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Spousal Cooperation and Agricultural Technology Adoption

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Abstract

Adoption of agricultural technologies is crucial for sustainable development, yet adoption of many relevant technologies remains low, especially among smallholder farmers in Africa. While there is an extensive literature aimed at understanding drivers of adoption, intra-household factors have received much less attention. In this study, we examine the relationship between spousal cooperation, an important intra-household factor, and the adoption of agricultural technologies among smallholder farmers in Cameroon. Specifically, we focus on improved seed varieties, inorganic fertilizers, intercropping, and minimum tillage as technologies. We combine survey and lab-in-the-field experimental data and employ multivariate probit models to account for simultaneous adoption. We also estimate associations between cooperation and the number of technologies adopted. The results suggest that spousal cooperation is positively associated with the adoption of improved varieties and intercropping. However, we find no associations between cooperation and adoption of inorganic fertilizers and minimum tillage, although the coefficients are positive. We also find that cooperation is positively associated with the number of technologies adopted. Lastly, we find interesting complementarities between the various technologies. Our findings suggest that promoting spousal cooperation could serve as an important leverage point for the adoption of modern agricultural technologies.

Keywords: Spousal cooperation, intra-household dynamics, technology adoption, smallholders, Cameroon.

JEL Codes: D13, Q12, Q16.

1. Introduction

Adoption of modern agricultural technologies such as improved seeds, inorganic fertilizers, and intercropping is widely recognized as essential for sustainable development by increasing farm productivity, income, food security, and reducing poverty (Amankwah & Gwatidzo, 2024; Geffersa et al., 2022; Guye et al., 2025; Lele & Goswami, 2017; Wainaina et al., 2018; Wordofa et al., 2021). When properly applied, these technologies may also aid in environmental protection. However, these technologies differ substantially in their input requirements, risk profiles, and knowledge intensity, which implies that their adoption may be shaped by distinct constraints and incentives. Yet, adoption of these technologies remains low, especially among smallholder farmers in Africa (Suri & Udry, 2022; Wainaina et al., 2016). While there is an extensive literature identifying drivers of adoption, intra-household factors have received less attention even though they may matter for adoption (Euler et al., 2024; Kassie et al., 2015; Teklewold, 2023). An important intra-household factor that could drive adoption is spousal cooperation. Spousal cooperation could allow households to pool income and labour, thereby reducing the cash and labour constraints associated with adoption of the different technologies. For instance, inorganic fertilizers and improved seeds warrant cash outlays from households while intercropping may be associated with higher labour needs. Cooperation could also improve women's empowerment through involvement in strategic decision-making and income control. Since women's involvement in decision-making has been shown to improve adoption (Euler et al., 2024), cooperation could thus improve adoption through women's empowerment. In this paper, we examine the role of cooperation on the adoption of agricultural technologies.

In many smallholder farming systems, men and women perform distinct and interdependent roles with gendered division of labour across farming activities (Van Campenhout et al., 2023). These differentiated roles are also closely linked to patterns of intra-household decision making over resources with men mostly controlling income and productive assets (Bryan et al., 2024; Kieran et al., 2015). Consequently, women's limited control of resources as well financial and labour constraints may hinder technology adoption by restricting their ability to invest in inputs, mobilize labour, and participate in key production decisions. These intra-household dynamics may thus influence agricultural decisions, including adoption of technologies. A growing body of literature has looked at such intra-household dynamics by focusing on women’s bargaining power and decision-making on adoption decisions, showing that women’s bargaining power and involvement in decision-making is positively associated with adoption (Euler et al., 2024; Gilligan et al., 2020).

However, these studies conceptualize the household as individuals with competing interests (Doss & Quisumbing, 2020). This may be limited in a context where agricultural production and technology adoption are frequently joint decisions that require coordination between spouses (Malabayabas et al., 2023; Teklewold, Kassie, & Shiferaw, 2013). Moreover, since the costs and benefits of adoption are distributed across spouses according to gender roles and resource control, adoption may depend not only on bargaining power but also on the degree of cooperation between spouses. At the same time, adoption of modern technologies or new crops has also been shown to alter gender roles, in some cases reducing women’s decision-making power and control over income (Fischer & Qaim, 2012; Gichungi et al., 2021; Mehraban et al., 2022). In this context, spousal cooperation becomes relevant as it can allow spouses to pool and jointly manage resources, share the costs of adoption, and maintain women’s control of income and involvement in decision-making, possibly increasing the likelihood of adopting technologies. Yet, there is limited evidence on how spousal cooperation may influence adoption.

To our knowledge, only Lecoutere & van Campenhout (2023) have attempted to examine how cooperation may influence agricultural technology adoption. Studying coffee producing households in Uganda, they found that spouses that participated in an intensive coaching program aimed at promoting participatory decision-making and cooperated were more likely to adopt agronomic practices such as soil and moisture control with trenches, pruning of coffee, mulching, organic manure and improved seedlings in Uganda compared to those who did not cooperate. They concluded that cooperation mediated the relationship between participatory decision-making and adoption of the adoption of these agronomic practices. However, their study does not look at the direct links between cooperation and adoption as they focus only on mediating role of cooperation. Also, while their study focuses on a set of agronomic practices among coffee farmers only, they treat adoption decisions as independent and do not consider the potential complementarities that may exist in adoption decisions which may lead to the simultaneous adoption of multiple technologies by farming households.

In this study, we address this gap by explicitly analysing the role of spousal cooperation on the adoption of four agricultural technologies; improved varieties, inorganic fertilizer, intercropping, and minimum tillage, which are widely promoted in the study area. These technologies were also selected because they represent distinct categories of technologies with different requirements for adoption. Improved varieties and inorganic fertilizer are cash intensive while intercropping and minimum tillage are labour intensive. These different requirements allow us to examine how spousal cooperation addresses different constraints and influences adoption decisions across technologies with different resource demands. We combine survey and experimental data from rural Cameroon. We first employ a matching approach to reduce observed differences in the data and then employ a multivariate probit (MVP) model to account for potential adoption of technologies in combination. We also estimate associations between spousal cooperation and the number of technologies adopted. We find that cooperation is positively associated with the adoption of improved seeds and intercropping. We also find that cooperation is positively associated with the number of technologies adopted. Lastly, we find complementarities between the various technologies.

Our study contributes to both the intra-household and technology adoption literature by expanding the sparse literature on intra-household factors as drivers of technology adoption. By focusing on cooperation, we offer novel insights on an intra-household factor that could serve as leverage point for promoting technology adoption among farming households. We also lend more evidence to policy initiatives that aim at promoting spousal cooperation among farming households.

The rest of the paper is organized as follows. In section two, we provide a conceptual framework and hypotheses that guide the study. Section three presents the data and methods; section four presents the results while section five concludes and suggests some policy directions.

2. Conceptual framework

Our conceptualization of spousal cooperation originates from the view of households as units that face collective action problems similar to those observed in natural resource management settings as espoused by Doss & Meinzen-Dick (2015). These collective action problems imply that a household member may engage in strategic behaviour and still benefit from the household without contributing to it or a household member may contribute to the household but does not fully benefit from it (Doss & Meinzen-Dick, 2015; Lecoutere & Jassogne, 2019). Like in natural resource management settings, such collective action problems can be addressed through cooperation between spouses where they may pool different resources for household use. Cooperation could thus take many forms such as pooling of resources like income and labour as well sharing of tasks among spouses. The particular form of cooperation that exists in a household may depend on the context, hence nuance is needed to better understand cooperation.

We present a conceptual framework on how spousal cooperation may influence agricultural technology adoption as shown in Figure 1. The role of cooperation on adoption may depend on the nature of the technology whether it is a technology that requires income from households or a technology that may be labour-increasing. We consider four types of technologies in this study: improved seed varieties and inorganic fertilizer, which require capital, and labour-increasing technologies like intercropping and minimum tillage. In some cases, these technologies have also been shown to influence intra-household gender roles either through shifting income control, decision-making, or labour allocation (Gichungi et al., 2021; Teklewold, Kassie, Shiferaw, et al., 2013). Thus, we discuss the role of cooperation with respect to the specificities of these technologies and generate testable hypotheses that guide the study.

Cooperation may allow households to pool income, thereby reducing income constraints that limit farmers' adoption of certain technologies. Income constraints are one of the key barriers to technology adoption (Tshikala et al., 2019). Modern technologies such as improved seeds and inorganic fertilizers are usually promoted for their yield-enhancing capacity. However, these technologies mostly require income from farmers, which is a major constraint to many farmers in many developing countries. Through cooperation, spouses may pool income relaxing income constraints and allowing households to access these technologies. Based on this, we generate our first hypothesis:

H1: Spousal cooperation promotes the adoption of improved varieties and inorganic fertilizer.

Another important factor that may matter for technology adoption is labour. Technologies such as intercropping and minimum tillage have been shown to be labour-increasing,

increasing household labour needs (Grabowski et al., 2016; Kotir et al., 2022; Ngoma, 2018; Teklewold, Kassie, Shiferaw, et al., 2013; Thierfelder et al., 2024). For instance, since minimum tillage means that the soil is mostly undisturbed, weed grows faster (Grabowski et al., 2016). To this end, minimum tillage increases the labour needed for weeding especially in areas where the use of herbicides is low (Giller et al., 2009; Ngoma, 2018). Intercropping increases the labour needed to plant, manage, and harvest multiple crops (Thierfelder et al., 2024). These technologies are thus associated with increased labour needs. Through cooperation, spouses may pool labour, overcoming such labour constraints. Furthermore, in a context where household labour is insufficient and there exists labour markets, cooperation may allow households to pool income and hire additional labour, reducing labour constraints.

Also, additional labour from the adoption of labour-increasing technologies is usually borne by women. This is especially the case for technologies like minimum tillage, which may be associated with more weeding, considered a woman's activity (Teklewold, Kassie, Shiferaw, et al., 2013). If this additional labour adoption is to be borne solely by the woman, it may stifle adoption. However, through cooperation, spouses may share the additional labour that results from adoption, which may improve adoption. To this end, we generate our second hypothesis:

H2: Spousal cooperation promotes the adoption of intercropping and minimum tillage.

Moreover, adoption of technologies that may increase yields or income has been shown to reduce women's decision-making power and control over income (Fischer & Qaim, 2012; Mehraban et al., 2022). This loss of decision-making power and control of income may stifle adoption of technologies that require contributions from both spouses in terms of income or labour especially in situations where women already have limited decision-making power and limited control over income. However, through cooperation, women may either gain more decision-making power and control over income or maintain them in cases where they already had, even upon adoption of such technologies. This may also influence adoption as women's decision-making power has been shown to matter for adoption (Euler et al., 2024; Gilligan et al., 2020).

Given that technologies such as improved varieties, inorganic fertilizers, intercropping, and minimum tillage have been shown to have complementary benefits in terms of yields, income, and food security (Bello et al., 2024; Tabe-Ojong et al., 2023; Teklewold, Kassie, Shiferaw, et al., 2013), they are likely to be adopted in combination. Adoption of different types of technologies in combination implies simultaneously addressing both income and labour constraints as well as sharing the costs of adoption, which can be attained through spousal cooperation as described above. We thus generate our third hypothesis:

H3: Spousal cooperation promotes the adoption of different technologies in combination.

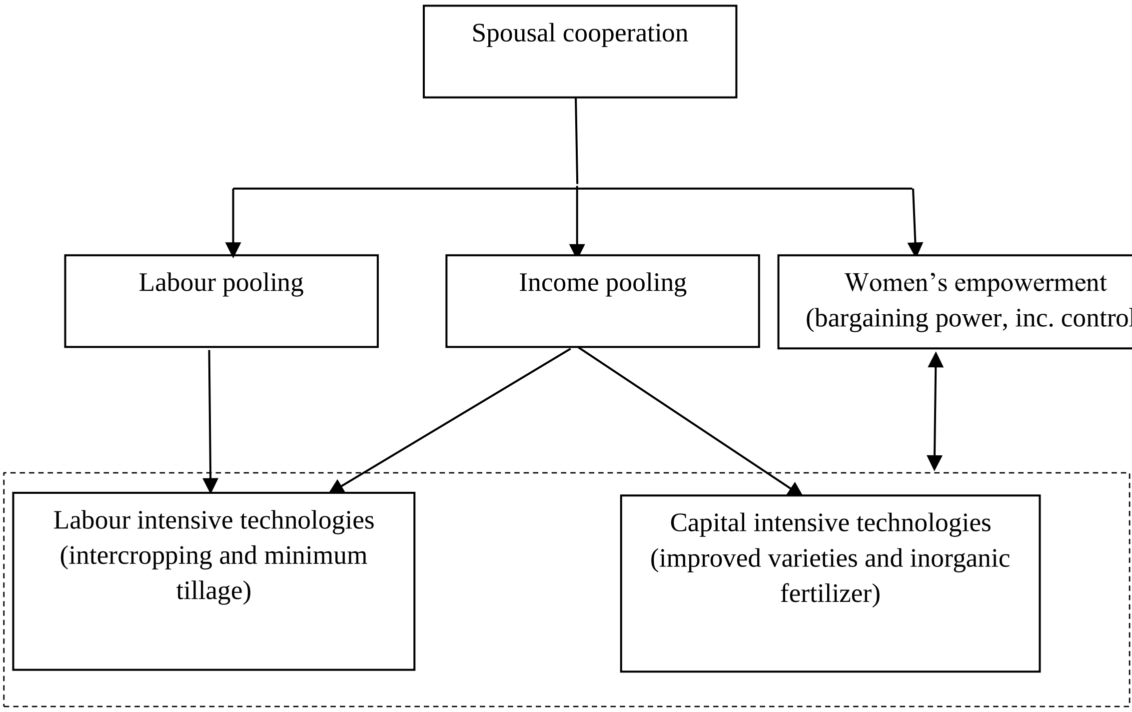


Figure 1. Conceptual framework

Source: authors' conceptualization

3. Materials and methods

3.1. Study area and data

The focus of this study is the West Region of Cameroon, where agriculture is the main activity and the region is one of the country's major food production basins (Fosso & Nanfosso, 2016). Unlike in other areas where there is a clear distinction between cash and food crops, this is not the case in the study area. While a few households cultivate perennial cash crops like cocoa and oil palm, the major crops produced in the area are maize, beans, potatoes, and vegetables, which serve for both home consumption and sales[1] (Fosso & Nanfosso, 2016; Wenda et al., 2025). There are no households that exclusively produce only perennial cash crops.

Although households may own many plots/farmlands, agricultural production is mainly organized at the household level where households produce crops mostly on plots jointly managed by spouses. However, some farm activities are differentiated along gender lines. For example, men are mostly involved in land preparation and pesticide application while women are focused on activities such as planting, weeding, harvesting, and post-harvest management activities. These roles sometimes overlap and both spouses can engage in the sale of agricultural produce.

This joint management system implies that how spouses coordinate their activities is crucial to several aspects of production, including the adoption of agricultural technologies by the household. This is especially true as adoption of technologies is low in the area (Fosso & Nanfosso, 2016). In such a context, spousal cooperation, through pooling of resources can play an important role in enabling households to overcome resource coordination constraints as well as share the costs of adoption.

The data employed for this study are obtained from a household survey and lab-in the field experiments conducted between July and September 2024. We employed a multi-stage sampling strategy to select households. In the first stage, we purposively selected the West Region of Cameroon since it is one of the main agricultural regions in the country (Soh Wenda et al., 2024). The region has a high prevalence of smallholder agriculture and mixed farming systems, which require coordinated labour and joint decision-making within households, making it well suited for studying spousal cooperation in technology adoption. At the same time, there are also diverse household types, which allowed us to easily obtain households in spousal relationships, hence capturing spousal cooperation.

In the second stage, we purposively selected three agriculture intensive divisions- the Noun, Menoua, and Bamboutous. In the third stage, we randomly selected three sub-divisions within each division. Villages were then randomly selected within these sub-divisions on a probability

[1] To this end, when we talk about technology adoption, we are focused on food crops since most of the cash crops are perennials.

proportional to size basis. Lastly, households in spousal relationships were randomly selected within the villages on a probability proportional to size basis. With this sampling framework, 440 households were sampled in 37 villages. The main research instrument was the questionnaire, which comprised of several modules such as household demographics, asset holdings, consumption expenditures, agricultural production, and agricultural technology adoption.

The questionnaire also had individual sections which spouses (husbands and wives) responded to separately. This section of the questionnaire allowed us to implement lab-in-the-field experiments with spouses independent of the other spouse's interference. Specifically, a public goods game (PGG) was played by spouses to elicit spousal cooperation. Public goods games capture individual behaviour and are increasingly used in the intra-household literature to capture spousal cooperation (Barr et al., 2019; Bjorvatn et al., 2020). Prior to the game, the enumerators explained the details of the game such as what a household and private account represented and how allocations and payouts were to be shared. Money allocated to the private account could be used by the spouse involved without consultation of the other spouse. However, both spouses had to decide how to use the money allocated to the household account. Several explanations were made until the respondents confirmed that they understood the game properly. Ethical consent for the survey and the experiment were obtained from the ethics board of the Center for Development Research, University of Bonn. In addition, informed consent was sought from all respondents. Only respondents who provided consent were interviewed. Trained enumerators conducted the survey and experiment.

3.2. Technologies considered

In this study, we consider two broad types of technologies; capital demanding technologies and labour-increasing technologies. The former involves inorganic fertilizer and improved seed varieties while the latter involves minimum tillage and intercropping. These are some of the most promoted technologies in the study area owing to their benefits. Improved seed varieties possess important agronomic characteristics that are yield-enhancing. Hence, their adoption is promoted as a means of boosting farmers' yields. Adoption of improved varieties have been shown to improve yields and food security (Takam-Fongang et al., 2019; Tsambou & Tagang Tene, 2024). Inorganic fertilizers provide readily available nutrients to crops, and could thus boost yields (Wato et al., 2024). Wenda et al. (2025) show that adoption of inorganic fertilizer improved household food security. It should be noted that the excessive use of inorganic fertilizers may also be associated with environmental issues such as poor soil quality and biodiversity loss (Mozumder & Berrens, 2007).

Intercropping is the combination of different crops on the same piece of land. While this may serve as a common diversification strategy, which may be important for household food security, the crops may also provide complementary benefits to each other. For example, other crops tend to benefit from additional nitrogen when intercropped with legumes due to the nitrogen-fixing potentials of legumes, leading to increased productivity (Wang et al., 2014). Hence, in most intercropping systems, legumes are combined with other crops. In the study area, when adopted, beans are intercropped with maize and other crops. Intercropping has been shown to increase farm income (Nchanji et al., 2016). Minimum tillage reduces the likelihood of soil erosion and maintains soil quality by facilitating the build-up of soil organic matter (Thierfelder et al., 2017). Generally, in the area, farmers till the soil and make ridges before planting. Minimum tillage implies no ridges are made as farmers only make small holes to plant the seeds or seedlings of the crop involved. Minimum tillage accompanied with mulching has been shown to increase yields (Naudin et al., 2010).

3.3. Measurement of key variables

3.3.1. Agricultural technologies adoption

Our main outcome variables of interest are adoption of four technologies; improved seed varieties, inorganic fertilizer, intercropping, and minimum tillage and the number of technologies adopted. We consider adoption for any crop because adoption in the area is generally low. Also, since most households practice mixed farming systems, it is difficult to distinguish adoption for specific crops especially for technologies like inorganic fertilizer, intercropping, and minimum tillage. We measure the adoption of these technologies as dummy variables that take a value of 1 if the household adopted the technology on any of their plots during the previous cropping season and zero otherwise. Other studies have used a similar approach (Euler et al., 2024; Ngoma, 2018). The number of technologies adopted is measured as the count of the number of technologies used by a household during the previous season. It ranges between 0 and 4.

3.3.2. Spousal cooperation

Our measure of spousal cooperation is based on spouses' allocation to the household account in the PGG. In the game, spouses were given a monetary endowment of 500FCFA (West African franc) each (approximately 0.8Euros) in envelopes. Spouses were then asked to allocate the amount between a household and a private account. Allocations to the household account were multiplied by 1.5 and shared equally between spouses while allocations to the private account remained the same and were given to the spouse involved. The game is similar to what has been used in other settings (Barr et al., 2019; Bjorvatn et al., 2020). Cooperative couples are expected to allocate more to the household account compared to their private accounts (Bjorvatn et al., 2020). While the PGG is primarily about income-pooling, it also proxies for trust and cooperation more generally since these contributions are largely driven by trust between spouses (Gürdal et al., 2024). Trust that one's partner is likely to contribute to the household may influence not just a spouse's willingness to contribute but also how much is contributed to the household. Hence, it can serve as a measure of cooperation and has been used by other studies to measure cooperation (Barr et al., 2019; Bjorvatn et al., 2020).

Based on the allocations to the household and private accounts, we compute two measures of cooperation. Our first measure is a dummy variable, which takes a value of 1 if both spouses allocate at least half of the endowment to the household account and zero otherwise. This measure has also been used by other studies (Hoel et al., 2021). Since we are also interested in understanding the extent to which spouses cooperate, we compute a second measure of cooperation based on an index. The index is computed as husband's plus wife's allocation divided by 1000, which is the maximum amount that spouses can jointly allocate. This second measure of cooperation is thus a continuous variable that is bounded between 0 and 1, which allows us to directly gauge the extent to which spouses cooperate. It also allows us to directly compare households.

3.4. Modelling adoption decision

We are interested in estimating conditional associations between spousal cooperation and adoption of four agricultural technologies. The adoption decisions maybe modelled individually with single equation models like logit or probit. However, since the technologies can be adopted as a bundle, driven by the same factors, the error terms of the independent probit or logit models may be correlated, leading to biased estimates (Wooldridge, 2010). To capture the interdependencies between adoption of various technologies, we employ the multivariate probit (MVP) model which takes into consideration the correlation of the error structures of independent adoption equations and could thus produce less biased estimates. The MVP model is also argued to be most suited in cases where the outcome has several unordered categories as in our case with different technologies. Hence, it has been employed by several studies to model joint adoption (Kassie et al., 2015; Ndiritu et al., 2014; Teklewold, 2023; Teklewold, Kassie, & Shiferaw, 2013; Wainaina et al., 2016).

The MVP can be modelled in a system of two equations (Ndiritu et al., 2014). The first is a linear equation where the outcome is a latent variable of the benefits associated with adopting technologies. This is given in equation (1) as:

$$A_{hi}^{*} = \boldsymbol{X}_h \alpha_t + \boldsymbol{C}_h \theta_i + \varepsilon_h \quad \text{(i=1,2,3,4)} \qquad (1)$$

h and i, represent a household and technology, respectively. A_{hi}^{*} is the expected benefit of adopting the technologies and **X** is a vector of observed household and spousal characteristics, **C** represents spousal cooperation indicators of a household and ε is a multivariate normally distributed error term.

Since these expected benefits are not directly observed, they are reflected in a household's decision to adopt such technologies. Hence, we observe a household's decision to adopt different technologies as shown in equation (2):

$$A_{hi} = \begin{cases} 1 \; if \; A_{hi}^{*} > 0 \\ 0 \;\; otherwise \end{cases} \qquad (2)$$

A_{hi} is the adoption of the ith technology described above. The variance-covariance matrix, M, of the error term is given as:

$$M = \begin{pmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 \end{pmatrix} \qquad (3)$$

Where 1,2,3,4 represent the various technologies; improved varieties, inorganic fertilizers, intercropping, and minimum tillage. The off-diagonal elements, which represent the correlations between the error terms of each adoption decision, determine whether the different technologies are complements or substitutes. A positive correlation indicates that the technologies are complements while a negative correlation suggests that they are substitutes. We estimate the MVP model through simulated maximum likelihood.

We are also interested in estimating associations between cooperation and the number of technologies adopted. To do so, we estimate models of the form:

$$N_h = \boldsymbol{X}_h\beta + \boldsymbol{C}_h\lambda + \varepsilon_h \tag{4}$$

Where N is the number of technologies adopted by a household, and the other variables are as previously defined. The parameters to be estimated are β and λ, with λ being the parameter of interest, which gives the association between cooperation and the number of technologies adopted. We estimate equation 4 using ordinary least square (OLS). Given the count nature of the number of technologies, a Poisson estimator could also be used. However, the Poisson estimator relies on restrictive assumptions such as equi-dispersion, which is difficult to satisfy. To this end, we prefer the OLS which is less restrictive and the estimates are easier to interpret.

A possible issue with the estimations is that the estimates may be biased due to the endogeneity of spousal cooperation which may arise from unobserved heterogeneity or reverse causality. Given the cross-sectional nature of the data and absence of appropriate instrumental variables, we cannot appropriately deal with such endogeneity. However, we try to control for observed differences. We employ a matching approach to make the two groups (spouses that cooperate and those that do not based on the cooperation dummy) comparable across observed characteristics. Since the two groups may differ systematically across observed and unobserved factors, we restrict our analysis to the sample where the observed characteristics of the two groups are similar. We do so by employing a matching approach. We first estimate a treatment model and then predict propensity scores. We then match observations based on these propensity scores. After matching, we retain only observations from the two groups that have similar propensity scores and hence, within the common support area. With this matching procedure, we lose 8 observations that are outside the common support area. We then use the remaining 432 observations to estimate all the models. It is important to point out that this approach only eliminates differences due to observed characteristics. Given that we fail to control for differences from unobserved characteristics such as risk preferences and motivation that may drive technology adoption as well possible reverse causality issues, we interpret our estimates as associations and not causal.

We further control for observed differences by including many relevant observed factors that may influence adoption. These variables are represented by the vector, **X,** in the regression models. These variables are based on the vast literature on technology adoption (Grabowski et al., 2016; Issahaku & Abdulai, 2020; Ngoma, 2018; Wainaina et al., 2016). We control for spouses' age, educational level, and engagement in off-farm work. Age may influence adoption of technologies. Evidence shows that younger farmers are more likely to adopt modern technologies compared to older farmers owing to inertia. However, the relationship may be non-linear, hence we also include the square of age in line with Wainaina et al., (2016). More educated farmers, who are probably aware of the benefits of technologies are more likely to adopt modern technologies, hence educational level may also influence adoption decision. Off-farm income serves as an additional income source to that from agriculture. This may also reduce a household's liquidity constraints, allowing the household to access modern technologies such as improved seeds and fertilizers. We also control for spouses' access to institutional factors such as extension access and cooperative membership. These serve as conduits of technology-related information in most developing countries and have been shown to influence technology adoption decisions (Kahsay & Endalew, 2025; Lambrecht et al., 2016; Pan et al., 2018; Wossen et al., 2017).

Household size may reduce household labour constrains allowing them to adopt labour-increasing technologies. Livestock production serves as an additional source of income and a source of organic fertilizers, which may influence a household's use of inorganic fertilizers as they may serve as substitutes. Remittances serve as an extra source of income to households. Evidence shows that remittances increase the likelihood of adopting fertilizers in Kenya (Tshikala et al., 2019). Asset value serves as a proxy for wealth. Wealth could reduce households' liquidity constraints, hence influence adoption decision. We control for the number of plots cultivated by a household[2]. Number of plots cultivated have been shown to

[2] We cannot control for plot size since we did not collect the data at plot level and households cultivate multiple plots. We use the number of plots as a proxy.

matter for adoption (Ngoma, 2018). The variables used in the study and their definition are described in Table 1.

Table 1. Variables and description

Variables	Description
Technologies	
Improved varieties (1/0)	1 if a household used any during the previous season on any plot
Inorganic fertilizer (1/0)	1 if a household used any during the previous season on any plot
Intercropping (1/0)	1 if a household used during the previous season on any plot
Minimum tillage (1/0)	1 if a household used during the previous season on any plot
Number of technologies (count)	A count of the number of technologies adopted by a household
Cooperation indicators	
Cooperation dummy (1/0)	1 if both spouses allocate at least half endowment to HH account
Cooperation index (0-1)	ratio of husbands plus wives' allocation to total possible allocation
Controls	
Age husband (years)	in full years
Age wife (years)	in full years
Education husband (years)	years of schooling
Education wife (years)	years of schooling
Off-farm work husband (1/0)	1 if husband engaged in any off-farm work during past 12 months
Off-farm work wife (1/0)	1 if wife engaged in any off-farm work during past 12 months
Extension access husband	1 if husband had access to extension
Extension access wife	1 if wife had access to extension
Cooperative membership husband (1/0)	1 if husband is a member of a cooperative organization
Cooperative membership wife (1/0)	1 if wife is a member of a cooperative organization
Household size (number)	number of people in the household
Livestock production (1/0)	1 if household produces any livestock
Remittance (1/0)	1 if household received any form of remittance within the last 12 months
Asset value (0000FCFA)	Monetary value of sum of agricultural and non-agricultural assets
Number of plots (number)	Number of plots cultivated by a household over the previous season

1 USD=600FCFA

4. Results

4.1. Summary statistics

Table 2 presents the summary statistics of the variables used in the study. In this sample, husbands are older than wives. Husbands have an average education of 10 years while wives have 9 years. As expected, more husbands (69%) are engaged in off-farm work compared to wives (45%), while 7% of husbands have access to extension services, compared to only 1% of wives. Similarly, 6% of husbands and 2% of wives are members of a cooperative organization. Households have an average of 3.8 people. In addition to crop production, about 15% of the sampled households also produce livestock. While remittance could be an important source of income, only 10% of household receive any form remittances. Households have a mean asset value of 890,000FCFA (1578 USD) and cultivate 1.5 plots on average.

With regard to spousal cooperation indicators, over 74% of spouses allocate more than half of their endowment to the household account, suggesting that most spouses cooperate. For the cooperation index, spouses jointly allocate over 55% of their endowments to the household account.

Turning to the technologies considered, all technologies are adopted by more than 20% of the sampled households. The most adopted technology is inorganic fertilizer, which is adopted by about 67% of the households while the least adopted technology is minimum tillage adopted by 25% of households. Improved varieties and intercropping are adopted by 29% and 28% of households, respectively. Households also adopt an average of 1.5 technologies suggesting simultaneous adoption of multiple technologies.

Table 2. Summary statistics

Variables	Mean	Sd
Technologies		
Improved varieties	0.298	0.458
Inorganic fertilizer	0.677	0.468
Intercropping	0.282	0.45
Minimum tillage	0.252	0.435
Number of technologies	1.509	1.021
Spousal cooperation indicators		
Cooperation dummy	0.743	0.437
Cooperation index	0.551	0.185
Controls		
Age husband	48.518	14.025
Age wife	39.43	12.552
Education husband	10.491	4.946
Education wife	9.148	4.377
Off-farm work husband	0.698	0.46
Off-farm work wife	0.459	0.499
Extension access husband	0.077	0.267
Extension access wife	0.018	0.134
Cooperative membership husband	0.066	0.248
Cooperative membership wife	0.02	0.142
Household size	3.793	1.146
Livestock production	0.157	0.364
Remittance	0.1	0.3
Asset value	89.096	187.506
Number of plots	1.518	0.685
Observations	440	

Figure 2 shows the average allocation of spouses and their joint allocation. On average, husbands allocate about 282.9 FCFA, which is higher than wives' average allocation of 268.1 FCFA, similar to other studies that reported higher average allocation by husbands (Bjorvatn et al., 2020; Kebede et al., 2014). However, husband and wife jointly allocate more than half (about 550.9FCFA) of the endowment to the household account.

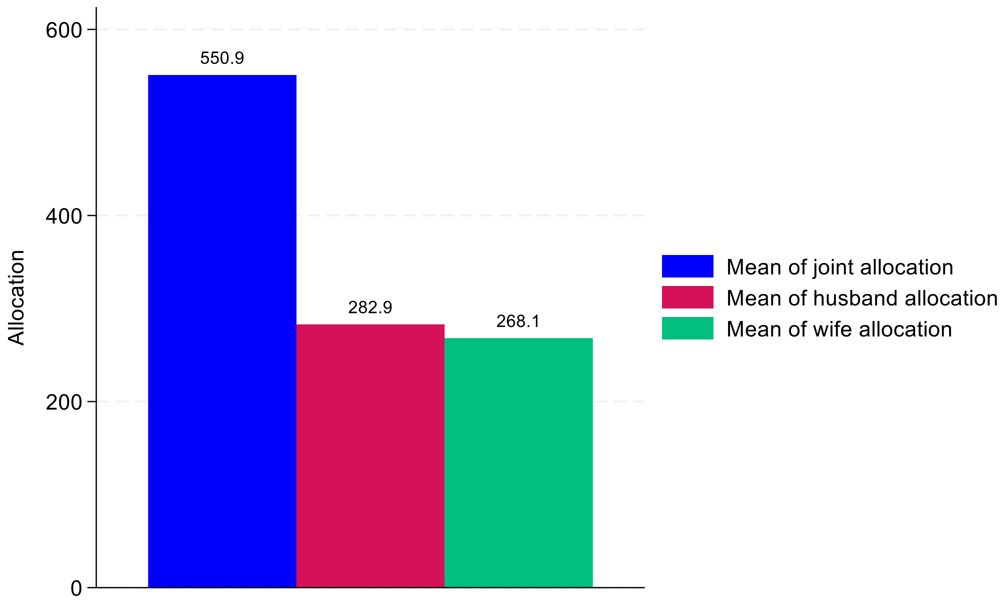


Figure 2. Husband, wife, and joint allocation to the household account in FCFA

Source: Authors' calculation from field data.

Figure 3 shows the percentage of households that adopt different technologies between spouses that cooperate and those that do not. For all technologies considered, spouses that cooperate tend to adopt more.

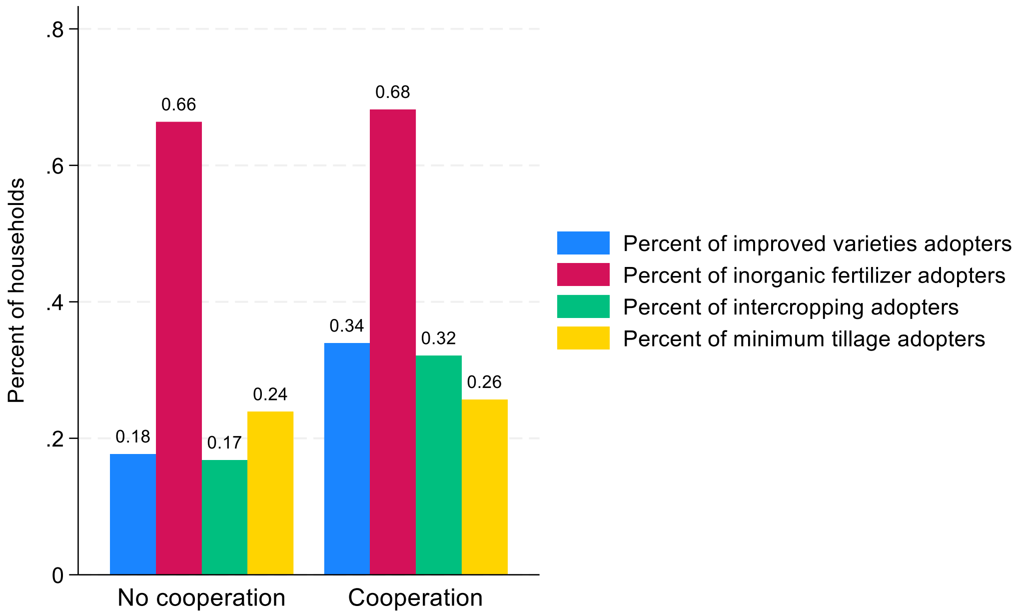


Figure 3. Technology adoption rates by cooperation status

Source: Authors' calculation from field data.

4.2 Associations between spousal cooperation and technology adoption

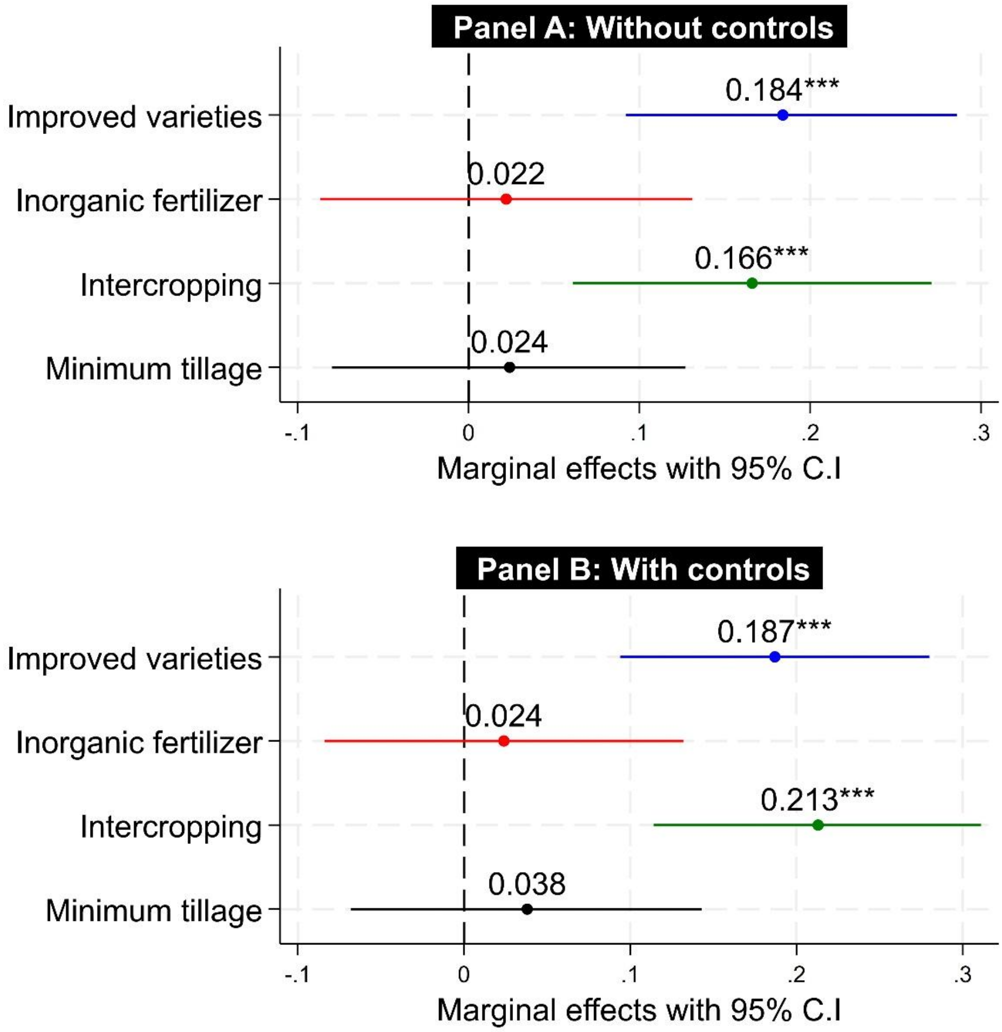
In this section, we present the MVP model results of cooperation on joint adoption of technologies. We present the results where we treat spousal cooperation as a dummy in Figure 4 using the matched sample (the full results are available in the appendix as Table A1). As robustness checks, we present MVP results where use the cooperation index for the matched sample (results available in the appendix as Table A2). We also present results where we use the cooperation dummy and index for the unmatched sample with all 440 observations (the results which are very similar, are available in the appendix as Tables A3 and A4, respectively). The likelihood ratio test ($p<0.0000$) under Figure 4 suggests that the errors are correlated, supporting the use of an MVP model instead of independent probit models. Since we do not address the endogeneity of spousal cooperation, we interpret our estimates as associations.

We present the results without and with controls, but interpret only the results with controls. The results suggest that even after controlling for different spousal and household characteristics, spousal cooperation is positively associated with the adoption of the different technologies, although only the coefficients of improved varieties and intercropping are statistically significant. Specifically, spousal cooperation measured with the cooperation dummy is associated with 18.7 percentage points higher likelihood of adopting improved seed varieties. This represents about a 63% increase relative to the mean adoption rate. The finding is in line with Lecoutere & Van Campenhout (2023) who find positive mediation effects of cooperation between participatory decision-making and adoption of improved varieties. More broadly, our findings fit within the broader literature that shows that intra-household factors are also important drivers of agricultural technologies like improved wheat and potato varieties (Euler et al., 2024; Gilligan et al., 2020).

The positive association between spousal cooperation and the adoption of improved varieties is in line with our expectations that cooperation may have allowed households to pool income, reducing the liquidity constraints that usually stifle the adoption of such technologies. Owing to more pooled income, households could then access improved varieties. Improved varieties may directly lead to higher yields but farmers mostly access improved varieties commercially, highlighting the important role of reducing liquidity constraints. Also, it is possible that through cooperation, women do not lose control of income or decision-making power after adopting such technologies.

However, we find no statistically significant association between cooperation and adoption of inorganic fertilizer. Perhaps, the coefficients are not significant because inorganic fertilizers are already widely adopted in the area with an adoption rate of about 70% among the sampled households. Also, unlike improved seeds, inorganic fertilizers can easily be substituted with organic fertilizers, hence farmers may rather invest in improved seeds. In the study area, households also raise animals, which may act as a source of organic fertilizer.

Spousal cooperation is also associated with 21.3 percentage points higher likelihood of adopting intercropping. This represents about a 75% increase relative to the mean adoption rate. This is also in line with our expectations. As hypothesized, cooperation may have allowed households to pool labour, reducing the labour constraints associated with the adoption of this technology for the planting and management of different crops. Also, cooperation may have allowed spouses to pool income and hire additional labour, further reducing labour constraints. Similarly, Lecoutere & Van Campenhout (2023) found that cooperation also has positive mediation effects between participatory decision and adoption of agronomic farm practices among coffee farmers. However, we find no association between cooperation and minimum tillage. A plausible explanation is that with limited labour, spouses may rather allocate their labour to a technology that yields immediate benefits, in this case, intercropping.



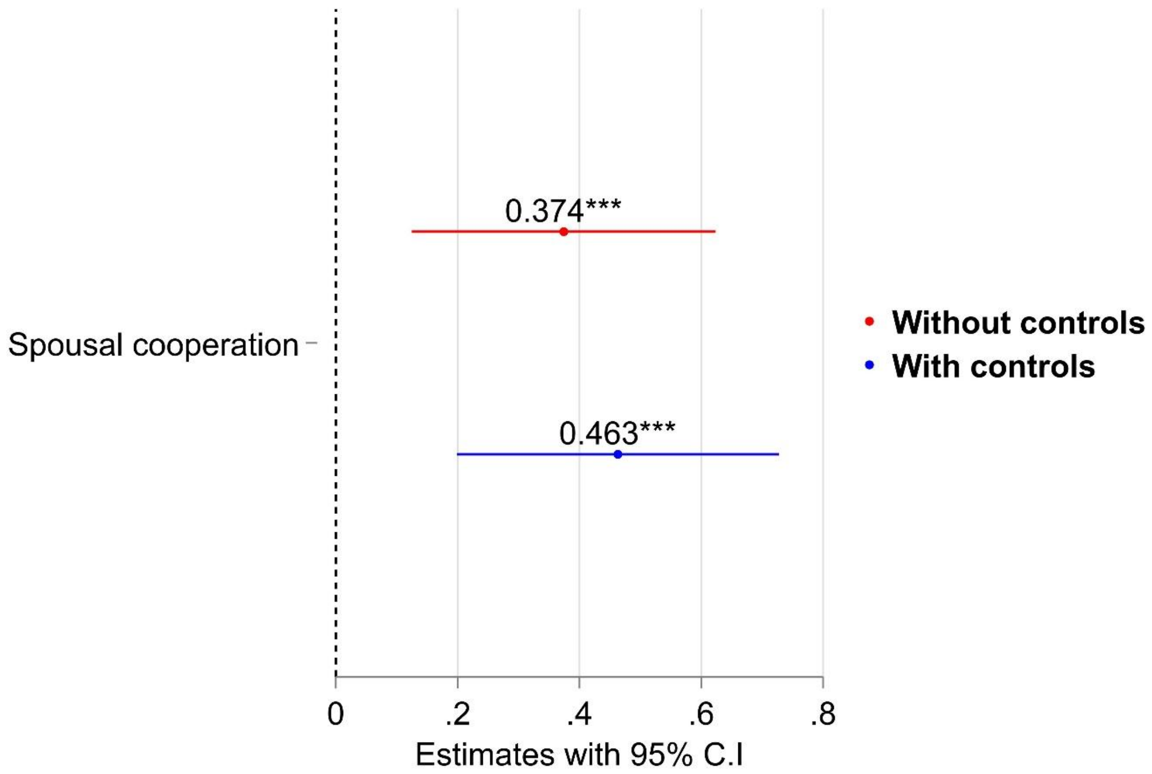
*** p<0.01, ** p<0.05, * p<0.1

Figure 4. Associations between spousal cooperation (dummy) and adoption of technologies based on the matched sample.

Note: Full results available in the appendix as Table A1.

Now we turn to the number of technologies adopted. Figure 5 shows associations between spousal cooperation and the number of technologies adopted without and with controls based on the matched sample (full results are available in the appendix as Table A5). As robustness checks, we obtain similar results when we use the cooperation index on the matched sample (results available in the appendix as Table A5). We also obtain similar results when we use the cooperation dummy and index for the unmatched sample (results available in the appendix as Table A6). Lastly, we obtain similar results with the Poisson estimator on the matched sample (the results are available as Table A7).

Focusing on the results with controls, we find positive associations suggesting that spousal cooperation promotes the adoption of multiple technologies. Specifically, cooperation is associated with the adoption of 0.46 additional technologies. This further confirms the role of cooperation in simultaneously reducing different constraints, hence promoting the adoption of multiple technologies.



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

Figure 5. Associations between spousal cooperation and the number of technologies adopted.

Note: Full results available in the appendix as Table A5.

4.3. Potential complementarity and substitutability.

Given that we hypothesized that these technologies are adopted simultaneously as a bundle, we also check the correlation coefficients to confirm if the technologies are substitutes or complements. Positive correlation coefficients imply that the technologies are complements while negative coefficients imply that they are substitutes. Table 3 presents the correlation matrix where we use cooperation as a dummy[3]. We find that most of the correlation coefficients are positive and statistically significant. Specifically, there is a positive correlation between improved varieties and inorganic fertilizer, in line with the findings of Wainaina et al. (2016) and Kassie et al. (2015). We also find positive correlations between improved varieties and intercropping, and improved varieties and minimum tillage similar to what was observed in Kenya by Kassie et al. (2015). This suggests that the technologies are complements and hence, farmers adopt them as a bundle. Although the correlation coefficient between inorganic fertilizer and intercropping is negative, it is not statistically significant. Cognizant of the fertilization benefit of intercropping, farmers who intercrop may thus choose not to apply inorganic fertilizer, relying on the legume intercrop as a source of fertilizer. The correlation coefficient between intercropping and minimum tillage is negative, but also not statistically significant.

Table 3. Correlation matrix between technologies

Variables	Improved varieties	Inorganic fertilizer	Intercropping	Minimum tillage
Improved varieties	1	0.273***	0.250***	0.407***
		(0.082)	(0.095)	(0.105)
Inorganic fertilizer		1	-0.095	0.261***
			(0.088)	(0.071)
Intercropping			1	-0.065
				(0.081)
Minimum tillage				1

5. Conclusion and policy implications

Although modern agricultural technologies are crucial for improving the welfare of smallholders and contributing to sustainable development, their adoption remains low, especially in Africa. While different factors have been identified as constraints to adoption, the role of intra-household factors such as spousal cooperation has been overlooked. This study addresses this gap by analysing the role of spousal cooperation as a driver of technology adoption. We combine survey and experimental data and employ multivariate probit models

[3] The results are similar when we use the cooperation index. For brevity purposes, we do not report the correlation matrix where we use the cooperation index here.

to capture the simultaneous adoption of technologies. We also employ OLS models to estimate the relationship between cooperation and the number of technologies adopted. The findings suggest that spousal cooperation is positively associated with the adoption of improved varieties and intercropping. We also find that cooperation is positively associated with the number of technologies adopted. We finally show that most of the technologies are complements and thus are jointly adopted by farmers.

Our findings offer a few implications. First, promoting spousal cooperation could serve as a key leverage point to boost adoption of modern technologies. Programmes that aim at promoting technology adoption should look beyond farm, farmer, institutional, and environmental factors as main drivers of technology adoption. Attention should also be given to intra-household factors such as spousal cooperation, which could address different kinds of constraints, particularly income and labour constraints as well as maintain or enhance women's decision-making power and income control, and thus promote the adoption of different but inter-related technologies. Although cooperation has been shown to improve different household outcomes, promoting it as a driver of technology adoption could further improve its benefits as adoption of modern technologies have been shown to improve farmers' welfare. Policies and programmes should actively involve both spouses in agricultural training and extension activities to ensure that decision-making, knowledge, and skills are shared within the household. Organizing workshops and trainings on the importance of cooperation as well as joint management and ownership of resources are other potential ways of promoting cooperation. However, there is need for further research on other means of boosting cooperation.

We end by highlighting some limitations. The first is the internal validity of our findings. We interpret our estimates as associations due to the potential endogeneity of spousal cooperation. Future studies with more robust designs could improve on causal identification and make more definitive causal statements about the relationship between cooperation and technology adoption. Second is the external validity of our findings. We focus only on a small area in Cameroon. Although the intra-household and agricultural settings of the area are more or less similar to some other regions in the country, we are still cautious in making any generalizations. Moreover, adoption of technologies has been shown to be context-specific. Hence, it is not clear if the observed relationship between cooperation and adoption would be the same in other settings. Future studies with wider geographical coverage will be instructive in expanding the external validity. These limitations notwithstanding, our study speaks to the important role intra-household factors such as cooperation could play in the adoption of different modern technologies.

References

Amankwah, A., & Gwatidzo, T. (2024). Food security and poverty reduction effects of agricultural technologies adoption − a multinomial endogenous switching regression application in rural Zimbabwe. *Food Policy*, *125*, 102629. https://doi.org/10.1016/j.foodpol.2024.102629

Barr, A., Dekker, M., Janssens, W., Kebede, B., & Kramer, B. (2019). Cooperation in polygynous households. *American Economic Journal: Applied Economics*, *11*(2), 266–283. https://doi.org/10.1257/app.20170438

Bello, L. O., Awotide, B. A., & Sakurai, T. (2024). Climate change adaptation and smallholder farmers welfare: Empirical evidence from the Sahelian Region of West Africa. *Land Use Policy*, *142*, 107181. https://doi.org/10.1016/j.landusepol.2024.107181

Bjorvatn, K., Getahun, T. D., & Halvorsen, S. K. (2020). Conflict or cooperation? Experimental evidence on intra-household allocations in Ethiopia. *Journal of Behavioral and Experimental Economics*, *85*, 101508. https://doi.org/10.1016/j.socec.2019.101508

Bryan, E., Alvi, M., Huyer, S., & Ringler, C. (2024). Addressing gender inequalities and strengthening women’s agency to create more climate-resilient and sustainable food systems. *Global Food Security*, *40*, 100731. https://doi.org/10.1016/j.gfs.2023.100731

Doss, C. R., & Meinzen-Dick, R. (2015). Collective action within the household: Insights from natural resource management. *World Development*, *74*, 171–183. https://doi.org/10.1016/j.worlddev.2015.05.001

Doss, C. R., & Quisumbing, A. R. (2020). Understanding rural household behavior: Beyond Boserup and Becker. *Agricultural Economics*, *51*(1), 47–58. https://doi.org/10.1111/agec.12540

Euler, M., Jaleta, M., & Gartaula, H. (2024). Associations between women’s bargaining power and the adoption of rust-resistant wheat varieties in Ethiopia. *World Development*, *178*, 106567. https://doi.org/10.1016/j.worlddev.2024.106567

Fischer, E., & Qaim, M. (2012). Gender, agricultural commercialization, and collective action in Kenya. *Food Security*, *4*(3), 441–453. https://doi.org/10.1007/s12571-012-0199-7

Fosso, P. K., & Nanfosso, R. T. (2016). Adoption of agricultural innovations in risky environment: The case of corn producers in the west of Cameroon. *Review of*

Agricultural, Food and Environmental Studies, *97*(1), 51–62. https://doi.org/10.1007/s41130-016-0008-3

Geffersa, A. G., Agbola, F. W., & Mahmood, A. (2022). Improved maize adoption and impacts on farm household welfare: Evidence from rural Ethiopia. *Australian Journal of Agricultural and Resource Economics*, *66*(4), 860–886. https://doi.org/10.1111/1467-8489.12489

Gichungi, H., Muriithi, B., Irungu, P., Diiro, G., & Busienei, J. (2021). Effect of technological innovation on gender roles: The case of fruit fly IPM adoption on women's decision-making in mango production and marketing in Kenya. *The European Journal of Development Research*, *33*(3), 407–426. https://doi.org/10.1057/s41287-020-00282-z

Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. *Field Crops Research*, *114*(1), 23–34. https://doi.org/10.1016/j.fcr.2009.06.017

Gilligan, D. O., Kumar, N., McNiven, S., Meenakshi, J. V., & Quisumbing, A. (2020). Bargaining power, decision making, and biofortification: The role of gender in adoption of orange sweet potato in Uganda. *Food Policy*, *95*, 101909. https://doi.org/10.1016/j.foodpol.2020.101909

Grabowski, P. P., Kerr, J. M., Haggblade, S., & Kabwe, S. (2016). Determinants of adoption and disadoption of minimum tillage by cotton farmers in eastern Zambia. *Agriculture, Ecosystems & Environment*, *231*, 54–67. https://doi.org/10.1016/j.agee.2016.06.027

Gürdal, M. Y., Gürerk, Ö., Kaçamak, Y., & Kart, E. (2024). How to increase and sustain cooperation in public goods games: Conditional commitments via a mediator. *Journal of Economic Behavior & Organization*, *228*, 106789. https://doi.org/10.1016/j.jebo.2024.106789

Guye, A., Tefera, T., Sileshi, M., & Edriss, A.-K. (2025). Impact of multiple maize technology package adoption on the production efficiency and food security of smallholder farmers in Ethiopia: Evidence from the Sidama region. *Heliyon*, *11*(1), e41280. https://doi.org/10.1016/j.heliyon.2024.e41280

Hoel, J. B., Hidrobo, M., Bernard, T., & Ashour, M. (2021). What do intra-household experiments measure? Evidence from the lab and field. *Journal of Economic Behavior & Organization*, *188*, 337–350. https://doi.org/10.1016/j.jebo.2021.05.019

Issahaku, G., & Abdulai, A. (2020). Adoption of climate-smart practices and its impact on farm performance and risk exposure among smallholder farmers in Ghana. *Australian Journal of Agricultural and Resource Economics*, *64*(2), 396–420. https://doi.org/10.1111/1467-8489.12357

Kahsay, G. A., & Endalew, Y. G. (2025). The role of cooperatives in promoting climate-smart agriculture: Panel evidence From Ethiopia. *Agricultural Economics*, *56*(4), 637–665. https://doi.org/10.1111/agec.70011

Kassie, M., Teklewold, H., Jaleta, M., Marenya, P., & Erenstein, O. (2015). Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy*, *42*, 400–411. https://doi.org/10.1016/j.landusepol.2014.08.016

Kebede, B., Tarazona, M., Munro, A., & Verschoor, A. (2014). Intra-household efficiency: An experimental study from Ethiopia. *Journal of African Economies*, *23*(1), 105–150. https://doi.org/10.1093/jae/ejt019

Kieran, C., Sproule, K., Doss, C., Quisumbing, A., & Kim, S. M. (2015). Examining gender inequalities in land rights indicators in Asia. *Agricultural Economics*, *46*(S1), 119–138. https://doi.org/10.1111/agec.12202

Kotir, J. H., Bell, L. W., Kirkegaard, J. A., Whish, J., & Aikins, K. A. (2022). Labour demand – The forgotten input influencing the execution and adoptability of alternative cropping systems in Eastern Australia. *Agricultural Systems*, *203*, 103516. https://doi.org/10.1016/j.agsy.2022.103516

Lambrecht, I., Vanlauwe, B., & Maertens, M. (2016). Agricultural extension in Eastern Democratic Republic of Congo: Does gender matter? *European Review of Agricultural Economics*, *43*(5), 841–874. https://doi.org/10.1093/erae/jbv039

Lecoutere, E., & Jassogne, L. (2019). Fairness and efficiency in smallholder farming: The relation with Intrahousehold decision-making. *The Journal of Development Studies*, *55*(1), 57–82. https://doi.org/10.1080/00220388.2017.1400014

Lecoutere, E., & Van Campenhout, B. (2023). Joint forces: The impact of intrahousehold cooperation on welfare in East African agricultural households. *Feminist Economics*, *29*(1), 266–297. https://doi.org/10.1080/13545701.2022.2120206

Lele, U., & Goswami, S. (2017). The fourth industrial revolution, agricultural and rural innovation, and implications for public policy and investments: a case of India. *Agricultural Economics*, *48*(S1), 87-100.

Malabayabas, M. L. L., Mishra, A. K., & Pede, V. O. (2023). Joint decision-making, technology adoption and food security: Evidence from rice varieties in eastern India. *World Development*, *171*, 106367. https://doi.org/10.1016/j.worlddev.2023.106367

Mehraban, N., Debela, B. L., Kalsum, U., & Qaim, M. (2022). What about her? Oil palm cultivation and intra-household gender roles. *Food Policy*, *110*, 102276. https://doi.org/10.1016/j.foodpol.2022.102276

Mozumder, P., & Berrens, R. P. (2007). Inorganic fertilizer use and biodiversity risk: An empirical investigation. *Ecological Economics*, *62*(3–4), 538–543. https://doi.org/10.1016/j.ecolecon.2006.07.016

Naudin, K., Gozé, E., Balarabe, O., Giller, K. E., & Scopel, E. (2010). Impact of no tillage and mulching practices on cotton production in North Cameroon: A multi-locational on-farm assessment. *Soil and Tillage Research*, *108*(1–2), 68–76. https://doi.org/10.1016/j.still.2010.03.002

Nchanji, Y. K., Nkongho, R. N., Mala, W. A., & Levang, P. (2016). Efficacy of oil palm intercropping by smallholders. Case study in South-West Cameroon. *Agroforestry Systems*, *90*(3), 509–519. https://doi.org/10.1007/s10457-015-9873-z

Ndiritu, S. W., Kassie, M., & Shiferaw, B. (2014). Are there systematic gender differences in the adoption of sustainable agricultural intensification practices? Evidence from Kenya. *Food Policy*, *49*, 117–127. https://doi.org/10.1016/j.foodpol.2014.06.010

Ngoma, H. (2018). Does minimum tillage improve the livelihood outcomes of smallholder farmers in Zambia? *Food Security*, *10*(2), 381–396. https://doi.org/10.1007/s12571-018-0777-4

Pan, Y., Smith, S. C., & Sulaiman, M. (2018). Agricultural extension and technology adoption for food security: Evidence from Uganda. *American Journal of Agricultural Economics*, *100*(4), 1012–1031. https://doi.org/10.1093/ajae/aay012

Soh Wenda, B. D., Fon, D. E., Molua, E. L., & Longang, S. G. (2024). Women, income use and nutrition quality: Effects of women's decision-making in rural households in Cameroon. *Agriculture & Food Security*, *13*(1), 29. https://doi.org/10.1186/s40066-024-00480-6

Suri, T., & Udry, C. (2022). Agricultural technology in Africa. *Journal of Economic Perspectives*, *36*(1), 33–56. https://doi.org/10.1257/jep.36.1.33

Tabe-Ojong, M. P. Jr., Aihounton, G. B. D., & Lokossou, J. C. (2023). "Climate-smart agriculture and food security: Cross-country evidence from West Africa." *Global Environmental Change*, *81*, 102697. https://doi.org/10.1016/j.gloenvcha.2023.102697

Takam-Fongang, G. M., Kamdem, C. B., & Kane, G. Q. (2019). Adoption and impact of improved maize varieties on maize yields: Evidence from central Cameroon. *Review of Development Economics*, *23*(1), 172–188. https://doi.org/10.1111/rode.12561

Teklewold, H. (2023). Understanding gender differences on the choices of a portfolio of climate-smart agricultural practices in sub-saharan Africa. *World Development Perspectives*, *29*, 100486. https://doi.org/10.1016/j.wdp.2023.100486

Teklewold, H., Kassie, M., & Shiferaw, B. (2013). Adoption of multiple sustainable agricultural practices in rural Ethiopia. *Journal of Agricultural Economics*, *64*(3), 597–623. https://doi.org/10.1111/1477-9552.12011

Teklewold, H., Kassie, M., Shiferaw, B., & Köhlin, G. (2013). Cropping system diversification, conservation tillage and modern seed adoption in Ethiopia: Impacts on household income, agrochemical use and demand for labor. *Ecological Economics*, *93*, 85–93. https://doi.org/10.1016/j.ecolecon.2013.05.002

Thierfelder, C., Chivenge, P., Mupangwa, W., Rosenstock, T. S., Lamanna, C., & Eyre, J. X. (2017). How climate-smart is conservation agriculture (CA)? – Its potential to deliver on adaptation, mitigation and productivity on smallholder farms in southern Africa. *Food Security*, *9*(3), 537–560. https://doi.org/10.1007/s12571-017-0665-3

Thierfelder, C., Mhlanga, B., Nyagumbo, I., Kalala, K., Simutowe, E., Chiduwa, M., MacLaren, C., Silva, J. V., & Ngoma, H. (2024). Two crops are better than one for nutritional and economic outcomes of Zambian smallholder farms, but require more labour. *Agriculture, Ecosystems & Environment*, *361*, 108819. https://doi.org/10.1016/j.agee.2023.108819

Tsambou, A. D., & Tagang Tene, N. S. (2024). Adoption of innovation and farm productivity in the Sudano-Saharan zone in Cameroon. *Cogent Social Sciences*, *10*(1), 2282419. https://doi.org/10.1080/23311886.2023.2282419

Tshikala, S. K., Kostandini, G., & Fonsah, E. G. (2019). The impact of migration, remittances and public transfers on technology adoption: The case of cereal producers in rural Kenya.

Journal of Agricultural Economics, *70*(2), 316–331. https://doi.org/10.1111/1477-9552.12295

Van Campenhout, B., Lecoutere, E., & Spielman, D. J. (2023). Hiding or pleasing: Spousal disagreement among Ugandan maize farmers. *The Journal of Development Studies*, *59*(1), 39–57. https://doi.org/10.1080/00220388.2022.2113065

Wainaina, P., Tongruksawattana, S., & Qaim, M. (2016). Tradeoffs and complementarities in the adoption of improved seeds, fertilizer, and natural resource management technologies in Kenya. *Agricultural Economics*, *47*(3), 351–362. https://doi.org/10.1111/agec.12235

Wainaina, P., Tongruksawattana, S., & Qaim, M. (2018). Synergies between Different Types of Agricultural Technologies in the Kenyan Small Farm Sector. *The Journal of Development Studies*, *54*(11), 1974–1990. https://doi.org/10.1080/00220388.2017.1342818

Wang, Z.-G., Jin, X., Bao, X.-G., Li, X.-F., Zhao, J.-H., Sun, J.-H., Christie, P., & Li, L. (2014). Intercropping enhances productivity and maintains the most soil fertility properties relative to sole cropping. *PLoS ONE*, *9*(12), e113984. https://doi.org/10.1371/journal.pone.0113984

Wato, T., Negash, T., Andualem, A., & Bitew, A. (2024). Significance of organic and inorganic fertilizers in maintaining soil fertility and increasing crop productivity in Ethiopia: A review. *Environmental Research Communications*, *6*(10), 102002. https://doi.org/10.1088/2515-7620/ad79be

Wenda, B. D. S., Njoya, H. M., Awoke, M. D., Kimaro, P. E., Sieber, S., & Löhr, K. (2025). Integrated soil fertility management for sustainable food security: Evidence from Cameroon. *Food and Energy Security*, *14*(5), e70145. https://doi.org/10.1002/fes3.70145

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2. ed). MIT Press.

Wordofa, M. G., Hassen, J. Y., Endris, G. S., Aweke, C. S., Moges, D. K., & Rorisa, D. T. (2021). Adoption of improved agricultural technology and its impact on household income: A propensity score matching estimation in eastern Ethiopia. *Agriculture & Food Security*, *10*(1). https://doi.org/10.1186/s40066-020-00278-2

Wossen, T., Abdoulaye, T., Alene, A., Haile, M. G., Feleke, S., Olanrewaju, A., & Manyong, V. (2017). Impacts of extension access and cooperative membership on technology adoption and household welfare. *Journal of Rural Studies*, *54*, 223–233. https://doi.org/10.1016/j.jrurstud.2017.06.022

Appendix

Table A1. Full MVP results of spousal cooperation (dummy) on adoption of technologies based on matched sample

	Improved varieties		Inorganic fertilizer		Intercropping		Minimum tillage	
Variables	Coef	M.E	Coef	M.E	Coef	M.E	Coef	M.E
Spousal cooperation (dummy)	0.670***	0.187***	0.070	0.024	0.702***	0.213***	0.130	0.038
	(0.170)		(0.162)		(0.166)		(0.184)	
Age husband	0.183***	0.051***	-0.087*	-0.031*	0.113**	0.034**	0.155**	0.045**
	(0.060)		(0.049)		(0.052)		(0.061)	
Age husband squared	-0.002***	-5.00E-04***	0.001	1.00E-04	-0.001**	-3.00E-04**	-0.002***	-4.00E-04**
	(0.001)		(1.00E-04)		(3.00E-04)		(0.001)	
Age wife	-0.032	-0.009	0.066	0.023	-0.167**	-0.051**	-0.029	-0.009
	(0.041)		(0.055)		(0.067)		(0.069)	
Age wife squared	1.00E-04	1.00E-04	-1.00E-04	-1.00E-04	0.002**	0.001	1.00E-04	1.00E-04
	(3.00E-04)		(0.001)		(0.001)		(0.001)	
Education husband	0.007	0.002	-0.018	-0.006	0.014	0.004	-0.01	-0.003
	(0.019)		(0.022)		(0.019)		(0.020)	
Education wife	0.005	0.001	0.034	0.012	-0.04	-0.012	-0.02	-0.006
	(0.025)		(0.021)		(0.027)		(0.018)	
Off-farm work husband	0.212	0.059	0.067	0.023	0.136	0.041	0.28	0.082
	(0.192)		(0.202)		(0.238)		(0.198)	
Off-farm work wife	-0.122	-0.034	-0.035	-0.012	0.243	0.074	-0.174	-0.051
	(0.175)		(0.183)		(0.182)		(0.151)	
Extension access husband	0.707***	0.197***	-0.229	-0.078	0.193	0.058	0.584*	0.171*
	(0.274)		(0.352)		(0.345)		(0.322)	
Extension access wife	0.392	0.109	1.00E-04	1.00E-04	0.443	0.134	0.477	0.139
	(0.532)		(0.522)		(0.598)		(0.536)	
Cooperative membership husband	0.559**	0.156**	0.968***	0.329***	-0.349*	-0.106*	-0.46	-0.134
	(0.272)		(0.338)		(0.194)		(0.337)	
Cooperative membership wife	1.129**	0.315**	-0.176	-0.061	0.944**	0.286**	0.524	0.153
	(0.477)		(0.505)		(0.369)		(0.561)	
Household size	0.02	0.005	0.146***	0.051***	0.051	0.015	-0.015	-0.004
	(0.050)		(0.041)		(0.076)		(0.065)	
Asset value	4.00E-04	1.00E-04	1.00E-04	1.00E-04	-0.001*	-0.003*	1.00E-04	1.00E-04
	(5.00E-04)		(0.001)		(0.001)		5.00E-04	
Livestock production	0.191	0.053	-0.2	-0.068	0.252	0.076	0.222	0.065
	(0.173)		(0.184)		(0.187)		(0.190)	

	Improved varieties		Inorganic fertilizer		Intercropping		Minimum tillage	
Variables	Coef	M.E	Coef	M.E	Coef	M.E	Coef	M.E
Remittance	0.965***	0.269***	0.084	0.029	-0.824***	-0.251***	0.477*	0.139*
	(0.251)		(0.252)		(0.309)		(0.259)	
Number of plots	0.168	0.047	0.061	0.021	0.311***	0.094***	-0.089	0.026
	(0.108)		(0.092)		(0.117)		(0.112)	
Observations	432		432		432		432	

Robust standard errors in parentheses clustered at village level. *** p<0.01, ** p<0.05, * p<0.1. Likelihood ratio test of rho chi2(6) = 42.8598 Prob > chi2 = 0.0000

Table A2. Full MVP results of spousal cooperation (index) on adoption of technologies based on matched sample

	Improved varieties		Inorganic fertilizer		Intercropping		Minimum tillage	
Variables	Coef	M.E	Coef	M.E	Coef	M.E	Coef	M.E
Spousal cooperation (index)	1.348***	0.378***	0.472	0.160	1.312***	0.402***	0.414	0.121
	(0.521)		(0.315)		(0.188)		(0.424)	
Age husband	0.176***	0.049***	-0.087*	-0.029*	0.111**	0.034**	0.153**	0.045**
	(0.061)		(0.049)		(0.051)		(0.060)	
Age husband squared	-0.002***	-5.00E-04***	1.00E-04	1.00E-04	-0.001**	-3.00E-04**	-0.001***	-4.00E-04***
	(0.001)		(4.00E-04)		0.001		(0.001)	
Age wife	-0.028	-0.008	0.067	0.023	-0.166**	-0.051**	-0.028	-0.008
	(0.040)		(0.055)		(0.065)		(0.069)	
Age wife squared	1.00E-04	1.00E-04	2.00E-04	-1.00E-04	0.002**	1.00E-04**	4.00E-04	1.00E-04
	(3.00E-04)		(0.001)		(0.001)		(0.001)	
Education husband	0.008	0.002	-0.02	-0.007	0.017	0.005	-0.011	-0.003
	(0.019)		(0.022)		(0.019)		(0.021)	
Education wife	0.009	0.002	0.033	0.011	-0.036	-0.011	-0.02	-0.006
	(0.023)		(0.022)		(0.026)		(0.019)	
Off-farm work husband	0.226	0.063	0.076	0.026	0.159	0.049	0.289	0.084
	(0.197)		(0.199)		(0.232)		(0.207)	
Off-farm work wife	-0.138	-0.039	-0.027	-0.009	0.21	0.589	-0.174	-0.051
	(0.172)		(0.181)		(0.175)		(0.151)	
Extension access husband	0.733***	0.206***	-0.235	-0.081	0.222	0.068	0.581*	0.171*
	(0.275)		(0.348)		(0.368)		(0.328)	
Extension access wife	0.304	0.085	-0.016	-0.005	0.355	0.109	0.459	0.134
	(0.503)		(0.513)		(0.584)		(0.536)	
Cooperative membership husband	0.539*	0.151*	0.952***	0.323***	-0.382*	-0.117*	-0.47	-0.137
	(0.281)		(0.331)		(0.205)		(0.335)	
Cooperative membership wife	1.053**	0.295**	-0.158	-0.053	0.785**	0.241**	0.517	0.151
	(0.451)		(0.504)		(0.365)		(0.559)	
Household size	0.02	0.006	0.147***	0.049***	0.053	0.016	-0.016	-0.005
	(0.051)		(0.041)		(0.079)		(0.065)	
Asset value	1.00E-04	1.00E-04	2.00E-04	1.00E-05	-0.001*	-3.00E-04*	1.00E-04	0.0001
	(2.00E-04)		(0.001)		(0.001)		3.00E-04	
Livestock production	0.219	0.061	-0.203	-0.069	0.271	0.083	0.228	0.067
	(0.183)		(0.183)		(0.177)		(0.189)	
Remittance	0.928***	0.26***	0.083	0.028	-0.870***	-0.267***	0.472*	0.138*
	(0.258)		(0.248)		(0.307)		(0.256)	

	Improved varieties		Inorganic fertilizer		Intercropping		Minimum tillage	
Variables	Coef	M.E	Coef	M.E	Coef	M.E	Coef	M.E
Number of plots	0.156	0.045	0.07	0.023	0.301***	0.092***	-0.087	-0.025
	(0.110)		(0.097)		(0.116)		(0.111)	
Observations	432		432		432		432	

Robust standard errors in parentheses clustered at village level. *** p<0.01, ** p<0.05, * p<0.1. Likelihood ratio test of rho chi2(6) = 43.8713 Prob > chi2 = 0.0000

Table A3. Full MVP results of spousal cooperation (dummy) on adoption based on unmatched sample

	Improved varieties		Inorganic fertilizer		Intercropping		Minimum tillage	
Variables	Coef	M.E	Coef	M.E	Coef	M.E	Coef	M.E
Spousal cooperation (dummy)	0.678***	0.189***	0.084	0.029	0.727***	0.222***	0.114	0.034
	(0.171)		(0.160)		(0.167)		(0.180)	
Age husband	0.163***	0.045	-0.092*	-0.031	0.115**	0.035	0.171***	0.05
	(0.060)		(0.048)		(0.054)		(0.061)	
Age husband squared	-0.002***	-4.00E-04***	0.001	2.00E-04	-0.001**	-3.00E-04**	-0.002***	-5.00E-04***
	(0.001)		(1.00E-04)		(0.001)		(0.001)	
Age wife	-0.013	-0.003	0.069	0.023	-0.166**	-0.051**	-0.035	-0.01
	(0.046)		(0.053)		(0.069)		(0.069)	
Age wife squared	3.00E-05	2.00E-05	3.00E-04	-1.00E-04	0.002**	5.00E-04**	1.00E-04	1.00E-04
	(0.001)		(0.001)		(0.001)		(0.001)	
Education husband	0.004	0.001	-0.021	-0.007	0.016	0.005	0.001	3.00E-04
	(0.019)		(0.020)		(0.021)		(0.020)	
Education wife	0.001	3.00E-04	0.034	0.011	-0.039	-0.012	-0.023	-0.007
	(0.024)		(0.022)		(0.025)		(0.019)	
Off-farm work husband	0.209	0.058	0.065	0.022	0.124	0.038	0.288	0.085
	(0.193)		(0.200)		(0.237)		(0.189)	
Off-farm work wife	-0.148	-0.041	-0.03	-0.01	0.287	0.088	-0.18	-0.053
	(0.165)		(0.168)		(0.178)		(0.149)	
Extension access husband	0.634**	0.177**	-0.165	-0.056	0.135	0.041	0.524*	0.154*
	(0.247)		(0.351)		(0.335)		(0.312)	
Extension access wife	0.627	0.175	0.113	0.039	0.343	0.105	0.713	0.209
	(0.476)		(0.530)		(0.550)		(0.521)	
Cooperative membership husband	0.553**	0.154**	0.905***	0.308***	-0.342*	-0.105*	-0.43	-0.126
	(0.273)		(0.325)		(0.199)		(0.317)	
Cooperative membership wife	1.233**	0.343**	-0.107	-0.036	0.838**	0.256**	0.443	0.13
	(0.504)		(0.486)		(0.328)		(0.505)	
Household size	0.026	0.007	0.135***	0.046***	0.041	0.012	-0.004	-0.001
	(0.050)		(0.040)		(0.075)		(0.068)	
Asset value	0.001	1.00E-04	4.00E-04	4.00E-05	-0.001*	-3.00E-04*	1.00E-04	1.00E-04
	1.00E-04		(0.001)		1.00E-04		3.00E-04	
Livestock production	0.215	0.061	-0.197	-0.067	0.267	0.081	0.186	0.055
	(0.183)		(0.184)		(0.187)		(0.176)	

	Improved varieties		Inorganic fertilizer		Intercropping		Minimum tillage	
Variables	Coef	M.E	Coef	M.E	Coef	M.E	Coef	M.E
Remittance	0.944***	0.263***	0.101	0.034	-0.633**	-0.193**	0.523**	0.154**
	(0.262)		(0.253)		(0.255)		(0.259)	
Number of plots	0.173	0.048	0.061	0.021	0.318***	0.097	-0.084	-0.025
	(0.108)		(0.093)		(0.113)		(0.109)	
Observations	440		440		440		440	

Robust standard errors in parentheses clustered at village level. *** p<0.01, ** p<0.05, * p<0.1. Likelihood ratio test of rho chi2(6) = 50.2514 Prob > chi2 = 0.0000

Table A4. Full MVP results of spousal cooperation (index) on adoption of technologies based on unmatched sample

	Improved varieties		Inorganic fertilizer		Intercropping		Minimum tillage	
Variables	Coef	M.E	Coef	M.E	Coef	M.E	Coef	M.E
Spousal cooperation (index)	1.283**	0.360**	0.509	0.172	1.355***	0.418***	0.472	0.138
	(0.525)		(0.326)		(0.206)		(0.396)	
Age husband	0.154**	0.043**	-0.092*	-0.031*	0.110**	0.034**	0.167***	0.049***
	(0.060)		(0.049)		(0.052)		(0.060)	
Age husband squared	-0.001***	-4.00E-04***	0.001	2.00E-04	-0.001**	-3.00E-04**	-0.002***	-4.00E-04***
	(1.00E-04)		(1.00E-04)		(4.00E-04)		(0.001)	
Age wife	-0.007	-0.002	0.071	0.024	-0.162**	-0.049**	-0.032	-0.009
	(0.047)		(0.053)		(0.067)		(0.068)	
Age wife squared	4.00E-04	4.97E-04	1.00E-04	1.00E-04	0.002**	5.00E-04**	1.00E-04	1.00E-04
	(0.001)		(0.001)		(0.001)		(0.001)	
Education husband	0.004	0.001	-0.023	-0.008	0.017	0.005	-0.001	-0.0003
	(0.018)		(0.021)		(0.020)		(0.020)	
Education wife	0.005	0.001	0.032	0.011	-0.035	-0.011	-0.023	-0.007
	(0.022)		(0.023)		(0.024)		(0.019)	
Off-farm work husband	0.219	0.062	0.074	0.025	0.147	0.045	0.296	0.087
	(0.197)		(0.197)		(0.232)		(0.196)	
Off-farm work wife	-0.16	-0.045	-0.022	-0.007	0.253	0.078	-0.176	-0.052
	(0.162)		(0.167)		(0.172)		(0.149)	
Extension access husband	0.653***	0.183***	-0.174	-0.059	0.152	0.047	0.52	0.153
	(0.244)		(0.348)		(0.363)		(0.322)	
Extension access wife	0.563	0.158	0.102	0.034	0.268	0.083	0.701	0.206
	(0.443)		(0.522)		(0.537)		(0.519)	
Cooperative membership husband	0.541*	0.152*	0.892***	0.302***	-0.368*	-0.113*	-0.445	-0.131
	(0.282)		(0.319)		(0.207)		(0.316)	
Cooperative membership wife	1.147**	0.322**	-0.083	-0.028	0.716**	0.221**	0.45	0.132
	(0.465)		(0.479)		(0.318)		(0.496)	
Household size	0.027	0.007	0.136***	0.046***	0.044	0.014	-0.003	-0.001
	(0.052)		(0.040)		(0.079)		(0.068)	
Asset value	0.001	1.00E-04	5.00E-04	4.00E-04	-0.001*	-3.00E-04	1.00E-04	1.00E-04
	(2.00E-04)		(0.001)		(0.001)		(3.00E-04)	
Livestock production	0.238	0.067	-0.203	-0.069	0.277	0.086	0.186	0.055
	(0.194)		(0.183)		(0.179)		(0.178)	

	Improved varieties		Inorganic fertilizer		Intercropping		Minimum tillage	
Variables	Coef	M.E	Coef	M.E	Coef	M.E	Coef	M.E
Remittance	0.907***	0.255***	0.097	0.033	-0.706***	-0.218***	0.518**	0.152**
	(0.266)		(0.247)		(0.253)		(0.257)	
Number of plots	0.16	0.045	0.069	0.023	0.310***	0.096***	-0.079	-0.023
	(0.110)		(0.098)		(0.112)		(0.109)	
Observations	440		440		440		440	

Robust standard errors in parentheses clustered at village level. *** p<0.01, ** p<0.05, * p<0.1. Likelihood ratio test of rho chi2(6) = 50.6679 Prob > chi2 = 0.0000

Table A5. Full OLS results of spousal cooperation on the number of technologies adopted based on matched sample.

	Number of technologies	
Variables	(1)	(2)
Spousal cooperation (dummy)	0.463***	
	(0.130)	
Spousal cooperation (index)		1.033***
		(0.281)
Age husband	0.058**	0.059**
	(0.028)	(0.028)
Age husband squared	-0.001***	-0.001***
	(0.000)	(0.000)
Age wife	-0.024	-0.026
	(0.043)	(0.042)
Age wife squared	0.000	0.000
	(0.000)	(0.000)
Education husband	-0.006	-0.005
	(0.014)	(0.014)
Education wife	-0.006	-0.003
	(0.014)	(0.012)
Off-farm work husband	0.219	0.235
	(0.144)	(0.142)
Off-farm work wife	-0.010	-0.032
	(0.114)	(0.109)
Extension access husband	0.380	0.392
	(0.251)	(0.256)
Extension access wife	0.414	0.364
	(0.534)	(0.506)
Cooperative membership husband	0.192	0.172
	(0.171)	(0.158)
Cooperative membership wife	0.781**	0.691**
	(0.326)	(0.307)
Household size	0.073*	0.073
	(0.041)	(0.044)
Asset value	0.000	0.000
	(0.000)	(0.000)
Livestock production	0.136	0.149
	(0.109)	(0.115)
Remittance	0.279	0.265*
	(0.167)	(0.155)
Number of plots	0.135*	0.130*
	(0.071)	(0.073)
Constant	-0.379	-0.641
	(0.545)	(0.613)
Observations	432	432
R-squared	0.130	0.126

Robust standard errors in parentheses clustered at village level. *** p<0.01, ** p<0.05, * p<0.1

Table A6. Full OLS results of spousal cooperation on the number of technologies adopted based on the unmatched sample

	Number of technologies	
Variables	(1)	(2)
Spousal cooperation (dummy)	0.462***	
	(0.127)	
Spousal cooperation (index)		1.042***
		(0.296)
Age husband	0.057*	0.057*
	(0.029)	(0.028)
Age husband squared	-0.001**	-0.001**
	(0.000)	(0.000)
Age wife	-0.023	-0.023
	(0.043)	(0.042)
Age wife squared	0.000	0.000
	(0.000)	(0.000)
Education husband	-0.005	-0.006
	(0.013)	(0.013)
Education wife	-0.008	-0.006
	(0.014)	(0.012)
Off-farm work husband	0.214	0.230
	(0.143)	(0.142)
Off-farm work wife	0.010	-0.011
	(0.107)	(0.104)
Extension access husband	0.326	0.328
	(0.244)	(0.251)
Extension access wife	0.484	0.451
	(0.478)	(0.451)
Cooperative membership husband	0.205	0.190
	(0.171)	(0.158)
Cooperative membership wife	0.785**	0.705**
	(0.302)	(0.285)
Household size	0.072*	0.073*
	(0.040)	(0.043)
Asset value	0.000	0.000
	(0.000)	(0.000)
Livestock production	0.130	0.138
	(0.102)	(0.111)
Remittance	0.342*	0.321*
	(0.183)	(0.167)
Number of plots	0.139*	0.136*
	(0.071)	(0.073)
Constant	-0.386	-0.632
	(0.562)	(0.636)
Observations	440	440
R-squared	0.134	0.132

Robust standard errors in parentheses clustered at village level. *** p<0.01, ** p<0.05, * p<0.1

Table A7. Poisson estimates of spousal cooperation on the number of technologies adopted.

	Number of technologies	
Variables	(1)	(2)
Spousal cooperation (dummy)	0.497***	
	(0.145)	
Spousal cooperation (index)		1.017***
		(0.271)
Age husband	0.077**	0.077**
	(0.035)	(0.034)
Age husband squared	-0.001***	-0.001***
	(0.000)	(0.000)
Age wife	-0.035	-0.037
	(0.045)	(0.044)
Age wife squared	0.001	0.001
	(0.000)	(0.000)
Education husband	-0.006	-0.006
	(0.014)	(0.014)
Education wife	-0.005	-0.000
	(0.013)	(0.012)
Off-farm work husband	0.216	0.232*
	(0.143)	(0.140)
Off-farm work wife	-0.006	-0.031
	(0.111)	(0.108)
Extension access husband	0.309*	0.312
	(0.186)	(0.197)
Extension access wife	0.350	0.299
	(0.368)	(0.338)
Cooperative membership husband	0.146	0.129
	(0.133)	(0.121)
Cooperative membership wife	0.615***	0.497**
	(0.220)	(0.200)
Household size	0.069*	0.068
	(0.039)	(0.042)
Asset value	0.000	0.000
	(0.000)	(0.000)
Livestock production	0.130	0.147
	(0.095)	(0.102)
Remittance	0.281**	0.271**
	(0.133)	(0.123)
Number of plots	0.130**	0.127*
	(0.064)	(0.067)
Observations	432	432

Robust standard errors in parentheses clustered at village level. *** p<0.01, ** p<0.05, * p<0.1. Reported values are marginal effects