows that in the couples' training group, for one more spouse task with sole responsibility listed in the action plan, the proportion of plots (respectively rubber plots) with phytosanitary increases by 1 (respectively 1.1) percentage points (Panel B). If we compare this 1.1 percentage point increase to the six-percentage point increase in the proportion of plots with phytosanitary found in the couples' group (Table 5), these are substantial shifts in input use. When the wife is listed as a manager in the action plan, there are also substantial increases in the use of fertilizer, with one more spouse task with sole responsibility leading to a 0.7 percentage point increase in the proportion of plots with chemical fertilizer (Panel B), again to be compared to a four-percentage point increase in the couple group compared to the control group. We also note that the planter's reported ability to delegate rubber management to his wife increases the use of organic fertilizer in the couples' training group (Panel D), while the effect is negative among the individual training group for phytosanitary (Panel C).

Now turning to labor inputs, in Table 13 we find that one more spouse task listed in the action plan is associated with a 0.55 hour increase in the number of hired labor hours per week per rubber hectare in the couples' training group (Panel B). This effect is larger in the individual training group, amounting to 2.8 hours (Panel A). The other two action plan variables (Panel C to Panel F) also closely relate to the impacts on rubber labor hours observed in Table 7. We note that the planter's ability to delegate rubber management to his wife results in a large increase in his labor hours: a 2.5 hour increase in the couples' training group (Panel D). In addition, the more the planter assigns control of future rubber revenue to his wife, the more time she spends working on rubber. A 1-point increase on the 9-point scale results in a 0.39 increase in rubber labor hours by the wife (Panel F). This relationship between the woman's productive incentives and her labor hours only holds in the couples' training group: in the individual training group, the more control over future rubber revenue is assigned, the less the man ends up working in rubber.

Lastly, in Appendix Table 12 we examine whether spouses are likelier to work on the same or different tasks. The results are restricted to households that used fertilizer (first three rows) and phytosanitary (last three rows). We again see that the share of households in which only women apply these inputs is highest in the couples' training group. Compared to the individual training group, we note increased economic specialization in fertilizer application and a significant increase in women being solely responsible for phytosanitary application.

Taken together, these results suggest that couples who attended the rubber extension training together not only planned out the management of rubber cultivation differently, notably by making women co-managers on paper, but actually shifted their management patterns in the field. Couples' training households that made women sole managers of tasks also used more factors of production by increasing the proportion of plots using non-labor inputs, and by mobilizing more hired labor on the field. Moreover, couples' training households where the planter felt able to delegate rubber management to his wife observe increased rubber labor hours by the planter, perhaps because they decide to specialize and go ‘all in’ on rubber cultivation. Couples’ training households in which the husband assigns more future control of rubber revenue to his wife during the training witness increased total labor supply on rubber, and increased labor supply by the wife. These patterns are not observed among the individual training group. Our data also suggests a close match between planned input tasks and input application in the field, providing additional evidence of how spouses in the couples’ training group are empowered to take on a larger role of co-manager in the field, now in charge of factors of production.

Table 12: Relationship of endline inputs and post-training outcomes

	Proportion of plots with phytosanitary	Proportion of rubber plots with phytosanitary	Proportion of plots with org fert.	Proportion of rubber plots with org fert.	Proportion of plots with chemical fert.	Proportion of rubber plots with chemical fert.
Panel A: Individual training observations with spouse tasks as a main explanatory variable (449 observations)						
Spouse tasks with sole responsibility	0.009	0.024	-0.001	0.002	-0.002	0.001
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Ind. Training Mean	0.299	0.282	0.070	0.061	0.103	0.099
Panel B: Couples training observations with spouse tasks as a main explanatory variable (478 observations)						
Spouse tasks with sole responsibility	0.010*	0.011**	0.005**	0.003	0.007**	0.009**
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Couples Training Mean	0.424	0.384	0.080	0.070	0.144	0.130
Ind. Training = Couples Training (p-val)	0.98	0.56	0.27	0.83	0.15	0.41
Panel C: Individual training observations with planters' opinion on spouse ability to make decisions (267 observations)						
Planter willing to delegate	-0.109*	-0.116*	-0.058	-0.033	-0.024	0.003
	(0.06)	(0.07)	(0.04)	(0.05)	(0.05)	(0.05)
Ind. Training Mean	0.293	0.297	0.085	0.077	0.114	0.110
Panel D: Couples training observations with planters' opinion on spouse ability to make decisions (311 observations)						
Planter willing to delegate	0.018	0.007	0.089**	0.083**	0.011	0.015
	(0.06)	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)
Couples Training Mean	0.439	0.413	0.092	0.088	0.136	0.129
Ind. Training = Couples Training (p-val)	0.10	0.11	0.01	0.04	0.54	0.85
Panel E: Individual training observations with planter opinion on who should control rubber income (280 observations)						
Who should control rubber income	-0.009	-0.009	0.005	-0.007	0.017	0.001
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
Ind. Training Mean	0.289	0.291	0.081	0.073	0.119	0.116
Panel F: Couples training observations with planter opinion on who should control rubber income (315 observations)						
Who should control rubber income	0.012	-0.001	-0.011	-0.012	-0.009	-0.008
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Couples Training Mean	0.433	0.404	0.091	0.087	0.134	0.127
Ind. Training = Couples Training (p-val)	0.31	0.70	0.26	0.74	0.12	0.58

Robust and clustered standard errors in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Note: For all variables, individuals who did not take part in the training had missing values, which were recoded as zeros. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Table 13: Relationship of endline work hours and post-training outcomes

	Total hrs per week per rubber plot hectare	Planter hrs per week per rubber plot hectare	Spouse hrs per week per rubber plot hectare	HH hrs per week per rubber plot hectare	Hired labor hrs per week per rubber plot hectare
Panel A: Individual training observations with spouse tasks as a main explanatory variable (449 observations)					
Spouse tasks with sole responsibility	3.512	0.787	0.440	-0.340**	2.787*
	(2.26)	(0.67)	(0.40)	(0.14)	(1.51)
Ind. Training Mean	18.900	5.791	2.284	2.211	7.899
Panel B: Couples training observations with spouse tasks as a main explanatory variable (478 observations)					
Spouse tasks with sole responsibility	0.339	-0.086	0.023	-0.044	0.548**
	(0.40)	(0.09)	(0.07)	(0.05)	(0.26)
Couples Training Mean	22.094	6.277	2.862	2.304	9.683
Ind. Training = Couples Training (p-val)	0.14	0.17	0.28	0.04	0.12
Panel C: Individual training observations with planters' opinion on spouse ability to make decisions (267 observations)					
Planter willing to delegate	3.421	-0.803	-0.015	-0.479	3.486
	(4.62)	(1.37)	(0.81)	(0.81)	(2.75)
Ind. Training Mean	19.528	5.907	2.475	2.212	8.197
Panel D: Couples training observations with planters' opinion on spouse ability to make decisions (311 observations)					
Planter willing to delegate	5.913	2.501**	0.962	1.320	0.287
	(4.33)	(1.25)	(0.74)	(0.80)	(2.88)
Couples Training Mean	23.700	6.501	3.116	2.542	10.709
Ind. Training = Couples Training (p-val)	0.67	0.05	0.33	0.08	0.38
Panel E: Individual training observations with planter opinion on who should control rubber income (280 observations)					
Who should control rubber income	-0.952	-0.595**	-0.266	-0.224	0.081
	(0.88)	(0.28)	(0.17)	(0.30)	(0.56)
Ind. Training Mean	19.159	5.971	2.441	2.175	7.869
Panel F: Couples training observations with planter opinion on who should control rubber income (315 observations)					
Who should control rubber income	2.722*	0.693	0.387*	0.488	0.871
	(1.62)	(0.45)	(0.22)	(0.34)	(0.93)
Couples Training Mean	23.159	6.281	3.094	2.513	10.632
Ind. Training = Couples Training (p-val)	0.03	0.01	0.01	0.09	0.43

Robust and clustered standard errors in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Note: For all variables, individuals who did not take part in the training had missing values, which were recoded as zeros. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

5.2.3 Intra-household power and incentives

Finally, we turn to examining changes to decision-making power, economic control and other household dynamics. Recall that we administered a gender awareness training to both the individual and couples' group to net out any unintended signaling effects on gender equality not operating though the skills or management channel. However, these channels—in particular, the effective management channel—may themselves result in changes in women's productive incentives. Table 14 shows the planter's and wife's declared decision-making power at endline. Couples' training spouses claim around 0.32 more of a decision in agriculture than the control group's spouses at endline (a 10% increase), while the planters symmetrically claim 0.33 fewer decisions (or 4.2% less power).

Table 14: Household decision-making

	Of 10 important decisions on agri: you would decide how many? (planter)	Of 10 important decisions on agri: you would decide how many? (spouse)	Of 10 important decisions on rubber: you would decide how many? (planter)	Of 10 important decisions on rubber: you would decide how many? (spouse)
Seedling Subsidy	-0.16	0.24	-0.09	-0.04
	(0.13)	(0.15)	(0.14)	(0.20)
Couples' Training	-0.05	0.08	-0.24	0.19
	(0.16)	(0.20)	(0.16)	(0.21)
Seedling Subsidy + Couples' Training (beta)	-0.20	0.32*	-0.33**	0.15
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.14	0.10	0.03	0.40
Observations	1393	1038	1392	1037
Mean for control group	7.45	3.27	7.93	2.74
Mean for individual training	7.22	3.48	7.79	2.75

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

This higher decision-making power claimed by spouses translates into slightly more economic control. Table 15 shows a significant increase in the amount of rubber income for which the spouse partakes in control of, as well as in the proportion of rubber plots for which spouse partakes in income decisions, compared to the control group. While women partake in income decisions for 0.1% of rubber plots in the control group, they do so in 1.8% of rubber plots in the couples' training group. It must be stressed that the absolute value of these indicators of income controlled remains low: these are large changes relative to a low baseline, but by no means transformative. However, they do provide evidence that the couples' training may have slightly increased women's incentives to invest time in agricultural production via strengthening their claims over the proceeds.

Table 15: Spouse control over harvest revenues

	Amount of total harvest revenue spouse partakes in control of ($)	Amount of rubber harvest revenue spouse partakes in control of ($)	Proportion of plots for which spouse partakes in income decisions	Proportion of rubber plots for which spouse partakes in income decisions
Seedling Subsidy	7.97	0.24*	-0.004	0.010**
	(15.27)	(0.13)	(0.020)	(0.005)
Couples' Training	-8.01	0.15	-0.014	0.007
	(15.05)	(0.20)	(0.023)	(0.007)
Seedling Subsidy + Couples' Training (beta)	-0.04	0.39***	-0.018	0.017***
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	1.00	0.01	0.400	0.006
Observations	1435	1435	1435	1435
Mean for control group	45.66	0.05	0.102	0.001
Mean for individual training	51.74	0.30	0.098	0.011

Robust and clustered standard errors in parentheses. Revenue amounts winsorized at 99%.

* p<0.1 ** p<0.05 *** p<0.01

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

What changes does all this imply for the couple? We see no significant shift in either the planter's or the spouse's perception of teamwork, or their satisfaction with the relationship (Appendix Table 13). Appendix Table 14 shows a modest increase in the planter's involvement in housework in the individual training group, specifically in the preparation of food and feeding of children. However, these results disappear when restricting results to households where both the planter and their spouse respond to the question. We see zero changes in housework arrangements among the couples' training group compared to the control group. Finally, in Appendix Table 15, we look at gender attitudes to see if the changes in production decisions might be related to a shift in gender dynamics. The results are not conclusive. In the couples' training group, both the planter and the spouse are likely to recognize that housework is really a job, but they are also both more likely to agree that a woman who earns money independently is unruly. All of these effects are fairly small and most are significant at the 10 percent level.

6 Conclusion

Our results provide novel evidence on how the integration of women in economic management can improve the efficiency of production. We run a field experiment with 1,491 (male) lead farmers selected to receive 2 hectares' worth of improved rubber seedlings, which require upfront care but take up to six years to start producing latex. Half of these lead farmers were randomly selected to attend a mandatory agricultural extension training, where they were taught rubber maintenance skills and completed an action plan covering the first two years of cultivation, by themselves. The other half were assigned to complete the training with their wives.

We find that wives being present during the training leads to a significant and meaningfully higher level of investment for households: 20 percent higher than if the man alone attends. Furthermore, these couple-trained households achieve this investment without a large drop in current production and productivity, costs that the individual-trained group incurs.

How does this happen? Joint planning of household production emerges as the primary mechanism underlying our results. There is no indication that this intervention worked through an increase in aggregate knowledge, and the increase in women's control over decision making and share of rubber proceeds is modest compared to observed changes in production and investment. Rather, two heads were better than one in a management sense: couples' households moved to higher resource use and changes in how they did things. At the planning stage, couples' households make a more complete action plan and retain it in the years following the training. In their action plans, women and other household members assume a greater role in production, particularly through accountability for tasks. Notably, wives are assigned management of over three times more tasks compared to households in the individual training group.

In the years following the writing of the plan, men increase labor supply across all plots, and their wives increase their labor on rubber plots. Those in the couples' training group also use more chemical inputs—both phytosanitary and fertilizer—the responsibility for which was more likely to have been assigned to women. Our evidence suggests a close match between what households planned for during the extension training and what happened in the field: households where spouses are empowered as co-managers on paper also use more factors of production in the field, and women are more frequently in charge of these inputs. Moreover, couples' training households in which husbands made women sole managers of tasks, were comfortable delegating, and assigned slightly more future control of rubber revenue to their wives saw an increase in labor and non-labor input use—unlike in the individual group. This points to how—underlying our results on production choices and production outcomes—changes in joint planning led to a shift in intra-household management in the field.

The intervention was highly cost-effective. The cost for APROMAC to implement the intervention was $25 per household, consisting of an increased number of workdays for the agricultural extension agents delivering the training. The additional cost of researcher time to design the training was $3,400. Assuming 544 beneficiaries, this would come out to a total of $31 per household.[12] Compared to the $346 offset in the value of rubber production we see in the couples' training group compared to the individual group, shown in Table 4, the intervention has a return factor of eleven.

These findings have implications for policymakers and practitioners looking to increase income among poor households. Including women in household planning for the most profitable aspect of agriculture, commercial production, can help households increase their expected future production without sacrificing current production—decreasing the cost of economic investment—by mobilizing additional resources and changing how the household manages the farm. Our results also suggest that the standard approach used in the delivery of agricultural extension and training (targeting only one member in the household, frequently the primary plot owner) may need revising.

Future research should test whether our results generalize to other types of crops, especially those that require less skill and duration to harvest, and food staples— where yields remain far below their potential in much of Sub-Saharan Africa. Another fruitful avenue for research is to tackle the question of *which* two heads are better than one. While the couple is an important decision making unit within households across much of the continent,[13] this does not preclude other intervention variants from being equally (or more) cost-effective. Future trainings could test involving all household members in creating an action plan or involving someone other than the spouse in households without a married couple. Finally, although our results show that including women in economic planning can improve the efficiency of household production further work is needed to understand how to increase their share of control over these increased resources.

[12] APROMAC did indicate that they believe the cost may increase when the couples' training is implemented at scale, particularly for organizations that do not have their decentralized agricultural extension agent network. They projected the cost may increase to $34 per household when implemented at scale. Including staff design cost, the total projected cost of the training would thus be $41/household.

[13] Across 23 Sub-Saharan African countries, less than 5% of married couples report that someone else other than the husband or the wife is involved in making decisions over large household purchases (Annan et al. 2021).

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8 Appendix

Appendix Table 1: Control variables at baseline (1435 observations)

	Pure control (508)		Individual Training (449)		Couples Training (478)		Control - Ind. training		Control - Couples' training		Ind. training - Couples' training	
VARIABLES	Mean	SD	Mean	SD	Mean	SD	Diff.	P-val	Diff.	P-val	Diff.	P-val
Age of household head	46.09	11.04	45.50	11.87	45.27	10.75	0.59	0.43	0.82	0.24	0.23	0.76
Household size	6.47	3.43	6.12	3.53	6.08	3.35	0.35	0.12	0.39*	0.07	0.04	0.86
Number of adults	3.14	1.72	2.93	1.70	2.87	1.67	0.20*	0.06	0.27**	0.01	0.06	0.56
Number of children	3.15	2.35	2.98	2.44	3.06	2.27	0.17	0.26	0.09	0.55	-0.08	0.58
Dependency ratio	1.16	0.85	1.17	0.89	1.23	0.90	-0.02	0.76	-0.07	0.19	-0.06	0.34
Married planter	0.91	0.29	0.89	0.31	0.89	0.31	0.02	0.40	0.02	0.40	-0.00	0.99
Polygamous relationship	0.15	0.42	0.11	0.34	0.10	0.31	0.04*	0.07	0.05**	0.03	0.01	0.76
Planter has IGA	0.62	0.49	0.64	0.48	0.71	0.45	-0.02	0.46	-0.10***	0.00	-0.07**	0.02
Asset index	9.84	1.98	9.84	2.23	9.83	2.07	0.00	0.97	0.01	0.91	0.01	0.95
Credit constrained	0.13	0.34	0.13	0.34	0.13	0.34	0.00	0.98	0.00	0.92	0.00	0.94
Share of plots owned	0.95	0.19	0.94	0.22	0.93	0.22	0.01	0.44	0.02	0.22	0.01	0.68
Average distance to plots (minutes)	65.53	49.66	64.23	48.12	70.18	58.96	1.30	0.68	-4.65	0.18	-5.95*	0.09
Number of plots	2.46	1.44	2.23	1.34	2.39	1.35	0.24***	0.01	0.07	0.42	-0.17*	0.06
Average plot size	3.86	3.70	3.66	3.40	3.52	3.23	0.20	0.39	0.34	0.12	0.14	0.52

Appendix Table 2: Differences between randomized sample and a sample of completed training

	Pooled Sample					**Couples' Training**					**Individual Training**				
	Randomized Sample		Treated Sample		Difference in Means	Randomized Sample		Treated Sample		Difference in Means	Randomized Sample		Treated Sample		Difference in Means
	Obs.	Mean (A)	Obs.	Mean (B)	(B-A)	Obs.	Mean (A)	Obs.	Mean (B)	(B-A)	Obs.	Mean (A)	Obs.	Mean (B)	(B-A)
Age of household head	1218	45.23	629	44.86	-0.37	617	45.36	362	44.78	-0.59	601	45.09	267	44.96	-0.13
Household size	1491	5.28	712	5.60	0.32*	741	5.31	403	5.71	0.39*	750	5.24	309	5.45	0.21
Number of adults	1218	2.89	629	2.93	0.04	617	2.84	362	2.96	0.12	601	2.94	267	2.88	-0.06
Number of children	1218	2.94	629	2.98	0.03	617	2.99	362	3.03	0.04	601	2.90	267	2.90	0.00
Dependency ratio	1216	1.17	628	1.15	-0.02	616	1.20	361	1.15	-0.06	600	1.13	267	1.15	0.02
Married planter	1491	0.72	712	0.78	0.07***	741	0.73	403	0.79	0.06**	750	0.70	309	0.78	0.07**
Polygamous relationship	1491	0.10	712	0.13	0.03	741	0.10	403	0.13	0.03	750	0.09	309	0.12	0.03
Matrilineal ethnicity	1214	0.26	628	0.28	0.02	617	0.29	362	0.33	0.04	597	0.23	266	0.21	-0.02
Planter has IGA	1215	0.69	628	0.70	0.01	617	0.71	362	0.72	0.01	598	0.66	266	0.67	0.01
Asset index	1491	11.34	712	10.82	-0.52***	741	11.20	403	10.60	-0.60***	750	11.48	309	11.11	-0.36
Credit constrained	1218	0.13	629	0.14	0.01	617	0.13	362	0.16	0.03	601	0.12	267	0.10	-0.02
Share of plots owned	1207	0.93	621	0.93	-0.00	613	0.93	358	0.92	-0.01	594	0.93	263	0.93	0.00
Average distance to plots (minutes)	1205	70.54	621	71.33	0.78	612	72.30	358	78.06	5.76	593	68.73	263	62.16	-6.57*
Number of plots	1207	2.33	621	2.24	-0.09	613	2.39	358	2.31	-0.08	594	2.28	263	2.14	-0.14
Average plot size	1198	3.51	618	3.82	0.31**	608	3.49	356	3.75	0.26	590	3.53	262	3.90	0.38

Appendix Table 3: Number of plots and intercropped plots, per crop

Crops	Number of plots	Plots intercropped with rubber	Total harvest value (thousand $)
Cocoa	1,121	188	784.32
Palm oil	251	55	705.73
Rubber	999	...	212.91
Peanuts	75	15	188.26
Cassava	439	86	127.97
Coffee	299	62	116.58
Cashews	110	10	26.33
Rice	155	21	26.23
Plantains	232	51	22.30
Other	55	8	12.44
Maize	212	64	7.27
Yam	218	31	6.14
Eggplant	56	11	5.33
Okra	59	12	2.86
Tomato	14	4	1.98
Chili Pepper	80	13	1.35
Taro	43	6	0.13
Pineapple	5	1	0.02
Fallow	131	0	0.00
Wood trees	44	7	0.00
Other fruit trees	42	8	0.00
Millet	1	0	0.00

Appendix Table 4: Harvests and productivity for rubber plots at baseline

	Total harvest ($)	Rubber harvest ($)	Cocoa harvest ($)	Other crops harvest ($)	Total yield ($/ha)	Rubber yield ($/ha)	Cocoa yield ($/ha)	Other crops yield ($/ha)
Seedling Subsidy	-431.03***	-221.69***	-57.61*	-39.49	-83.05***	-60.21***	-10.51	-6.18
	(105.27)	(82.59)	(29.26)	(25.80)	(23.65)	(18.92)	(7.18)	(7.75)
Couples' Training	400.13***	269.14***	-22.10	65.75***	58.62**	46.68**	-8.16	7.89
	(114.12)	(94.08)	(30.20)	(25.06)	(27.66)	(21.83)	(7.40)	(7.00)
Seedling Subsidy + Couples' Training (beta)	-30.90	47.45	-79.72***	26.26	-24.43	-13.53	-18.66***	1.70
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.79	0.65	0.01	0.33	0.43	0.64	0.01	0.83
Observations	925	925	925	925	925	925	925	925
Mean for control group	839.07	446.86	173.74	91.64	200.97	118.27	39.83	20.94
Mean for individual training	407.01	234.13	111.20	49.61	133.60	76.19	27.39	17.51

Robust and clustered standard errors in parentheses. All values are winsorized at 99%. Household-level regressions.

* p<0.1 ** p<0.05 *** p<0.01

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size. Contemporaneous control variables in all regressions: Rubber-cocoa intercrop, Any other intercrop.

Appendix Table 5: Harvest and productivity for cocoa plots at baseline

	Total harvest ($)	Rubber harvest ($)	Cocoa harvest ($)	Other crops harvest ($)	Total yield ($/ha)	Rubber yield ($/ha)	Cocoa yield ($/ha)	Other crops yield ($/ha)
Seedling Subsidy	-199.78**	-98.66**	-89.23*	5.37	-22.25	-16.93***	8.37	-3.71
	(84.01)	(39.85)	(52.08)	(20.89)	(22.97)	(6.45)	(18.45)	(5.82)
Couples' Training	182.40*	51.70	106.27	42.16	17.57	11.58**	1.54	6.29
	(97.90)	(35.19)	(69.60)	(32.70)	(26.26)	(5.49)	(21.53)	(7.48)
Seedling Subsidy + Couples' Training (beta)	-17.38	-46.96	17.04	47.52*	-4.68	-5.35	9.91	2.57
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.82	0.14	0.76	0.09	0.81	0.35	0.55	0.73
Observations	1050	1050	1050	1050	1050	1050	1050	1050
Mean for control group	758.20	170.08	460.86	85.85	184.06	27.25	120.97	23.16
Mean for individual training	520.07	69.11	357.54	81.34	158.78	10.83	124.84	20.07

Robust and clustered standard errors in parentheses. All values are winsorized at 99%. Household-level regressions.

* $p<0.1$ ** $p<0.05$ *** $p<0.01$

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size. Contemporaneous control variables in all regressions: Rubber-cocoa intercrop, Any other intercrop.

Appendix Table 6: Labor hours per week per cocoa plots

	Total hrs per week per cocoa plot hectare	Planter hrs per week per cocoa plot hectare	Spouse hrs per week per cocoa plot hectare	HH hrs per week per cocoa plot hectare	Hired labor hrs per week per cocoa plot hectare
Seedling Subsidy	-0.04	-0.15	-0.11	-0.23	0.28
	(1.64)	(0.43)	(0.30)	(0.32)	(0.83)
Couples' Training	-1.96	0.22	0.08	-0.41	-1.44*
	(1.85)	(0.50)	(0.35)	(0.33)	(0.84)
Seedling Subsidy + Couples' Training (beta)	-2.00	0.07	-0.03	-0.64**	-1.16
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.17	0.87	0.91	0.05	0.15
Observations	1435	1435	1435	1435	1435
Mean for control group	11.81	3.24	1.85	1.78	4.41
Mean for individual training	10.93	2.95	1.59	1.33	4.46

Robust and clustered standard errors in parentheses. All values are winsorized at 99%.

* p<0.1 ** p<0.05 *** p<0.01

Note: Household (HH) hours exclude planter and spouse work hours. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Table 7: Labor hours per week on non-rubber and non-cocoa plots

	Total hrs per week per not-rubber/cocoa hectare	HH hrs per week per not-rubber/cocoa hectare	Planter hrs per week per not-rubber/cocoa hectare	Spouse hrs per week per not-rubber/cocoa hectare	Hired labor hrs per week per not-rubber/cocoa hectare
Seedling Subsidy	-1.26	-0.23	-0.13	-0.24	-0.35
	(1.41)	(0.24)	(0.37)	(0.26)	(0.75)
Couples' Training	0.35	0.14	0.00	-0.08	0.38
	(1.38)	(0.24)	(0.36)	(0.27)	(0.71)
Seedling Subsidy + Couples'	-0.91	-0.09	-0.13	-0.32	0.03
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.50	0.73	0.75	0.29	0.96
Observations	1435	1435	1435	1435	1435
Mean for control group	7.60	1.05	2.16	1.25	2.46
Mean for individual training	6.01	0.72	1.96	1.00	2.00

Robust and clustered standard errors in parentheses. All values are winsorized at 99%.
* p<0.1 ** p<0.05 *** p<0.01
Note: Household (HH) hours exclude planter and spouse work hours. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Table 8: Non-agricultural activities

	In past 7 days, managed hh non-ag. activity (planter)	In past 7 days, managed hh non-ag. activity (spouse)	In past 7 days, helped hh non-ag. activity (planter)	In past 7 days, helped hh non-ag. activity (spouse)	In past 7 days, work in paid employment (planter)	In past 7 days, work in paid employment (spouse)
Seedling Subsidy	0.03	0.03	0.05**	0.04**	0.01	0.00
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.01)
Couples' Training	-0.09***	-0.06**	-0.09***	-0.08***	-0.03	-0.01
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
Seedling Subsidy + Couples' Training (beta)	-0.06**	-0.04	-0.04	-0.03*	-0.02	-0.01
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.02	0.17	0.13	0.09	0.25	0.64
Observations	1435	1435	1435	1435	1435	1435
Mean for control group	0.2	0.16	0.13	0.1	0.09	0.03
Mean for individual training	0.22	0.18	0.17	0.14	0.1	0.03

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Table 9: Action plan tasks without missing values

	All tasks in AP	Family tasks in AP	Planter tasks in AP	Spouse tasks in AP	Hired labor tasks in AP	Fraction of tasks with assigned person in AP
Couples' Training	-0.09	0.30**	0.28	1.46**	0.53	0.13
	(1.40)	(0.13)	(0.90)	(0.72)	(0.34)	(0.08)
Observations	477	477	477	477	477	477
Mean for individual training	9.65	0.14	4.07	1.23	0.57	0.68

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01

Note: Family tasks exclude planter and spouse work tasks. Excluded are individuals who did not take part in the training. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Table 10: Action plan phytosanitary tasks

	All phyto tasks	Planter phyto tasks	Spouse phyto tasks	Planter phyto tasks with sole responsibility	Spouse phyto tasks with sole responsibility
Couples' Training	0.04	-0.01	0.01	0.01	0.02***
	(0.04)	(0.03)	(0.02)	(0.02)	(0.01)
Observations	927	927	927	927	927
Mean for individual training	0.13	0.09	0.02	0.06	0.00

* p<0.1 ** p<0.05 *** p<0.01.

Note: For all variables, individuals who did not take part in the training had missing values, which were recoded as zeros. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Table 11: Action plan fertilizer tasks

	All fertilizer tasks	Planter fertilizer tasks	Spouse fertilizer tasks	Planter fertilizer tasks with sole responsibility	Spouse fertilizer tasks with sole responsibility
Couples' Training	0.03	0.01	0.01	0.01	0.02***
	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)
Observations	927	927	927	927	927
Mean for individual training	0.10	0.07	0.02	0.05	0.00

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01.

Note: For all variables, individuals who did not take part in the training had missing values, which were recoded as zeros. Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Table 12: Fertilizer and Phytosanitary Application at Endline

	Control Obs	Control Mean	Ind. Training Obs	Ind. Training Mean	Couples Training Obs	Couples Training Mean	Control - Ind. Training	Control - Couples Training	Ind. Training - Couples Training
Fertilizer: Both genders complete task	31	0.161	31	0.161	43	0.047	0.000	0.115	0.115
Fertilizer: Only men complete task	31	0.839	31	0.774	43	0.860	0.065	-0.022	-0.086
Fertilizer: Only women complete task	31	0.000	31	0.065	43	0.093	-0.065	-0.093**	-0.029
Phytosanitary: Both genders complete task	75	0.120	51	0.059	59	0.102	0.061	0.018	-0.043
Phytosanitary: Only men complete task	75	0.880	51	0.941	59	0.847	-0.061	0.033	0.094
Phytosanitary: Only women complete task	75	0.000	51	0.000	59	0.051	0.000	-0.051*	-0.051*

* p<0.1 ** p<0.05 *** p<0.01.

Appendix Table 13: Household relationships

	We are a team (planter)	We are a team (spouse)	Happy in relationship (planter)	Happy in relationship (spouse)	Stable relationship (planter)	Stable relationship (spouse)
Seedling Subsidy	0.02	0.05	-0.01	0.01	0.00	0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Couples' Training	-0.02	-0.04	0.01	0.02	-0.02	0.01
	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Seedling Subsidy + Couples' Training (beta)	0.01	0.02	-0.01	0.03	-0.02	0.06
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.88	0.62	0.82	0.44	0.70	0.14
Observations	1376	1038	1377	1038	1377	1038
Mean for control group	3.13	3.11	3.18	3.17	3.17	3.14
Mean for individual training	3.13	3.15	3.15	3.18	3.15	3.18

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Table 14: Household tasks

	I prepare food (planter)	I prepare food (spouse)	I prepare food - both reporting (planter)	I prepare food - both reporting (spouse)	I clean and do laundry (planter)	I clean and do laundry (spouse)	I clean and do laundry - both reporting (planter)	I clean and do laundry - both reporting (spouse)	I take care of kids (planter)	I take care of kids(spouse)	I take care of kids - both reporting (planter)	I take care of kids - both reporting (spouse)
Seedling Subsidy	0.14*	-0.03	0.09	-0.03	0.08	-0.01	0.02	-0.01	0.15*	-0.02	0.08	-0.02
	(0.07)	(0.06)	(0.07)	(0.06)	(0.07)	(0.06)	(0.06)	(0.06)	(0.09)	(0.09)	(0.10)	(0.09)
Couples' Training	-0.12	0.06	-0.15**	0.06	-0.09	0.06	-0.10	0.06	-0.12	0.15	-0.16	0.15
	(0.08)	(0.06)	(0.07)	(0.06)	(0.07)	(0.06)	(0.07)	(0.06)	(0.10)	(0.12)	(0.11)	(0.11)
Seedling Subsidy + Couples' Training (beta)	0.02	0.03	-0.06	0.03	-0.01	0.05	-0.08	0.05	0.02	0.13	-0.09	0.12
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.75	0.52	0.30	0.56	0.84	0.36	0.16	0.39	0.76	0.12	0.28	0.14
Observations	1384	1038	1035	1035	1386	1038	1035	1035	1384	1038	1035	1035
Mean for control group	0.70	3.73	0.54	3.73	0.72	3.71	0.56	3.71	1.19	3.08	1.10	3.08
Mean for individual training	0.84	3.72	0.63	3.72	0.81	3.72	0.58	3.72	1.32	3.08	1.16	3.08

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01

Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Table 15: Gender attitudes

	A man should have a final say in decisions (planter)	A man should have a final say in decisions (spouse)	Taking care of kids is the responsibility of women (planter)	Taking care of kids is the responsibility of women (spouse)	Domestic work is really a job (planter)	Domestic work is really a job (spouse)	Woman who earns money independently is unruly (planter)	Woman who earns money independently is unruly (spouse)
Seedling Subsidy	0.07	0.04	-0.01	0.07	0.06	0.09*	-0.01	0.04
	(0.05)	(0.06)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)
Couples' Training	-0.08	0.07	-0.00	-0.06	0.03	0.02	0.11*	0.04
	(0.06)	(0.07)	(0.06)	(0.07)	(0.05)	(0.06)	(0.06)	(0.06)
Seedling Subsidy + Couples' Training (beta)	-0.01	0.11*	-0.01	0.01	0.09*	0.11**	0.10*	0.08*
H0: Seedling Subsidy + Couples' Training = 0 (p-val)	0.90	0.08	0.86	0.81	0.06	0.03	0.07	0.09
Observations	1426	1038	1426	1038	1426	1038	1426	1038
Mean for control group	2.99	2.87	2.82	2.92	2.96	3.02	2.37	2.03
Mean for individual training	3.05	2.91	2.81	2.99	3.04	3.11	2.39	2.08

Robust and clustered standard errors in parentheses.

* p<0.1 ** p<0.05 *** p<0.01

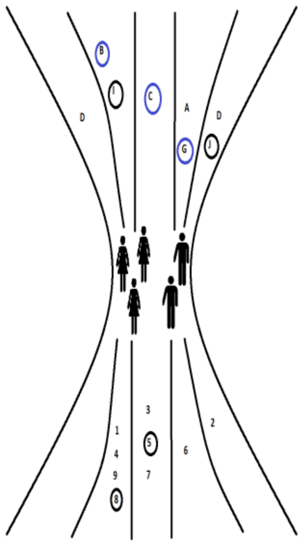
Note: Baseline control variables in all regressions: Age of household head, Household size, Number of adults, Number of children, Dependency ratio, Married planter, Polygamous relationship, Matrilineal ethnicity, Planter has IGA, Asset index, Credit constrained, Share of plots owned, Average distance to plots (minutes), Number of plots, Average plot size.

Appendix Figure 1: Rubber Training Curriculum

Part 1

COUPLE GENDER SENSITIZATION TRAINING

GENDER BALANCE TREE



Materials/prepared inputs
• Put up a blank flipchart at the front of the group for interactive presentation of the tool.
• Per participant: notebook diary and a pencil and black and green colored pens.

Timing: 1.5 hours

The Gender Balance Trees should be drawn together by the couple.

Step 1: Trunk: who is in the household?
Draw two lines in the middle of the paper for the trunk. Then put symbols for each household member on either side inside the trunk. Working women (including co-wives living in the same family) should go on the left side of the trunk, working men on the other, with dependents in the middle to the side of their respective sex. Note: it is best not to color code by gender or it gets confused with the colors of the fruits.

Step 2: Roots: who contributes what work?
A Draw two roots for women and two roots for men on the respective sides of the trunk in their respective colors. The central root is for joint activities but the line is in the color for women/men.

B On the outside root on each side put the activities which people of that sex performs alone for themselves. Ring those which take most time in black as something you may want to change. Ring those which earn most income with a blue ring, thickness indicating relative amount of income and something which you probably want to keep.

C On the inside roots put the activities which people of that sex perform alone for the family i.e. housework following the same size and ring convention.

D In the central root put those activities which both women and men do, putting the symbol on the side of the sex who does most. Again using the same size and ring convention.

Step 3: Branches who gets what fruit?
A Draw four branches corresponding to each root, women, men and central trunk for joint household expenses.

B On the outside branch on each side, draw symbols for personal expenditure that each sex makes for them alone. Ring the largest personal expenditures in black with thickest line for largest expenses as something you want to change.

C Household expenditure which only one person pays should be on the inside branch on each side. Ring the largest expenditures in black as something you want to change, with thickest line for largest expenses.

D Put similarly ringed symbols for joint expenditures in the middle top branch - putting the symbol to the side of the sex who contributes the most. Ring necessary expenditure in blue but the largest expenditures in black as things you may want to keep.

Step 4: What is pushing the tree?
On their respective side of the trunk put symbols for:

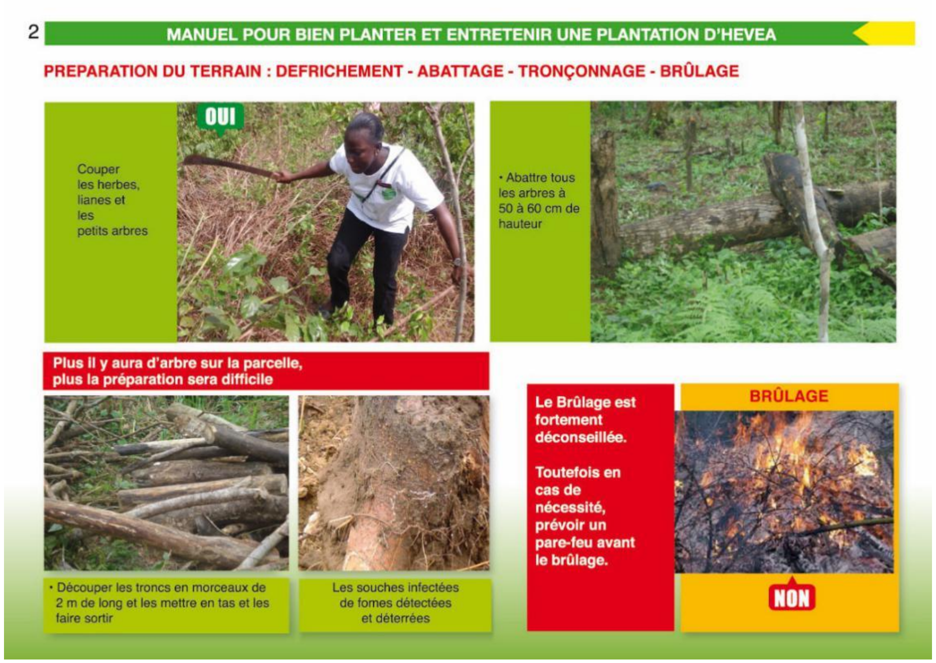
A The property which women and men own, e.g. who owns the land? who owns the livestock? who owns the house?

B The types of decisions which women and men make - which decisions are made by women only, which by men only, which are made jointly? Or is one person overall decision-maker or do they always sit down together?

Part 2

Agricultural training

Agricultural knowledge training proceeded in the same way (same content) in the treatment and control group. The only difference is that in the treatment group, the beneficiaries' partners also participated in the training. The training material relied heavily on pictures to maximize farmers' understanding. A sample page is rendered below:



Part 3

ACTION PLAN CREATION (DONE BY INDIVIDUAL IN CONTROL; COUPLE IN TREATMENT)

Materials required: Notebook, pens

First part: Write down answer to: a) Out of 10 important household decisions about growing rubber, how much will you take and how much will your partner take? b) If the sale of rubber gave you an income of 10,000 FCFA for example, how much will you control yourself, and how much will your partner control?

Second part: Action plan development

Step 1: Draw a vertical diagram in which the months of the year are listed down the left-hand side.

Step 2: Write down what actions need to be done during this period

Step 3: Next to each action, write down who will manage it, the resources required for this action, and source of funds if any.

Time before/after sowing	**Actions**	**Person Responsible (Name)**	**Resources Required (Input, Tool etc.)**	**Source of Funds**
June 2016				
July-August 2016 etc.				