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Farm Decision Making and Gender: Results from a Randomized Experiment in Ecuador

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Summary. — Substantial resources have been devoted to mitigating the asset gender gap in developing country agriculture. Efforts have been taken to understand the role of women in decision making and in farm operations. Recommendations for best practices in eliciting information on women's roles have emphasized the importance of sex-disaggregated data collection and analysis. Collection of sex-disaggregated data is not straightforward and careful attention to context is needed. In Ecuador's highlands, chemical use in agriculture is widespread, and outreach and training programs to reduce this use are essential. These programs should target the appropriate decision makers.

This paper presents results from a field experiment conducted in the Ecuador highlands where responding farm households are randomly assigned to one of three treatment groups: (i) a male respondent, (ii) a female respondent, and (iii) both adult male and female respondents (interviewed separately, but with knowledge that the other would also be interviewed). We assess whether treatment assignment affects responses to questions about decision making and responsibility for agricultural activities.

Perceptions about household decision making and who is responsible for agricultural activities vary substantially by type of respondent. Men are more likely to claim sole responsibility; women are more likely to claim responsibility or that decisions are jointly made. In households where both man and woman were interviewed (separately) we found stark differences in responses about responsibilities, with men claiming sole responsibility at higher rates. Interviewing both members led to less divergence in responses, but large differences in perceptions about responsibilities remain when both are interviewed. Best interviewing practices depend on the type of information needed: for precise quantification of gender roles, complex methods may be necessary, but where qualitative information is sufficient, single-member interviews may be sufficient.

Key words — household decision making, survey design, randomized control trial, integrated pest management, Ecuador

1. INTRODUCTION

It is now widely recognized that empowerment of women is an important pre-condition for broad-based agricultural growth. In addition to reproductive responsibilities including child rearing and early education, women provide as much as 50% of the agricultural workforce (Food & Agriculture Organization of the United Nations, 2011). Despite their obvious importance to agriculture, in many parts of the developing world women have less access than men to productive assets. The asset gender gap, which includes less access to land, inputs, labor, cash and credit, and training opportunities (human capital development), is associated with 20–30% lower productivity on women's fields and closing the asset gap could raise agricultural output globally by 2.5–4% (Food & Agriculture Organization of the United Nations, 2011). Women face unique obstacles to overcoming the asset gap; for example, lack of land title can constrain access to credit and lower levels of formal education can be compounded by less participation in extension meetings and agricultural training (Doss et al., 2011; Quisumbing et al., 2014).

Recognition of the gender asset gap has led to recommendations about best practices and how to ensure that women's roles and needs are adequately considered during program design and implementation (Alkire et al., 2012). While better understanding of gender dimensions of asset acquisition, accumulation, and use can lead to more effective programs, it is often sufficient to begin with an understanding of household decision making and gendered dimensions of farm operation (Quisumbing et al., 2014). This understanding will allow programs to target the appropriate recipients of training and other asset-building efforts. Research shows clearly, for example, that agricultural technology adoption is affected by gender-specific constraints (Meinzen-Dick et al., 2011) and that skills gaps between men and women might slow technology adoption (Quisumbing et al., 2014).

In Ecuador's highlands, chemical use in agriculture is widespread, and programs to reduce this use, such as through integrated pest management (IPM), are important to the sustainability of agriculture (Alwang et al., 2005, Chap. 5). Health problems have been associated with storage and application of toxic chemicals and over-application of pesticides leads to off-farm environmental damages (Crissman, Antle, & Capalbo, 1998; Sherwood, Cole, Crissman, & Paredes, 2005). IPM is a promising means of reducing pesticide use and promoting more sustainable agriculture (Carrión Yaguana, Alwang, Norton, & Barrera, 2016; Norton, Heinrichs, Luther, & Irwin, 2005; Yanggen, Cole, Crissman, & Sherwood, 2004). However, uptake of IPM has been slow and scarce outreach resources mean that IPM promotion programs need to be targeted to appropriate decision makers (Carrión Yaguana et al., 2016; Norton et al., 2005). IPM is

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a knowledge-intensive technology; for most IPM practices, few input purchases are needed as management know-how is substituted for chemical inputs (Norton et al., 2005). IPM training programs should be targeted based on the appropriate audience and the constraints they face.

Despite the recognition of the importance of gender roles and asset ownership, control and use, uneven guidance is provided in the literature about how to obtain this information. A recent overview of tools to quantify women's empowerment (Quisumbing et al., 2014) discusses quantitative (mostly survey-based) and qualitative methods such as key informant interviews, group interviews and focus group discussions. As a guidance for development program design, this overview recommends conducting a gender-focused analysis of asset ownership and household decision-making. A mixed method approach is recommended—one that combines quantitative and qualitative approaches. Qualitative methods provide nuanced information but depend critically on the skills of researchers to ensure quality (Quisumbing et al., 2014, p. 31).

The quality of information from quantitative surveys depends critically on survey design and to whom the questions are addressed (Bardasi, Beegle, Dillon, & Serneels, 2010; Dillon, Bardasi, Beegle, & Serneels, 2012). For programs to promote adoption of new agricultural technologies such as IPM and safe pesticide handling, relevant questions include what factors decision-makers consider to be important and who is responsible for key decisions (Alkire et al., 2012). Answers to these questions are not often straightforward. Best practices associated with measuring decision-making responsibility recognize these difficulties, but the most appropriate method depends on information needs of the program decision-maker.

Some studies seek to measure women's empowerment for purposes of program design and monitoring changes. For such studies, quantification can be important. For example, Alkire et al. (2012), in an effort at creating an index to reflect women's empowerment in agriculture (WEAI), suggest that male and female adults in the household should both be interviewed. The literature on WEAI acknowledges differences in responses between men and women when both are interviewed, but note that in an analysis of the data sets they collected "...these results imply that although males and females in the same household may not exactly agree about how decisions are made, their perspectives are more likely to agree than to be at complete odds with each other" (Alkire et al., 2012, p. 23). The WEAI is constructed based on an individual's response to subjective questions and Alkire et al. (2012) conduct numerous evaluations of the consistency of responses with theoretical constructs and whether there is consistency in responses by an individual across numerous questions. The purpose of the WEAI is to create an index to compare across contexts and over time.

For many purposes, however, the cost of data collection can outweigh the need for complete accuracy. In such cases, proxy responses, or having one person answer for multiple household members, can be used. The literature evaluating these proxy responses shows, however, that substantial errors in inference can be made when single respondents are used for the entire household. Responses to objective questions such as labor force participation, hours supplied, and earnings have been shown to be biased when proxy respondents are used (Anker, 1983; Bardasi et al., 2010; Fisher, Reimer & Carr, 2010). For example, men tend to under-report earnings of their wives, whether intentionally or due to imperfect information (Fisher, Reimer, & Carr, 2010). These errors and inconsistencies are consistent with Alkire et al. (2012) who find that male and female respondents differ in their impressions about who owns assets and who conducts which farm activities. Alkire et al. (2012) go beyond the proxy response literature by examining subjective questions such as who makes decisions and who controls different assets.

None of this literature examines the relationship between the respondent and his or her characteristics, and the consistency of responses to subjective questions. These questions include what factors are important in making decisions, who makes which decisions, and which household members are charged with major responsibilities. Enumerator biases can influence responses, particularly to subjective questions, and it is important to understand the relationship between the gender of the enumerator and the nature of the response. For design of a training program, approximate information may suffice; knowledge that women and men are both involved in decision making can inform what factors to stress and who to target during outreach and training. Information on decision making is clearly relevant for the design of an agricultural outreach program. For example, Buck and Alwang (2011) find that trust in information sources and willingness to accept information varies by gender; messages tailored to the appropriate audience can affect uptake of technologies such as crop varieties and new management techniques.

Since the cost of surveying grows as additional respondents in a household are questioned, it is important to understand tradeoffs. If single-person and proxy responses are relatively close to those gleaned from multiple-member responses, then resources can be saved by limiting questions to a single respondent. If responses differ substantially, single-member interviews will provide imperfect information and may lead to improper targeting of development programs. If precise information is needed for program targeting, implementation or evaluation, then multiple respondent surveys may be necessary, particularly if proxy responses are found to be misleading.

This paper presents results from a survey field experiment conducted in the Ecuador highlands where responding farm households are randomly assigned to one of three treatment groups: (i) a male respondent, (ii) a female respondent, and (iii) both adult male and female respondents (interviewed separately, but with knowledge that the other adult would also be interviewed). We assess whether treatment assignment affects responses to questions about decision making and responsibility for farm production, pesticide purchases and handling, and marketing. Randomized assignment to the interview protocol ensures unbiased identification of the effect of respondent type on reported responsibilities and other outcomes. If household members or enumerators are allowed to choose the respondent, factors affecting this choice may be correlated with the response. This correlation can lead to faulty inference. For example, better-educated members might be chosen to respond yet these members might be less familiar with day to day decision making, especially if they are engaged in off-farm employment. Their responses may not reflect average household conditions.

We find that perceptions about household decision making and who is responsible for agricultural activities vary substantially by type of respondent. Men are more likely to claim sole responsibility for decisions, farm management and sales; women are more likely to claim responsibility or that decisions are jointly made. In households where the senior man and woman were both interviewed (separately) we found stark differences in responses about responsibilities, with men again claiming sole responsibility at higher rates than women. Interviewing both members led to less divergence in responses (between men and women) compared to men and women (alone) responses. Large differences in perceptions about responsibilities are still found between the man and woman when interviewed jointly. We also find enumerator effects to be important, with the most significant of these effects being found when both members are interviewed (and knowing that the other is also being interviewed).

This paper adds to the literature in two ways. First, it examines the relationship between enumeration design and responses to objective and subjective questions in the clear context of an IPM program where training should be focused on decision makers and pest-related actors. Enumeration design includes not only the treatments described above, but the gender of the enumerator and how the response varies by it. Second, it assesses how respondent attributes and the specific nature of the question affect the relationship between the treatment and the outcome. The WEAI literature examines responses by gender with an eye on consistency; it does not examine differences by survey protocol—all members are interviewed. It also fails to provide insights into how individual and enumerator attributes affect findings. The proxy response literature rarely examines consistency of responses to clearly subjective questions.

The paper is organized as follows: the next section provides background and context for the study. Following this, the field experiment and data collection procedures are described. Next, results are presented and analyzed. The final section concludes the paper with a discussion of the implications of the findings.

2. BACKGROUND

A large literature finds that specific wording and structuring of survey questions affect responses, particularly to labor supply responses (Kalton & Schuman, 1982). Responses to more subjective questions or about activities that are irregular are more subject to errors; differences in perceptions about the meaning of the question or the intent of the questioner can contribute to response bias (Martin & Polivka, 1995). Responses and their accuracy have been found to be affected by characteristics of the respondent, with men and women exhibiting unique response patterns. While much of the literature on proxy responses and questionnaire design is focused on the US and other developed countries, there is growing literature on differences between men and women and their responses to survey questions in developing countries. For example, Fisher, Reimer, and Carr (2010) find that husband's estimates of their wives' income corresponded with objective measures in only 6% of surveys in Malawi, and men were much more likely to underestimate rather than overestimate income. Bardasi et al. (2010), using data from Tanzania, find that proxy responses are associated with underestimates of male labor force participation, women's hours worked and men's labor devoted to agriculture.

This literature also shows that women's roles are often underappreciated in standard surveys and women's labor supply is particularly subject to mis-measurement (Bardasi et al., 2010). Studies in developing countries show that women's work is undercounted in standard surveys, income contributions of women are undervalued, and women's roles in agricultural decision making are underappreciated (Dixon-Muller & Anker, 1990; Fisher, Reimer, & Carr, 2010; Twyman, Useche, & Deere, 2015). Underestimating women's work and contribution to household full income will lead to overestimate the benefits of activities that increase income but also increase women's workload (Johnson, Kovarik, Meinzen-Dick, Njuki, & Quisumbing, 2016). By under-estimating women's roles, surveys lead program designers to focus asset accumulation activities toward men and ignore potential efficiencies from a gender-inclusive approach. Quisumbing et al. (2014) describe the dangers of under-estimating women's roles, including lost productivity noted in Food and Agriculture Organization of the United Nations (2011) and conclude that while it may be difficult or more expensive for a program to incorporate gender considerations in its design, such incorporation will lead to better outcomes. Such inclusion requires gender analysis (Alkire et al., 2012; Meinzen-Dick et al., 2011; Quisumbing et al., 2014).

Detailed studies of rural households in developing countries show that women's roles are diverse: they produce on their own farms, and assume roles as laborers, processors, transporters, traders and entrepreneurs (Quisumbing & Pandolfelli, 2010). In the Andes, women are partners in agricultural production, often bear a primary responsible for marketing agricultural products (Amaya & Alwang, 2012), and Andean households have been described as two-headed, meaning that both husband and wife are involved in decision making (Deere & Twyman, 2012; Hamilton, 1998; Twyman et al., 2015). Twyman et al. (2015) examine determinants of how perceptions of participation in farming activities and farm decision-making vary between husbands and wives in a bargaining framework. They find that women landowners are involved in decision-making and joint decision-making predominates on Ecuador's farms (p. 495). They do not, however, examine the relationship between the structure of a survey and their findings.

Women farmers in developing countries frequently face disadvantages not faced by men. They have access to fewer assets, are less likely to receive extension advice and agricultural training and can be excluded from decision making (Doss, 2001; Quisumbing & Pandolfelli, 2010). Even when women are included in decision-making, their roles are often misunderstood or over-looked by program designers (Twyman et al., 2015). These disadvantages and oversights can accumulate over time and contribute to a worsening of the gender asset gap now recognized as a key contributor to lower productivity and other adverse outcomes for women and children in rural areas (Quisumbing et al., 2014).

In farming activities, women frequently lack access to information about pesticide inputs and their use, are avoided by male extension agents who predominate in most settings, and are therefore disadvantaged by inadequate access to pesticide-related decision-making-related decision making (Hamilton et al., 2005; Tanzo, 2005). In Ecuador, for example, women are frequently engaged in household decision making (Hamilton, 1998; Twyman et al., 2015). But, because of inadequate training, women and children are especially vulnerable to pesticides as chemical storage typically occurs in or near cooking spaces and women wash pesticide-laden clothing hand (Cole, Sherwood, Crissman, Barrera, & Espinoza, 2002; Hamilton et al., 2005; Sherwood et al., 2005). Despite high levels of exposure to pesticides, women in Ecuador participate at far lower rates than men in pesticide training (Cole et al., 2002). Excluding women from pesticide-related training can have important human health consequences and part of the explanation for low adoption of IPM is failure to involve women in training and outreach (Hamilton et al., 2005).

(a) *Study site*

In the Chimbo River watershed, Bolivar Province, Ecuador, farm families control relatively small holdings and produce potatoes and faba beans at high elevations; and maize, beans and Andean fruits at lower elevations (Barrowclough et al., 2016). Pesticide use is high as late blight and two insect pests affect potatoes; and Andean fruits (e.g. blackberries, tree tomatoes and naranjilla) face severe humidity-related problems such as fungal and bacterial diseases. Several donor-supported projects work in the area and two focus on increasing profitability of agriculture through promotion of more sustainable farming practices [E]. The government of Ecuador is interested in reducing pesticide use in these ecologically fragile areas and is concerned with water quality degradation from pesticide runoff and human health problems related to improper pesticide storage, handling and application (Barrowclough et al., 2016).

An important issue in the design of pest management information dissemination and training programs is to understand how decisions are made within the household. Small-scale studies from different agricultural regions show decision making to be varied: in indigenous farming communities, women tend to participate in farming decisions, while in mixed (mestizo) communities, males tend to dominate decision making (Hamilton et al., 2005). However, substantial heterogeneity in decision-making processes has been documented (Hamilton et al., 2005) and little is known about the effects of survey design on responses and subsequent inferences about gender roles in decision making. In Ecuador, a public agricultural extension service did not exist at the time of the study and projects sought innovative ways of inserting information into knowledge networks. Farmer field schools (FFS) have been found to be effective at transferring knowledge, but expensive (Carrion Yaguana et al., 2016; Mauceri, Alwang, Norton, & Barrera, 2007) and other ad hoc information transfer systems have met only limited success (Alwang et al., 2005, Chap. 5; Hamilton et al., 2005). Information about pest control and who makes decisions within households about amounts and types to purchase, where to purchase, application, and others will lead to more effective outreach. Differences in opinion about what to consider when choosing among pest control alternatives could also affect decisions.

3. THE SURVEY EXPERIMENT & METHODS

The effect of survey design on resulting statistics is ultimately an empirical question. Our survey experiment focused on three issues: (i) whether the responses were sensitive to the respondent type; (ii) whether the nature of the question affected this sensitivity; and (iii) whether the enumerator gender affected this relationship. The survey was conducted in the Chimbo River watershed, Bolivar Province, Ecuador. The watershed is comprised of two sub-watersheds, Illangama and Alumbre, where data collection took place. The Illangama micro-watershed covers roughly 32,000 acres and extends between 9,200 and 14,800 feet above sea level (fasl), with crop farming found between 9,200 and 12,000 fasl. The main farming system is potato-pasture production; other common crops include quinoa, barley, wheat, and faba beans. Illangama producers are indigenous and their families have been present in the area for generations. The Alumbre sub-watershed covers 16,000 acres and ranges from 6,600 to 9,200 fasl with agriculture found throughout (Barrera, Escudero, Alwang, & Andrade, 2012). Agriculture is mainly a mixed maize-bean system, with nearly continual maize cropping. Other crops include peas, wheat, and Andean fruit. The population is primarily mestizo and relatively new to farming, arriving in the area following different natural disasters in their home villages in the 1980s and 1990s.

The survey contained seven modules covering household socio-economic and demographics, marketing activities, pest management practices, knowledge of IPM and conservation agriculture practices, and household decision-making processes. It was administered from September to November, 2011 by bilingual (speaking both Spanish and Quichua) enumeration teams composed of men and women. The sample design was two-staged; the community was selected in the first stage and in the second, households within selected communities were selected. With no prior information on community-level characteristics, the first stage was an unweighted random sample of 42 villages. At the second stage, lists of villagers were obtained and 12 households were selected at random from each village. Upon arrival at each household, the first check was whether a married couple headed the household. Those (13 in the entire survey) with a single adult present were replaced with the next household on the list.

Before the interview, households were randomly assigned to treatments: (i) only the husband was interviewed; (ii) only the wife was interviewed; and (iii) both husband and wife were surveyed separately, but with knowledge that the other would also be interviewed. This assignment resulted in 91 households in the first treatment, 131 households in the second treatment, and 98 households in the third one, for a total of 320 households and 418 responding farmers.

The analysis focuses on two broad issues: (i) whether the treatment assignment affects the responses, and whether its effect depends on individual and household characteristics and the sex of the enumerator; and (ii) whether the treatment effect differs by type of question. The second question has important implications because different effects of treatment across broad classes of questions might suggest means of economizing on the survey. If responses are similar across treatments for some question classes, but not for others, then the bulk of the questionnaire can be enumerated to a single respondent, and particular modules can be double-enumerated, representing important potential savings.

To address these questions, we follow three steps. We first examine differences in clearly objective variables across treatment assignment. This step will establish statistical balance, that is whether the randomization worked and treatment and control groups are equalized on observable variables. While this step is often taken in randomized controlled trials, it is complicated in this case because there is no "gold standard" of comparison for survey questions. Different respondents may have different perceptions even about seemingly objective questions. Statistical balance on pre-treatment characteristics is not, however, necessary for making valid inferences about a treatment effect (Senn, 1994). We next compare the mean outcomes in responses to key subjective questions about the importance of different factors in pesticide decision making, who makes which decisions, and who is responsible for activities such as purchasing and applying chemicals and selling crops. Since the survey assignments are randomly allocated, we abstract from unobserved heterogeneity in individual, household, and village characteristics. Responses to these questions are multinomial; decision-making responsibilities can be the man's alone, the woman's alone, or joint.

In a third step, we formally estimate the marginal survey design effects using the following multinomial logit (MNL) specification:

$$Y_i = \alpha + \beta_T T_i + \beta_X X_i + \beta_D D_i + \varepsilon_c \quad (1)$$

where y_i are the stated responses, T is the treatment assignment, X are individual and household conditions, D represents a dummy variable for the watershed of residence of the i^{th} respondent and ε_h is the error term, clustered at the community level. α, β_T, β_X and β_D are coefficients or vectors of coefficients to be estimated. Summary statistics are presented in Table 1.

4. RESULTS

The treatment assignment resulted in four treatment groups reflecting the interviewee(s) for each household: (T1) husband alone, (T2) wife alone, (T3) husband interviewed in household where the spouse was also interviewed, and (T4) wife interviewed where the husband was also interviewed. To examine experimental balance, t-tests were conducted for differences in statistical significance of objective exogenous variables by treatment groups. The following variables were regressed separately on three treatment dummies (the base category was treatment group 1): distance to the main road (distance), altitude (in meters) of the house (measured by GPS—altitude), membership of a household member in an agricultural organization (organization), whether an extension agent visited in the past year (extension), number of farm workers in the household (workers), and total area farmed (hectares). An F-test for the joint significance of the coefficients was conducted (Table 2). For four out of six of these variables, the *F*-test is not significant at conventional levels, but for visit from an extension agent ($p = 0.047$) and the area farmed ($p = 0.000$), the treatment is significant and highly significant, respectively, with the male respondents (alone) reporting significantly higher visits from extension agents and more land being farmed compared to the other treatment groups.

When men and women are interviewed together in the family, their responses about area farmed are not significantly different, but T3 and T4 households (husband, wife, respectively in households where both members are interviewed separately), on average, report almost 3 hectares less land farmed than the male-alone respondents. This result is difficult to interpret because it may reflect different perceptions of area farmed by the respondents, but other sources have found gender-based differences in perceptions about land ownership and land farmed in Ecuador (Twyman et al., 2015). This difference in perception helps explain why balance is not achieved across this variable; T1 (male-only) households have larger areas farmed than households in other treatment groups. Separate tests of balance were conducted by watershed and two out of 12 tested balance variables were statistically significantly different across treatment (organization, $p = 0.037$ for Illangama; and hectares farmed, $p = 0.001$ for Alumbre). While the separate tests by watershed provide some

Table 1. *Variable description and summary statistics*

Variable	Description		
	Dependent variables (Who is responsible)	Responsible	%
Crop_manage	Who manages pests on crops	Man	52.87
		Woman	14.11
		Both	33.01
Pest_decide	Who decides how much to spend on pesticides?	Man	48.09
		Woman	14.59
		Both	37.32
Pest_purchase	Who purchases pesticides?	Man	58.13
		Woman	16.75
		Both	25.12
Pest_prepare	Who prepares pesticides?	Man	83.73
		Woman	10.53
		Both	5.74
Pest_apply	Who applies pesticides?	Man	82.78
		Woman	11.24
		Both	5.98
Crop_sales	Who sells crops?	Man	40.43
		Woman	17.46
		Both	42.11
	Independent variables	Mean	Std. Dev.
Age	Age of the respondent (years)	46.97	15.63
Educ_low	1 = Primary education completed or some secondary schooling (6–11 years of education)	0.5	0.5
Educ_high	1 = Secondary education completed or Post-secondary education (12 or more years of education)	0.15	0.36
Male-only (T1)	1 = Male respondent	0.22	0.41
Female-only (T2)	1 = Female respondent	0.31	0.46
Male-joint (T3)	1 = Jointly interviewed, male respondent	0.23	0.42
Female-joint (T4)	1 = Jointly interviewed, female respondent	0.23	0.42
Workers	Number of household members working on the farm	3.42	2.14
Distance	Meters from the house to the road	976.78	2,407.40
Hectares	Hectares available for production	3.55	5.06
Irrigation	1 = household has access to an irrigation system	0.27	0.44
Extension	1 = Extension agent visited the household in the past year	0.24	0.43
Altitude	Elevation of the house (meters)	2607.3	542.69
Organization	1 = Household member belongs to a farm organization	0.34	0.47
Alumbre	1 = From Alumbre sub-watershed	0.74	0.44

Source: Survey results, n = 418.

Table 2. *Balance checks*

Covariate	Treatment group				Test of equality across treatments	
	Male-only (T1)	Female-only (T2)	Male-joint (T3)	Female-joint (T4)	F(3, 414)	P
Altitude	2484.32	2642.87	2640.62	2640.62	0.75	0.523
Distance	1270.62	1010.92	799.133	835.939	2.01	0.112
Organization	0.322	0.29	0.454	0.309	2.55	0.056
Extension	0.231	0.191	0.347	0.224	2.67	0.047
Workers	3.275	3.183	3.663	3.643	1.45	0.228
Hectares	5.89	2.602	3.207	2.977	9.09	0

Source: Survey results, $n = 418$.

evidence of balance, on the whole the treatment cannot be called completely randomly assigned and the subsequent analysis focuses on the treatment effect conditional on relevant covariates. As Senn (1994) shows, this conditional analysis of an unbalanced experiment produces a valid inference.

(a) *Responses by treatment group*

Responses to questions about pesticide decisions, control and cropping decisions follow expectations: men, interviewed alone (T1) are far more likely to claim sole responsibility for pesticide and cropping decisions than all other respondent groups (Figure 1). Compared to men, women interviewed alone (T2) were more likely to claim that the woman has sole responsibility for the decisions (and less likely to claim that the male had sole responsibility). Women were also more likely than men to state that the decisions are jointly made. While pesticide preparation and application are overwhelmingly claimed by men to be male-only activities, nearly 30% of sole women respondents claimed either that women are responsible (alone) or jointly responsible for these tasks. Slightly less than 20% of women who were jointly (but separately) interviewed with male partners claimed that women are involved in managing pesticides; about 10% of men jointly interviewed

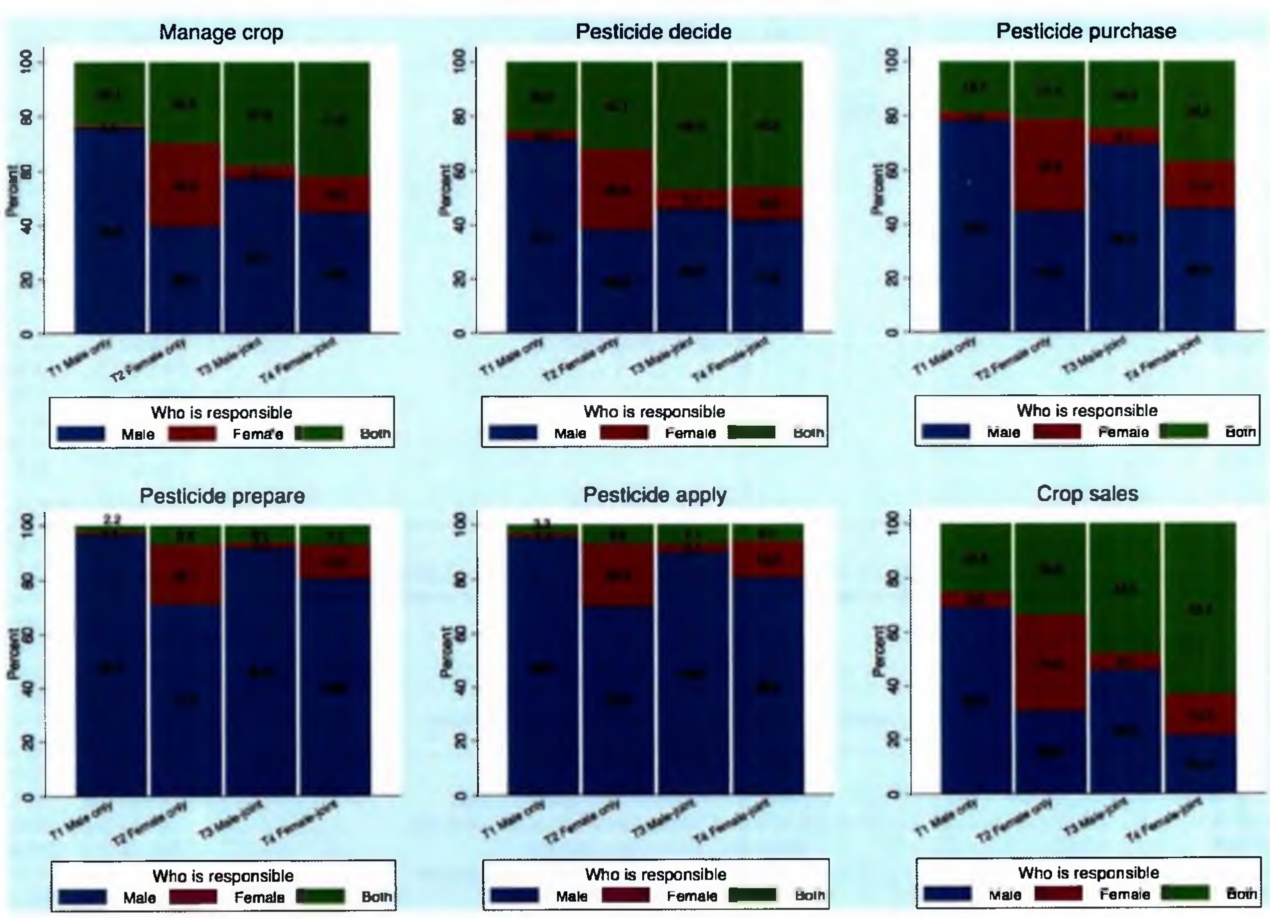

Figure 1. *Responses about decision-making responsibilities, by treatment.*

indicated some women's involvement. Joint interviewing leads to higher frequency of reporting of joint decision making and responsibilities.

A majority of women respondents claim some or all involvement in decisions about pesticide purchases and management of crop pests. About 60% of sole and jointly interviewed women respondents (T2 + T4) say that crop pest management is either the responsibility of the woman alone or a joint one (30% of sole-male respondents said women were in control of such activities). When women are asked knowing that their husband would also be asked (T4), they were more likely to claim joint male/female decision-making responsibility, in comparison to women alone (T2) who more often claim sole female responsibility. However, the sum of the responses saying women were involved in some way in decision making (i.e. women alone plus women jointly with the men) were about the same for the T2 and T4 treatments, with T2 reporting slightly higher women's participation (either as a primary or joint decision maker).

When men were asked about decision making while knowing that their spouse/partner would also be asked (T3), they reported more involvement of women (either alone or jointly with the man) in decision making than did male-alone respondents. In fact, for the decision about how much to spend on pesticides and the response about participation in crop sales, a majority of jointly interviewed males (T3) reported female involvement, either as a primary or a joint responsibility. In contrast, sole male respondents reported women's involvement in decisions about pesticide purchases in 29% of the cases, while only 33% of the T1 respondents reported any women's involvement in crop sales. Clearly, if we only focus on male responses, as is often the case, we would conclude that women are less involved in pesticide and crop decision making than they are likely to be.

(b) *Treatment effect estimates*

In order to evaluate the importance of respondent demographics, production characteristics and treatment assignment on responses about household decision making and responsibilities, multivariate models were estimated. Inclusion of covariates eliminates the issue of statistical imbalance noted above. By conditioning on variables such as watershed, hectares owned and others suspected of being associated with the responses, inferences about the effect of the treatment conditional on these covariates can be obtained within a regression model. Since responses about responsibilities are categorical (i.e., who is responsible—man, woman, joint?), a MNL model was used. In this framework, the probability that respondent i chooses response j (Pij) is specified as (Cameron and Trivedi, 2005):

$$P_{ij} = \frac{\exp(\alpha_j + \beta_{Tj}T_i + \beta_{xj}X_i + \beta_{Dj}D_i)}{\sum_{k=1}^{3}\exp(\alpha_k + \beta_{Tk}T_i + \beta_{xk}X_i + \beta_{Dk}D_i)} \quad (2)$$

where the coefficients and variables were described above. Since interpretation of the estimated coefficients in this type of model is not straightforward[2] marginal effects[3] are presented in Table 3. These marginal effects show the change in probability of the j^{th} outcome given a change in the independent variable. The j^{th} outcome is reflected in the columns of the table (i.e. man only, woman only, joint decision or responsibility).

In general, treatment assignment (who was interviewed) is a significant determinant of the choice (who the respondent claims is responsible for a decision or an activity). Of the 6x3 outcomes shown in Table 3, the treatment assignment variable is statistically significant in 41 (of 54) cases. The treatment assignment is least likely to have a significant impact on the probability that the respondent says the decisions/responsibilities are jointly taken. The assignment variable was significant for 8 (of 18) cases where the effect on the probability of a joint decision was estimated.

Compared to when the man alone was interviewed (T1—this is the excluded category of treatment in the table), the other treatment assignments are associated with a lower probability that the respondent says the decision/responsibility is the man's alone. For example, when the woman is interviewed alone, she is 31 percentage points less likely to say that crop management is a man only activity, 29 percentage points less likely to claim that the decision to purchase is a male-only decision and 27 percentage points less likely to say that the pesticide purchase decision is made only by men. Lower proportions of woman (compared to man only respondents) respondents report that activities such as pesticide preparation and pesticide application are male-only activities. All the treatments show a significantly lower probability (compared to a male interviewed alone) that crop sales are a man's responsibility alone. In particular, interviews with female members or joint interviews are associated with a 19–43 percentage point lower likelihood of concluding that males alone are responsible for crop sales. Conclusions about responsibilities for crop and pesticide management and crop sales depend on who is asked.

Assignment to treatment group 3 (man interviewed knowing that spouse would also be interviewed) has no significant differential effect on responses about pesticide purchases, preparation and application compared to males alone being interviewed (T1). In contrast, T3 assignment—males interviewed knowing their spouse would also be interviewed—compared to male-only interviews is associated with a significantly lower likelihood of claiming that crop management and crop sales are male-only responsibilities. The magnitudes of the marginal effects for the T3 treatment group are generally smaller than those for the T2 (woman alone) and T4 (woman whose husband would also be interviewed). This finding shows general consistency in men's perceptions about women's roles in pesticide purchases and management, but this consistency is a stark contrast with the responses of women.

When a single member of the household is surveyed, he/she is more likely to claim to make all the decisions and assume sole management responsibility. The sole respondent, whether male or female, evidently underestimates the role of others. Survey responses will differ by who is surveyed and how the survey is structured. It is impossible to make definitive conclusions about decision making except that men and women have different perceptions about the process and both sexes are engaged in some farming decisions. Male- or female-targeted training would not make sense given the variety of responses. To the degree that policy and programmatic decisions require information about gendered decision making and management responsibilities, alternatives to simple survey questions are necessary. Observational studies, ethnographic studies, and cognitive interviewing techniques can all be used to increase confidence about responsibilities for decision making and farming/marketing (Behrman, Meinzen-Dick, & Quisumbing, 2014).

The other covariates have uneven impacts on claimed decision-making responsibilities and management activities. The area farmed, a source of concern about balance, has only

Table 3. *Marginal effects estimates: Determinants of responses to decision making and other responsibilities*

	Crop manage						Pesticide decide					
	Male Only		Female Only		Joint		Male Only		Female Only		Joint	
	dy/dx	z	dy/dx	Z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Age	0.001	0.41	0.002	1.58	−0.003	−1.58	0.002	0.93	0.002*	1.93	−0.004**	−2.23
Educ_low	0.012	0.22	−0.012	−0.27	0.000	0.00	0.064	1.11	−0.062	−1.53	−0.002	−0.04
Educ_high	−0.042	−0.53	0.062	1.05	−0.020	−0.24	−0.045	−0.60	0.071	1.24	−0.026	−0.34
Workers	0.014	1.01	0.003	0.32	−0.017	−1.22	0.009	0.76	0.001	0.13	−0.010	−0.82
Distance	0.000	−1.28	0.000	0.37	0.000	1.13	0.000	−1.08	0.000	0.68	0.000	0.82
Hectares	0.005	0.93	0.002	0.63	−0.007	−1.48	0.009	1.55	−0.004	−0.92	−0.004	−0.79
Irrigation	0.040	0.66	−0.059	−1.59	0.019	0.29	0.036	0.61	−0.027	−0.67	−0.009	−0.15
Extension	0.059	0.86	0.034	0.71	−0.093	−1.54	0.017	0.25	0.015	0.30	−0.032	−0.59
Altitude	0.000	−0.39	0.000**	2.22	0.000	−0.97	0.000	−0.49	0.000**	2.46	0.000	−1.31
Organization	0.055	0.88	−0.015	−0.37	−0.039	−0.58	−0.043	−0.72	−0.019	−0.44	0.063	0.83
Alumbre	0.143	0.81	0.193***	2.71	−0.337*	−1.93	0.127	0.81	0.243***	3.32	−0.370**	−2.31
T2	−0.312***	−4.49	0.306***	6.69	0.006	0.10	−0.273***	−3.51	0.269***	5.71	0.005	0.07
T3	−0.183**	−2.46	0.046	1.44	0.136**	2.07	−0.221***	−3.34	0.051	1.37	0.170***	2.82
T4	−0.293***	−3.61	0.150***	3.85	0.142*	1.95	−0.272***	−3.79	0.116***	2.78	0.156**	2.22
N	410						410					
R2	0.1276						0.1291					
	Pesticide purchase						Pesticide prepare					
	Male Only		Female Only		Joint		Male Only		Female Only		Joint	
	dy/dx	z	dy/dx	Z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Age	0.000	0.19	0.002	1.27	−0.002	−1.20	−0.004**	−2.53	0.000	0.22	0.004***	3.61
Educ_low	0.076	1.28	−0.008	−0.21	−0.068	−1.20	0.020	0.47	0.024	0.68	−0.044*	−1.84
Educ_high	−0.023	−0.28	0.111*	1.94	−0.088	−1.21	0.020	0.47	0.059	1.40	−0.080***	−4.39
Workers	−0.010	−0.95	0.002	0.20	0.008	0.76	0.011	1.26	−0.013	−1.55	0.002	0.32
Distance	0.000	−0.38	0.000	0.28	0.000	0.20	0.000	0.98	0.000	−0.77	0.000	−0.23
Hectares	0.013**	1.98	−0.009	−1.23	−0.004	−0.74	0.002	0.33	−0.004	−0.80	0.002**	2.05
Irrigation	0.102*	1.67	−0.087**	−2.34	−0.015	−0.25	0.031	0.71	−0.002	−0.04	−0.029	−1.02
Extension	−0.011	−0.18	0.039	0.74	−0.028	−0.51	0.024	0.47	0.011	0.30	−0.035	−1.34
Altitude	−0.000***	−2.93	0.000***	2.94	0.000	0.37	−0.000***	−2.77	0.000*	1.93	0.000	1.33
Organization	0.074	1.52	−0.015	-0.41	−0.059	−1.12	0.026	0.72	−0.019	−0.62	−0.006	−0.30
Alumbre	−0.266***	−2.67	0.241***	3.65	0.025	0.24	−0.131*	−1.72	0.094	1.13	0.037	0.76
T2	−0.290***	−4.15	0.289***	5.81	0.001	0.02	−0.268***	−6.61	0.202***	5.48	0.066***	3.08
T3	−0.101	−1.53	0.038	1.00	0.064	1.05	−0.046*	−1.72	0.009	0.50	0.036*	1.87
T4	−0.343***	−4.27	0.170***	3.39	0.173**	2.37	−0.194***	−4.30	0.114***	2.84	0.080***	3.05
N			410						410			
R2			0.1228						0.2327			
	Pesticide apply						Crop sales					
	Male Only		Female Only		Joint		Male Only		Female Only		Joint	
	dy/dx	z	dy/dx	Z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Age	−0.004**	−2.27	0.001	0.45	0.003***	2.97	0.001	0.74	0.003*	1.92	−0.004**	−2.31
Educ_low	0.0	0.60	0.031	0.91	−0.057**	−2.37	0.044	0.93	−0.018	−0.45	−0.026	−0.44
Educ_high	0.0	−0.18	0.100**	2.15	−0.091***	−4.02	0.120	1.52	0.054	0.98	−0.175**	−2.34
Workers	0.0	1.36	−0.012	−1.43	0.000	−0.02	−0.007	−0.56	0.009	0.96	−0.002	−0.14
Distance	0.0	1.03	0.000	−0.77	0.000	−0.40	0.000	0.95	0.000	0.19	0.000	−0.99
Hectares	0.0	0.28	−0.002	−0.38	0.001	0.37	0.001	0.15	0.005	0.94	−0.005	−0.72
Irrigation	0.0	0.80	−0.006	−0.17	−0.029	−0.98	0.029	0.57	−0.053	−1.23	0.024	0.38
Extension	0.0	0.52	0.014	0.37	−0.040	−1.51	−0.066	−1.15	0.011	0.21	0.055	0.81
Altitude	−0.000**	−2.16	0.000	1.27	0.000	1.53	0.000	0.06	0.000	1.32	0.000	−1.08
Organization	0.0	0.86	−0.037	−1.26	0.005	0.22	0.118**	2.11	−0.048	−1.30	−0.070	−1.15
Alumbre	−0.102	−1.07	0.035	0.36	0.066	1.15	0.111	0.79	0.111	1.05	−0.222	−1.36
T2	−0.264***	−5.77	0.216***	5.40	0.047**	2.09	−0.323***	−4.58	0.330***	6.36	−0.007	−0.10
T3	−0.059*	−1.86	0.020	0.94	0.039	1.60	−0.191**	−2.52	0.021	0.57	0.170**	2.48
T4	−0.181***	−4.04	0.127***	2.81	0.054*	1.96	−0.434***	−6.08	0.134***	2.92	0.300***	4.13
N			410						410			
R2			0.2102						0.1415			

Notes: *, **, *** means statistically significant at the 10, 5, and 1% level respectively. R^2 is a pseudo value. T2 (woman only), T3 (husband when wife is also interviewed) and T4(wife when husband is also interviewed) are dummy variables for treatment assignment. They are compared to T1 (the deleted category) where the husband alone is interviewed.

Table 4. *Marginal effects with enumerator interactions included*

	Crop manage						Pesticide decide					
	Male Only		Female Only		Joint		Male Only		Female Only		Joint	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Age	0.001	0.35	0.002	1.46	−0.003	−1.52	0.001	0.84	0.002*	1.82	−0.004**	−2.05
Educ_low	0.012	0.23	−0.006	−0.14	−0.006	−0.11	0.067	1.20	−0.054	−1.39	−0.013	−0.23
Educ_high	−0.046	−0.57	0.063	1.05	−0.017	−0.21	−0.059	−0.76	0.083	1.38	−0.025	−0.31
Workers	0.016	1.18	0.001	0.06	−0.016	−1.19	0.009	0.86	−0.002	−0.26	−0.007	−0.65
Distance	0.000	−1.28	0.000	0.58	0.000	0.99	0.000	−0.93	0.000	1.02	0.000	0.38
Hectares	0.004	0.78	0.003	0.93	−0.008	−1.55	0.009*	1.75	−0.004	−0.82	−0.005	−1.05
Irrigation	0.049	0.77	−0.067*	−1.93	0.019	0.28	0.042	0.68	−0.034	−0.85	−0.008	−0.14
Extension	0.070	1.01	0.039	0.79	−0.109*	−1.81	0.034	0.51	0.023	0.42	−0.057	−1.03
Altitude	0.000	−0.33	0.000**	2.39	0.000	−1.14	0.000	−0.28	0.000***	2.64	0.000	−1.53
Organization	0.050	0.82	−0.018	−0.46	−0.032	−0.48	−0.047	−0.78	−0.017	−0.39	0.064	0.87
Alumbre	0.165	0.94	0.199***	3.01	−0.363**	−2.09	0.157	1.00	0.245***	3.49	−0.402**	−2.51
T2	−0.313***	−4.44	0.309***	7.71	0.004	0.07	−0.274***	−3.36	0.281***	4.37	−0.007	−0.10
T3	−0.206***	−2.64	0.039	1.36	0.167**	2.37	−0.244***	−3.53	0.054	1.54	0.189***	3.08
T4	−0.291***	−3.69	0.153***	5.91	0.138*	1.89	−0.270***	−3.90	0.120***	3.70	0.150**	2.23
Enum_male	0.029	0.58	0.076**	2.19	−0.105**	−2.38	0.080	1.30	0.075*	1.78	−0.154***	−3.33
N			410						410			
R2			0.1485						0.1491			

	Pesticide purchase						Pesticide prepare					
	Male Only		Female Only		Joint		Male Only		Female Only		Joint	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Age	0.000	0.05	0.002	1.19	−0.002	−1.01	−0.004**	−2.46	0.000	0.26	0.004***	3.11
Educ_low	0.076	1.29	−0.004	−0.11	−0.072	−1.28	0.022	0.51	0.026	0.75	−0.049**	−1.96
Educ_high	−0.027	−0.33	0.116**	1.98	−0.089	−1.24	0.022	0.47	0.063	1.54	−0.085***	−3.24
Workers	−0.010	−0.95	−0.001	−0.12	0.011	1.08	0.013	1.48	−0.014*	−1.71	0.001	0.17
Distance	0.000	−0.40	0.000	0.44	0.000	0.02	0.000	0.81	0.000	−0.50	0.000	−0.44
Hectares	0.013**	1.97	−0.008	−1.29	−0.005	−0.87	−0.004	−0.64	−0.005	−1.17	0.009**	2.25
Irrigation	0.104*	1.66	−0.091**	−2.54	−0.013	−0.21	0.027	0.62	0.003	0.07	−0.029	−1.12
Extension	−0.010	−0.16	0.039	0.72	−0.029	−0.52	0.020	0.40	0.016	0.41	−0.036	−1.53
Altitude	−0.000***	−2.75	0.000***	3.10	0.000	0.17	−0.000***	−2.70	0.000**	1.98	0.000	1.18
Organization	0.074	1.51	−0.014	−0.39	−0.060	−1.14	0.030	0.85	−0.016	−0.52	−0.014	−0.63
Alumbre	−0.251**	−2.34	0.245***	3.86	0.006	0.05	−0.119	−1.49	0.093	1.17	0.026	0.49
T2	−0.294***	−4.20	0.294***	5.86	0.000	−0.01	−0.276***	−6.45	0.207***	4.79	0.069***	4.70
T3	−0.109	−1.62	0.041	1.09	0.068	1.08	−0.046*	−1.73	0.005	0.26	0.042**	2.09
T4	−0.340***	−4.22	0.174***	3.68	0.166**	2.23	−0.195***	−4.01	0.113***	2.71	0.082**	2.40
Enum_male	0.029	0.56	0.056	1.37	−0.085**	−2.14	0.000	0.00	0.022	0.74	−0.022	−0.89
N			410						410			
R2			0.134						0.2585			

	Pesticide apply						Crop sales					
	Male Only		Female Only		Joint		Male Only		Female Only		Joint	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Age	−0.004**	−2.32	0.001	0.45	0.003***	3.04	0.001	0.66	0.003*	1.86	−0.004**	−2.22
Educ_low	0.028	0.65	0.033	0.95	−0.061**	−2.56	0.044	0.96	−0.011	−0.31	−0.033	−0.56
Educ_high	−0.008	−0.16	0.102**	2.24	−0.094***	−4.00	0.114	1.45	0.063	1.18	−0.177**	−2.42
Workers	0.012	1.38	−0.013	−1.54	0.001	0.17	−0.005	−0.41	0.004	0.45	0.001	0.07
Distance	0.000	0.93	0.000	−0.54	0.000	−0.61	0.000	0.92	0.000	0.68	0.000	−1.32
Hectares	0.002	0.54	−0.003	−0.58	0.000	0.15	0.002	0.27	0.004	0.85	−0.006	−0.75
Irrigation	0.030	0.68	−0.003	−0.07	−0.028	−0.94	0.031	0.58	−0.056	−1.32	0.026	0.41
Extension	0.022	0.44	0.018	0.48	−0.040*	−1.72	−0.061	−1.05	0.017	0.32	0.044	0.66
Altitude	−0.000**	−2.23	0.000	1.34	0.000	1.48	0.000	0.09	0.000	1.58	0.000	−1.24
Organization	0.034	0.97	−0.035	−1.18	0.001	0.04	0.115**	2.04	−0.044	−1.15	−0.071	−1.18
Alumbre	−0.109	−1.19	0.037	0.39	0.072	1.22	0.119	0.84	0.123	1.24	−0.242	−1.49
T2	−0.262***	−5.43	0.220***	5.11	0.042*	1.81	−0.328***	−4.64	0.339***	6.30	−0.011	−0.17
T3	−0.057*	−1.84	0.014	0.71	0.043*	1.78	−0.202***	−2.62	0.025	0.67	0.177**	2.54
T4	−0.180***	−3.90	0.126***	2.68	0.054*	1.82	−0.433***	−6.04	0.136***	3.09	0.297***	4.16
Enum_male	0.026	0.69	0.022	0.76	−0.048*	−1.89	0.016	0.30	0.090**	2.13	−0.106*	−1.83
N			410						410			
R2			0.2307						0.1542			

Notes: *, **, *** means statistically significant at the 10, 5, and 1% level respectively. R^2 is a pseudo value. Enum_male is a dummy variable taking the value 1 if the survey enumerator is male. The marginal effects for T2, T3, and T4 include the effect of the interaction with the enumerator gender variable.

Table 5. *Marginal effects of the treatment evaluated for male and female enumerator*

	Crop manage						Pesticide decide					
	Male Only		Female Only		Joint		Male Only		Female Only		Joint	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
T2												
enum_male=0	-0.309***	-2.90	0.288***	4.96	0.021	0.17	-0.210*	-1.71	0.224***	3.49	-0.014	-0.11
enum_male=1	-0.316***	-3.50	0.320***	5.65	-0.005	-0.06	-0.308***	-3.40	0.311***	3.77	-0.003	-0.04
T3												
enum_male=0	-0.401***	-2.96	0.000	0.61	0.401***	2.96	-0.329**	-2.36	0.095	1.59	0.234*	1.68
enum_male=1	-0.103	-1.22	0.059	1.36	0.044	0.55	-0.199***	-2.67	0.033	0.73	0.166**	2.43
T4												
enum_male=0	-0.285**	-2.23	0.075	1.56	0.210*	1.65	-0.178	-1.47	0.070	1.50	0.107	0.82
enum_male=1	-0.293***	-3.09	0.193***	5.21	0.100	1.06	-0.318***	-3.54	0.146***	3.14	0.172**	1.96
	Pesticide purchase						Pesticide prepare					
	Male Only		Female Only		Joint		Male Only		Female Only		Joint	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
T2												
enum_male=0	-0.285***	-3.10	0.257***	4.31	0.028	0.32	-0.257***	-3.51	0.135**	2.18	0.122***	2.67
enum_male=1	-0.298***	-3.15	0.314***	4.84	-0.015	-0.19	-0.286***	-4.32	0.245***	3.86	0.041	1.47
T3												
enum_male=0	-0.182	-1.59	0.063	0.89	0.119	0.99	-0.037	-0.68	-0.037	-1.00	0.074**	2.10
enum_male=1	-0.071	-0.84	0.030	0.67	0.041	0.53	-0.051	-1.52	0.027	1.33	0.025	1.09
T4												
enum_male=0	-0.393***	-3.44	0.069	1.08	0.323***	2.91	-0.182**	-2.35	0.108	1.55	0.074**	2.06
enum_male=1	-0.313***	-3.17	0.229***	3.92	0.084	0.89	-0.202***	-3.33	0.116***	2.63	0.086*	1.84
	Pesticide apply						Crop sales					
	Male Only		Female Only		Joint		Male Only		Female Only		Joint	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
T2												
enum_male=0	-0.230**	-2.46	0.163**	2.51	0.067	0.97	-0.249**	-2.25	0.227***	3.22	0.022	0.21
enum_male=1	-0.278***	-4.44	0.249***	4.15	0.029	1.02	-0.369***	-4.57	0.398***	5.49	-0.028	-0.37
T3												
enum_male=0	-0.047	-0.70	-0.035	-0.95	0.082	1.41	-0.230*	-1.91	0.047	0.73	0.184	1.51
enum_male=1	-0.063**	-2.01	0.040*	1.67	0.023	1.10	-0.187**	-2.16	0.014	0.34	0.173**	2.14
T4												
enum_male=0	-0.143*	-1.80	0.112	1.61	0.032	0.51	-0.381***	-3.32	0.032	0.52	0.349***	2.99
enum_male=1	-0.199***	-3.74	0.133**	2.56	0.066*	1.89	-0.461***	-5.67	0.191***	3.01	0.269***	2.91

Notes: *, **, *** means statistically significant at the 10, 5, and 1% level respectively. Cells highlighted in gray indicate that the treatment is statistically different according to enumerator gender. T2 (woman only), T3 (husband when wife is also interviewed) and T4(wife when husband is also interviewed) are dummy variables for treatment assignment. They are compared to T1 (the deleted category) where the husband alone is interviewed.

a weak association with the responses; respondents in households with larger areas farmed are more likely to say that men alone purchase pesticides, but the size of the effect is small (an additional hectare associated with a 0.1 percentage point higher probability of claiming the decision is male only). Respondents from larger farms are also more likely to say that pesticide preparation is a joint activity, but the magnitude of the coefficient (less than 0.1 percentage point increase in the probability of reporting joint preparation for each additional hectare of land farmed) is of little practical significance. Education of the respondent has significant impacts on some responses; namely, respondents with higher education are more likely to attribute pesticide purchases and applications to women (by about 10 percentage points), compared to more poorly educated respondents. Better-educated respondents are also less likely to claim joint responsibilities for pesticide preparation and application, and crop sales, so that education is associated with more ability to distinguish between responsibilities with respect to pesticide management and marketing.

These findings illustrate the importance of including covariates when analyzing responses to questions and of considering household and individual attributes during the survey process.

Interestingly, the dummy variable representing the respondent household being in the Alumbre watershed was significant for three outcome variables: crop management, pesticide purchase decisions and pesticide purchases. Alumbre residence was associated with a higher likelihood of an activity being female alone or a lower likelihood of it being male alone or joint. Reflecting very different agro-ecological and social conditions noted above, even controlling for all other factors, the watershed of residence has an important effect on many of the responses.

(c) *Effect of enumerator gender*

Since the enumeration teams were mixed and the interviews were conducted by individuals, it is important to understand whether the gender of the enumerator affects the estimated treatment effect. The multinomial logit models were re-run including a dummy variable reflecting the gender of the enumerator and interaction terms between the enumerator variable and the treatment variables. Across the 18 outcomes (6×3), the marginal effects for the enumerator gender are significant in eight cases (Table 4). In general, having a male enumerator is associated with a lower probability of claiming the decision/responsibility is joint (the marginal effect is negative and significant for all decisions/responsibilities except for the pesticide preparation activity) and the magnitude of the effect is 15 percentage points (for decisions about how much to spend on pesticides) or lower. Having a male enumerator also increases the probability that the female is identified as the person in charge of crop management, pesticide expenditures, and crop sales regardless of the treatment.

Next, the treatment marginal effects are evaluated for male and female enumerators separately to examine whether the enumerator gender affects conclusions about the sign and significance of the treatment (Table 5). A Wald test is performed to determine whether the marginal effects of the treatment are statistically different when the enumerator is a male versus a female. Of the 54 scenarios (6×9), the treatment statistically varies according to the gender of the enumerator seven times (highlighted in grey in Table 5). Statistical differences are found for pesticide purchase and application, and crop management and sales, and mainly in T3 and T4, i.e. when both spouses are interviewed separately.

Males in T3 (knowing that their spouse would also be interviewed) are less likely to report that they alone are responsible for crop management and more likely to report joint responsibility only when interviewed by a female enumerator. When interviewed by a man, husbands in T3 report similar crop management responsibilities as men in T1. Therefore, not disaggregating treatment effect by enumerator gender might lead to an incorrect conclusion, i.e. concluding that men who know their spouses are also being interviewed are less likely to claim sole responsibility and more likely to report joint responsibilities for crop management (findings reported in Table 3). This is only true when the enumerator is a woman. Notice that for T3, the absolute magnitude of the (negative) coefficient for a "male only" response is greater when the enumerator is female for crop management, pesticide decisions, pesticide purchases, and crop sales (although the difference in magnitude is only significant for crop management). The corresponding (positive) magnitude is greater for the "joint" response for T3 males with female enumerators. The findings are consistent and all indicate that male respondents tend to be deferential (that is, claim joint responsibilities more frequently) when they are interviewed by female enumerators.

Women, when interviewed by males, behave differently. For example, when women are interviewed by males, knowing that their husband would also be interviewed (T4), they claim more sole responsibility for pesticide purchase and crop sales than they do when they are in the same situation, but interviewed by a female. While it is beyond the scope of this paper to attribute meaning to this finding, it shows that women in such circumstances are not averse to stating they alone control market-related activities. When the woman alone is enumerated by a man (T2) she again is more likely to state that crop sales are her responsibility alone. In general, women are more likely to report that they are the only decision maker and assume sole management responsibility when the enumerator is a male compared with when the enumerator is a female. Differences by gender of enumerator are not statistically significant when decisions do not involve market activity (purchases of pesticides and sales of crops). The gender of the enumerator influences women's responses when dealing with market relationships; women make it clearer when interviewed by males that they are engaged in marketing activity.

5. CONCLUSIONS—IMPLICATIONS

Agricultural development interventions can benefit from information about which household members are responsible for decision making and which are engaged in specific activities. Training and the entire focus of such interventions can be better targeted with this information. The asset gender gap literature clearly shows that agricultural development can be stimulated by closing the gap and an important part of the asset gap is education and training. Projects that seek to diffuse knowledge-intensive agricultural practices, such as IPM, will benefit from solid understanding of who makes which decisions in the household; in many cases, women are heavily involved in decision making and, as in the case of pesticides, can directly benefit from additional information.

As a result, baseline studies, often a core component of project implementation, frequently ask questions about decision making and other responsibilities. However, the information from such surveys may be called into question if the findings are highly sensitive to the structure of the questionnaire and choice of respondent. Much of the recent development literature on survey design highlights the fragility of responses to reliance on proxy responses and to whom questions are targeted. Yet the wide literature on women in development shows clearly that women's empowerment is an important determinant of success of many agricultural development programs and the women's role in decision making needs to be understood during program design. The default position of the gender empowerment literature is that both men and women should be interviewed (Twyman et al., 2015; Quisumbing et al., 2014).

Results of this study provide insights into how male and female farmers in Ecuador's highlands perceive intra-household decision making and responsibilities for pest and crop management. Randomized assignment to a treatment (who is the respondent) allows us to obtain clean identification of the effect of the respondent gender on perceptions. Several clear conclusions emerge. First, men and women have dramatically different perceptions about responsibilities; male respondents are more likely to claim decision making as an exclusively male purview, while females are more likely to claim sole or joint responsibility. Relying on a single respondent to such questions will lead to misleading results, and the bias is likely to be exacerbated if household members are allowed to "choose" the respondent. For example, in male-dominated contexts, males are more likely to be selected as respondents and the survey will feed into an existing gender bias.

The finding of different perceptions is not new to the literature. As noted, Twyman et al. (2015) find similar differences. Alkire et al. (2012) identified gender differences in survey data from Bangladesh, Guatemala, and Uganda, but noted that the patterns differ by country and type of question. These authors all recommend interviewing both males and females in all households.

Second, interviewing both adults leads to less extreme (male-only or female-only) claims of responsibility and higher rates of response that decisions and responsibilities are joint.

However, even for respondents who were interviewed jointly with their spouse (separate, but with knowledge that the other would be interviewed), stark differences in conclusions about decision making remain. Thus, surveys of both members, which can be far more expensive to enumerate than single-member surveys, do not really solve the problem.

Third, it is likely, in the Ecuador case, that both adults are engaged in decision making and crop production. But, it is impossible to quantify with any degree of certainty the relative importance of men and women. The analysis shows that women in the area are involved in pest management activities and their roles should not be overlooked. They should be included in training and project activities should be designed with women's roles in mind. This finding was expected; the hope behind the survey was to better quantify individual roles. This quantification is likely to remain elusive. Fortunately, for the purposes of training, quantification is not necessary; knowledge of joint decision making is sufficient to conclude that women should be included in IPM training.

The fourth and most important conclusion from this exercise is that typical surveys will not provide sufficient information to answer the question: people have different perceptions about responsibilities and actions. The study calls into question the rationale behind inclusion of these respondent-sensitive questions in baseline surveys when the survey is used for targeting beneficiaries (particularly for targeting training). Their analysis is not likely to lead to anything conclusive. In cases where the baseline is being used to measure empowerment and use the baseline measurement to track changes over time, more finely tuned measures will be needed. One promising example of obtaining more nuanced quantitative information on decision-making responsibility is elicitation of subjective probabilities (Attanacio, 2009; Attanacio & Kaufman, 2014). The distribution of subjective probabilities provides additional information about overlap between perceptions of decision-making responsibilities. Such information may be important to tracking perception change over time. However, this elicitation itself requires substantial resources and cost may drive the program to focus on a single decision maker (the woman). Evolution of her subjective distribution of her own empowerment (or factors reflecting it) may be of interest from an empowerment monitoring perspective.

Alternative means of uncovering decision-making processes include focus group discussions, cognitive interviewing and anthropological studies. If project success depends critically on the relative responsibilities of men and women in decision making and agricultural management, more in-depth questioning with follow-up probing will be required. At a minimum, the survey questions should present a concrete hypothetical; for example, "suppose you saw an unusual symptom of disease on your potato plant....how would the household proceed? How would decisions be made about treatment?" Open-ended quantitative questions, although often difficult to code, could provide better information. If general information about responsibilities is needed, this information can come from qualitative processes that generally cost less than household surveys. The emerging literature on surveying indicates an important role of respondent fatigue and this paper hints at simple steps to reduce this fatigue. Interviewing a single household member (the woman) can reduce overall household resources devoted to survey responses.

Finally, the results in this paper are not generally sensitive to enumerator gender. While small some changes in the results were observed when enumerator effects are added, the results reinforce the findings compared to when the effects are not included. This promising result removes and important concern about how to assign enumerators according to the gender of the respondent. While the results are only valid for our survey at a point in time in Ecuador, they do provide evidence that enumerator effects are not critically important to the elicitation of subjective responses.

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NOTES

E. **ndnotes**The Integrated Pest Management (IPM CRSP) and the Sustainable Agriculture and Natural Resource Management (SANREM CRSP) Collaborative Research Support Projects (now known as Innovation Laboratories—ILs) conducted on-farm participatory research on pest management and sustainable agricultural practices in Chimbo from 2006 to 2013.

2. The interpretation in this model is more difficult than in ordinary linear regression because the relationship between the predicted probability and the independent variables is nonlinear.

3. The effect on the dependent variable that results from changing an independent variable by a small amount: $\partial Y_i/\partial X_i$.

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