
# Are seed distributions effective? Evidence from a randomly controlled experiment with improved bean seeds in rural Madagascar.

**This is a working draft. Please do not cite. Link to formally published article will be added when available.**

Christine Bosch, Manfred Zeller, Domenica Deffner

***Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia***

Manuscript for consideration at

The Fifth Conference of the African Association of Agricultural Economists (5th CAAAE)
"Transforming smallholder agriculture in Africa: The role of policy and governance."
26-29 September 2016, Addis Ababa, Ethiopia

Title: Are seed distributions effective? Evidence from a randomly controlled experiment with improved bean seeds in rural Madagascar.

Authors:

1. Christine Bosch (christine.bosch@uni-hohenheim.de), Hans-Ruthenberg Institute, University of Hohenheim. Wollgrassweg 43, 70593 Stuttgart, Germany.
2. Manfred Zeller, International Food Policy Research Institute / HarvestPlus, Kampala, Uganda.
3. Domenica Deffner, Hans-Ruthenberg Institute, University of Hohenheim, Stuttgart, Germany.

## Abstract

This paper studies access to and adoption of improved seeds and the diffusion of this information in a remote area in central Madagascar. The analysis is based on panel data gathered from 2009 to 2014 for 390 households in three villages. In 2013 a randomized treatment control design was applied in which 50% randomly selected households from the panel received 1.5 kapoaka (0.6 kg) of improved bean seeds (Pois du Cap/Morombe/Phaseolus lunatus). The beans were especially bred for dry regions and purchased at Fofifa (National Center of Applied Research and Rural Development). Of those households receiving, 50% randomly selected households were given information on how to store, plant and cultivate the seeds, as the distributed variety was unknown in the region and not available in the villages. These three groups are compared with respect to baseline characteristics, bean adoption, cultivation, information exchange with other farmers and diet diversity. 55% of the households that received seeds cultivated them, with an average yield of 3 kg. As non-compliance and spillovers exist, next to the average treatment effect on the treated (ATT), intention-to-treat (ITT) and local average treatment effect (LATE) is estimated. Additionally, willingness to pay (WTP) for improved bean seeds is estimated via the contingent valuation method (CVM). In order to ask the WTP, households were explained the benefits of improved bean seeds, which resulted in a WTP of 171% of the price of beans purchased on the local market.

# 1 Introduction

Agricultural productivity in Madagascar is low, among others due to climate hazards and a low uptake of improved agricultural technologies. Earlier studies in rural Madagascar found that communes with higher rates of adoption of improved agricultural technologies and higher crop yields enjoy lower food prices, higher real wages for unskilled workers and better welfare indicators (Minten and Barrett, 2008). The authors therefore strongly favor support for improved agricultural production as a strategy to poverty and food insecurity reduction. The low uptake of improved agricultural technologies is attributed to labor and liquidity constraints at planting time (Moser and Barrett, 2003; Moser and Barrett, 2006), high transaction costs especially because of poor transport infrastructure and social customs and social conformity effects which limit adoption of new methods (Moser and Barrett, 2003; Barrett, 2008 and Stifel et al., 2008; Stifel et al., 2011). Remoteness can significantly increase prices and be a huge impediment to adoption of improved inputs (Minten el al., 2013). Besides the low demand from farmers, low supply and therefore low access to agricultural inputs, mostly due to high transaction and transport costs, is a constraint to adoption (Minten et al., 2013).

This low uptake and low supply of technologies has also been studied in the seed market and through the lenses of seed aid as a disaster response (see e.g. Sperling et al., 2008). As a solution to this, local and more participatory seed production was studied. Some authors (Alemayehu et al., 2009; Sperling and McGuire, 2010; Katungi et al., 2011a;) argue that informal seed markets present a huge potential for more, higher quality and more diversified seeds, but are still not fully understood. They suggest establishing links between variety innovators and those who can multiply and distribute seed at a decent price. Then, new seed material from research could be delivered not only to parastatal and commercial entities, but directly to important community-based nodes (Sperling et al., 2008, Gibson, 2013).

Pois du cap (Phaseolus lunatus) are also known as Pois de Madagascar or Butter Bean. The plant is a perennial type and achieves highest yields in hot and humid tropics. It is tolerant to mild drought, high temperatures and poor soils. The maturing period lasts 150-200 days, sowing should take place around March and April in order to harvest between September and mid-November. Yields range between one to three tons per ha. (Ministry of Agriculture, 2004).

According to the Ministry of Agriculture (2004), Madagascar used to export around 20,000 t of Pois du Cap (PDC herafter), mainly from the region around Toliara (98%) in the 70s. Yet in recent years export faced a drastic decline from 7,738 t in 1995 to 2,666 t in 2003 due to several quality problems. First of all rainfall is very low in the area around Toliara (400 to 750 mm) with the possible consequence of severe droughts and failure in sowing. Consequently farmers lack seeds from their own production for the coming season and have to acquire seeds from other sources. Beans sold at the market are often a mixture of medium-quality PDC with a high ratio being subject to “pink eye”, a red spot around the hilus of a bean which becomes black after cooking, has negative impacts on production outcomes and depreciates selling quality. Malagasy beans are not competitive anymore on the European market which is dominated by the more bulgy Peruvian (Pallares variety) and the more buttery American (Lima bean variety) beans. To counteract these quality problems, FOFIFA is working on an improved PDC variety (personal interview with a representative from

FOFIFA, 2014). In the three study villages, the bean type was rarely known prior to distribution. A different bean type was known under the same name, which is a climbing plant and therefore is cultivated at fences around the house.

The Malagasy agricultural extension service (CSA), an NGO cooperating with the European Union is situated in Madagascar's rural districts and managed by local officials. It aims to contribute to increasing agricultural productivity by linking service demands of farmers with the appropriate service provider as well as training local representatives (Ministry of Agriculture, 2009). In the district capital Ambalavao, CSA provides free samples of improved seeds, mostly for rice and beans. Farmers can apply directly with the CSA or indirectly through local administration, requiring a written contract. Since 2013, a farmer in the commune of Fenoarivo is being trained as a CSA representative. In 2013, very few farmers knew about the possibility of obtaining seeds with CSA and until the end of 2013 no farmer in the sample had successfully applied for obtaining improved seeds. This was confirmed by the extension service. Additionally, there are problems on the supply side, those farmers who applied for obtaining improved seeds, often got the answer that seeds reserves were already exhausted. On the local market there are no improved seeds; seeds are usually produced and selected by the farmers themselves, exchanged among farmers or bought on the local market. Few farmers had knowledge on improved seeds in general. Due to another breeding and dissemination project on improved bean seeds of the variety Tsaramaso, the representative of the extension service in the commune knew that advantages of improved bean seeds are to obtain almost double the yield and the possibility of using all seeds for cultivation compared to seeds obtained from the local market, where only about half can be used.

Some villagers have cultural taboos (fady in Malagasy) concerning certain bean types which prohibit consumption, cultivation or even talking about beans. Voanjobory or PDC are believed to inhibit successful prevention of cattle rustling or rainfall. According to Ruud (1960) fadys are prohibitions in terms of objects which are not to come into contact with, places which have to be shunned, words which are not to be used or prohibitions on what to do. Fadys are often linked with eating habits, work taboos or burial practices. On the one hand they serve to respect and honor ancestors or elders and to identify with one's ethnic group or family. On the other hand they are often followed out of fear, as non-adherence is believed to lead to crop failure, illness or death. Jones et al. (2008) show the importance of fadys for resource conversation, Stifel et al. (2011) studied the impact of work taboos on agriculture and found that agricultural productivity and wealth is negatively affected.

About 55% of households planted one or more bean types in the season 2013 and around 8% sold their beans on the market, where average sales amounted to 106.000 Ariary (around 32€). Legumes are also important for consumption; in September 2013 legumes were consumed on average two times per week and average expenditure amounted to 1230 Ariary per week (Household survey 2013).

Legume consumption as dietary improvement has been extensively discussed in Aykroyd et al. (1982). Beans add essential vitamins and minerals to the diet, especially iron, and have a high protein value with about 27% of energy. Dietary fiber content is high as well, whereas fat content is very low with about 4% (Geil & Anderson, 1994; Messina, 1999).

Under- and malnutrition is prevalent in Madagascar, 33% of the population is undernourished (FAOSTAT, 2015). Calories are mainly obtained from staple food such as rice and cassava which leads to widespread hidden hunger. The share of cereals, roots and tubers in dietary energy supply was 79% in 2011, which is by far the highest value globally and has even been increasing since the 90s (FAOSTAT, 2011). Protein supply is very low with 48 g per capita and day, and less than the average of least developed countries. Moursi et al. (2008) showed that a higher diet diversity among Malagasy children led to improvements in diet as it was highly correlated with micronutrient density.

A higher crop diversity could contribute to a more diversified diet with higher nutritional quality. When looking at pathways from agriculture to nutrition, the evidence is mixed. Types of food, especially comparing crops and dairy products, context and location matter and effects vary greatly in size, however most studies support the hypothesis that household agricultural production has direct and important linkages with household dietary patterns and the nutrition of individual members (Carletto et al., 2015). Additionally, diversification could lead to less extended lean periods and higher agricultural incomes as it could increase selling of the products. Larochelle and Alwang (2014) found that adoption of improved bean seeds in Uganda led to an increased diet diversity, through the channels of home consumption, but also indirectly through farm income, productivity and empowerment of women. Similarly, Kabunga et al. (2014) found that fruit and vegetable production led to significant improvements in nutrition of the participating households. A higher bean cultivation and consumption in Madagascar might contribute to a more diversified diet and could help compensate deficiencies caused by little meat consumption as well as shorten the lean season. Kabunga et al. (2014) recommend more interventions involving experiments helping to better understand and establish causality of effects.

Randomized control trials to study adoption and diffusion of improved agricultural technologies are carried out more and more often (Duflo et al., 2006; Banerjee and Duflo, 2008; Barrett and Carter, 2010). Some of the experiments point to the fact that rates of return to improved agricultural technologies, like improved seeds or fertilizer might not turn out to be the same as in demonstration plots or more controlled conditions (Vandercasteelen et al., 2013), some studies found positive impacts on yields, but not on profit (Beaman et al., 2013). Fixed costs which include psychological costs of changing habits due to using new technologies might be substantial (Duflo et al., 2011). A growing number of experimental studies is looking at how information can best be disseminated among farmers (Jones and Konylis, 2014; Okello 2014; Vasilaky and Leonard, 2015; Hildebrandt et al., 2015)

Willingness-to-pay (WTP) surveys have often been used to assess social benefits of environmental policies or projects. The application to private goods, like agricultural products, is rather uncommon, as these goods are traded in markets and have observable prices. However, when it comes to the assessment of non-traded goods or value components which are not (yet) reflected by real market data, WTP surveys turn out to be a useful tool. Some recent studies assessed WTP of improved or certified seeds (Kaguongo et al., 2014; Dalton et al., 2011; Kassie et al., 2014), genetically modified seeds and foods or traditional varieties (Chelang'a et al., 2013), organically labeled and locally produced foods (Rodríguez et al., 2008; Adepoju and Oyewole 2014), inputs like fertilizer (Minten et al., 2007; Zapata and Carpio, 2014) and fortified foods (De Steur et al., 2012).

Bates et al. (2012) show by reviewing impact evaluations that receiving a product or a service for free can even increase peoples' likelihood to buy or WTP for it later. Banerjee et al. (2010) discuss the role of improved supply versus incentives in the provision of health care services. They conclude that ensuring a reliable supply was not the only important factor in adoption, but that small incentives increased adoption significantly.

Against this background, this article tries to add to the growing literature on randomized control trials to understand reasons for low adoption of improved agricultural technologies by answering the following questions:

- If seeds are distributed for free, do households cultivate them?
- Does information provided during the distribution process increase adoption and yield?
- Are people willing to pay for improved seeds?
- Do seed and information provision increase the willingness to pay for improved seeds?
- Do seed receipt and cultivation of beans improve diet diversity?

In chapter two, study design and implementation of the seed distribution, baseline and follow-up survey, focus group discussions, and the elicitation of the willingness to pay for improved bean seeds will be explained. In chapter three, results on the adoption of bean seeds, information dissemination, consumption and WTP will be given. Chapters four and five discuss the results and give recommendations for increased adoption of improved seeds as well as for an increased use of participatory experiments in the diffusion of improved agricultural methods in Madagascar.

## 2 Material and methods

### Randomized control trial - participants and study design

The study was carried out in the framework of an ongoing household survey panel between 2009 and 2014 of 390 households in three villages in a remote rural region in central Madagascar. Focus group discussions were done in the villages, dealing with seeds in 2013 and 2014. In 2014, net maps of the market for improved seeds were developed during focus group discussions.

In September / October 2013, when seeds were distributed, 390 households were eligible in the panel, 196 (50%) households received bean seeds, whereof 84 (43%) got detailed information on how to store and cultivate the seeds. The interviewers gave eligible households instructions following recommendations by FOFIFA. Seeds should be stored in plastic bags (beans were already given to households in plastic bags containing the 1.5 kpk portion size) and hung up high, ideally under the ceiling, so it is safely out of animals reach and should be sealed against insects. Sowing of the beans should take place in March at the end of the rainy season. PDC grows bushy on the ground, best growing location are flooded fields next to rice fields or rivers ("baiboho" in Malagasy). Fields should be prepared, ploughed and holes with a distance of two meters dug 20-25 centimeters deep. Cow dung should be put at the bottom of the hole and five to six seeds put in each hole. Plants should be watered every three weeks and weeded two to three times until flowering. After flowering plants do not need to be watered and weeded any more.

In November 2014, panel households were revisited in order to evaluate the seed distribution. Specifically reasons for adoption and non-adoption, as well as problems during cultivation, importance of information as well as the diffusion of this information, bean consumption and diet diversity for the two treatment groups and control group were examined. Additionally, WTP for improved bean seeds was estimated.

Focus group discussions were carried out prior to the household survey in order to shed light on the bean seed market and actors involved, the current bean seed price, knowledge and attitude towards improved seeds (Chilton and Hutchinson, 1999). "Net-Maps", a participatory interview-based mapping technique developed by Schiffer (2010), were used to let participants explain the seed market, actors involved, their linkages, their importance and influence and actors' individual objectives. Net-Maps are a tool used to "help people understand, visualize, discuss, and improve situations in which many different actors influence outcomes". As suggested by Schiffer, all actors involved in the bean market should be present at the focus group, due to the remoteness of the research area this was not possible. Therefore representatives of the agricultural extension service and the research station FOFIFA in Toliara were visited and interviewed separately about the market situation of bean seeds and improved varieties in particular in order to get a complete picture of the market and actors.

### Willingness to pay

Willingness to pay (WTP) can be defined as the amount of money an individual is willing to pay for a particular product or service. According to Bateman et al. (2002), WTP serves as indication for the monetary value individuals assign to benefits or costs. Revealed preference methods use experimental or real market data related to the good in question. WTP extracted from real markets, e.g. the decision of purchasing a particular product, are reliable indicators for consumers' preferences. When markets do not exist, as in the case of public or new goods, desired WTP information cannot be deduced from market data (Bateman et al., 2002). In this study, the distributed bean seeds can be considered a new product since improved seeds in general and PDC seeds specifically have not been sold on the local market before. Hence, there is no market data revealing consumers' WTP for these seeds.

In surveys the absence of markets can be circumvented by using hypothetical markets, where respondents have the opportunity to purchase a good or service, with the advantage that real purchasing power can be observed (Mitchell and Carson, 1989). Stated preference methods assess WTP through surveys. With survey-based techniques, where a preference is either directly or indirectly stated, buyer reactions can be collected quickly, larger sets of prices can be tested and product features can be varied. Indirect surveying methods, like conjoint analysis or discrete choice analysis, infer buyer preferences from choices made during the survey. Consumers are to decide if a product's price is acceptable or not, by deciding whether they would purchase alternative product profiles with set prices (Bateman et al., 2002; Mahieu et al., 2012).

A prominent direct stated-preference technique to assess WTP and to analyze the factors that determine the consumer's WTP is the Contingent Valuation Method (CVM). In a CVM study, a hypothetical market is created where the product in question is traded. Potential buyers are then asked how much they would be willing to pay for the product described in the

survey. The method owes its name to the fact that consumers are asked to state their WTP contingent on a description of an alternative or a specific hypothetical scenario (Mitchell and Carson 1989; Kaguongo et al., 2014). According to Bateman et al. (2002) indirect surveys should be chosen when WTP for certain attributes or relative values for different attributes are required and direct surveys like CVM when the WTP in total for the good in question is needed.

Since in this study the interest lies on the WTP for a bean variety in total and not for specific attributes, CVM is used. Bateman et al. (2002) and Antony and Rao (2010) compare different elicitation formats and explain benefits and restraints of each method. The dichotomous choice format needs a large sample in order to be representative and the payment card method is preferable to asking an open question, as the given reference values make it easier for respondents to answer. Therefore for this study the payment card was chosen as the most suitable format. For computing the WTP out of the obtained values of the payment card Haab and McConnell's (2002) formula was applied.

Whittington (1998) summarizes problems for implementation of WTP studies. Direct surveys such as CVM have several possible biases. WTP statements tend to be overstated because of prestige effects. Understatements can occur when consumers try to influence the final price in order to get the good in question for the lowest price possible (Carson and Hanemann, 2005, Breidert, 2006). Further biases are hypothetical bias, interviewer bias or range and centering biases in payment cards. Therefore, additional questions on perceptions of households were included, e.g. if the household thinks that seeds will be available on the market, how much of the seeds they would buy for the indicated price and which type of seeds households would prefer. Information from focus group discussions and net maps describing the seed market are used to validate information on WTP.

### Randomized control trial – empirical strategy

The objective of this study is to evaluate the impact of a seed distribution on yield, diet diversity and WTP of participating households. Impact evaluation generally aims to assess a program's effect against a counterfactual, which shows the situation in the absence of the program (Ravallion, 2008). Random assignment of households to a treatment guarantees that the control group is a valid counterfactual and allows simple comparisons of outcomes. If there are no differences in household characteristics between treatment and control group at baseline, any changes of outcomes can be attributed solely to the program, estimated by the average treatment effect (ATT).

ATT is the average gain of households from having received the seeds, whether they received it from an interviewer or from another household, ignoring random assignment to treatment. By adding additional controls, heterogeneity of impacts for observed control variables can be estimated (Abadie et al., 2003; Ravallion, 2008).

$$y_i = \alpha + \beta_1 treated_1 + \beta_2 treated_2 + \beta_3 x_i + \varepsilon_i$$

The intention-to-treat estimate (ITT) estimates the average treatment effect on those intended to treat with random assignment.

$$y_i = \alpha + \beta_1 treat\_intended_1 + \beta_2 treat\_intended_2 + \beta_3 x_i + \varepsilon_i$$

Yet, selective compliance and the existence of spill-overs to the control group can lead to biased estimates and underestimate the impact of the seed distribution. Some households which received seeds did not cultivate the seeds or transferred these to households in the control group. In the presence of spillovers, outcomes not just depend on random assignment but also on purposive assignment of others. Imbens and Angrist (1995) show that an average treatment effect under mild restrictions (LATE) can still be identified, even when there is no subpopulation for whom the probability of treatment is zero. They use the assignment to the treatment group in a randomized trial as an instrument variable. The actual treatment status may differ from the random assignment as some individuals may not comply with their assignment. LATE requires three conditions to be held. Eligibility for the treatment group has to be exogenous, which is held under random assignment by design of the study. The use of an instrument requires an exclusion restriction, which means that random assignment to the program only affects outcomes through actual participation in the program (Angrist et al., 1996). Condition three requires that anyone who would take the treatment if assigned to the control group would also take the treatment if assigned to the treatment group. If these conditions are hold, LATE is the average treatment effect for those households who always comply with their assignment or for those whose treatment status is changed by the instrument (Angrist et al., 1996; Galasso et al., 2004; Ravallion, 2008 and Khandker et al., 2010, Vandercasteelen et al., 2013).

## 3 Results

Baseline characteristics of the total panel originate from a household survey which took place between December 2012 and February 2013. Bean seeds were distributed in the framework of a second survey from September to November 2013.

**Table 1: Baseline characteristics**

| | Seeds + info (n=112) | Seeds (n=84) | Controls (n=194) | Total (n=390) | P value |
|---|---|---|---|---|---|
| **Household head** | | | | | |
| Age (years) | 44.3 | 47.2 | 46.6 | 46.0 | 0.368 |
| Education (years) | 4.5 | 4.1 | 4.2 | 4.3 | 0.835 |
| **Household** | | | | | |
| Size (number) | 6.1 | 5.8 | 6.5 | 6.2 | 0.300 |
| Workforce (number) | 4.0 | 3.8 | 4.4 | 4.1 | 0.343 |
| Dependents (number) | 2.2 | 2.3 | 2.3 | 2.3 | 0.369 |
| Maximum education (years) | 6.3 | 6.1 | 6.8 | 6.5 | 0.177 |
| Land per capita used (ha) | 0.48 | 0.37 | 0.41 | 0.42 | 0.273 |
| Land per capita total (ha) | 0.57 | 0.44 | 0.50 | 0.51 | 0.258 |
| Livestock per capita (number) | 2.8 | 2.0 | 2.6 | 2.5 | 0.417 |
| Agricultural equipment (dummy) | 0.71 | 0.62 | 0.62 | 0.64 | 0.272 |
| Rice yield (kg) | 1738 | 1393 | 1735 | 1663 | 0.767 |
| Cassava yield (kg) | 1718 | 1517 | 1672 | 1652 | 0.040** |
| Maize yield (kg) | 382 | 343 | 398 | 381 | 0.676 |
| Peanuts yield (kg) | 205 | 208 | 161 | 184 | 0.848 |
| Bean yield (kg) | 84 | 90 | 58 | 72 | 0.998 |
| Number of bean types cultivated | 1.5 | 1.5 | 1.5 | 1.5 | 0.883 |
| Selling to trader (dummy) | 0.89 | 0.87 | 0.85 | 0.87 | 0.853 |
| Livestock sales (dummy) | 0.65 | 0.51 | 0.63 | 0.61 | 0.096* |
| Public employment (dummy) | 0.05 | 0.01 | 0.09 | 0.06 | 0.050* |
| Own business (dummy) | 0.28 | 0.33 | 0.31 | 0.31 | 0.686 |
| Agricultural off-farm employment (dummy) | 0.56 | 0.55 | 0.57 | 0.56 | 0.956 |
| Wage work on Jatropha plantation (dummy) | 0.32 | 0.31 | 0.38 | 0.35 | 0.479 |
| Wealth self-assessment[1] | 4.0 | 3.4 | 3.7 | 3.7 | 0.120 |
| Diet diversity | 7.1 | 6.9 | 7.0 | 7.0 | 0.304 |
| Innovations[2] | 1.9 | 1.7 | 1.8 | 1.8 | 0.485 |
| Fady for at least one bean variety (dummy)[3] | 0.5 | 0.43 | 0.42 | 0.44 | 0.483 |
| Openness to innovations[4] | 4.0 | 4.1 | 4.0 | 4.0 | 0.836 |
| Social capital[5] | 2.8 | 2.8 | 2.7 | 2.8 | 0.095* |
| Social networks index[6] | 0.1 | -0.04 | -0.04 | 0 | 0.595 |

Source: Household survey 2012 and 2013

[1] Subjective wealth in the village, scale from 1-10, [2] Innovations for crops, technologies, markets and traders and work organization, ranging from 0 -5, [3] Cultural taboo to grow beans on the fields in the village, [4] Agreement to "Can hard work improve your living standard?", [5] Agreement to certain norms in the village, [6] Magnitude of social network of the household

As shown in table 1, four variables in the baseline characteristics of the households significantly differ between groups, cassava yield, livestock sales, public employment and social capital. As these four values are significantly lower for the group of households who received seeds but not information, this might hint to a problem in random assignment of information.

### Adoption of bean seeds

In 2013, when the seeds were distributed, 179 (88%) of the 203 households that received bean seeds stated that they planned to plant the seeds. Five households said they are going to give the seeds to another person, seven rejected the seeds or said they are going to cook them, reporting they cannot plant them due to fadys. Planting was recommended to take place in April 2014 and harvest in September/ October 2014. The follow-up survey was therefore carried out in November/ December 2014. As shown in table 2, 354 households were revisited, whereof 178 who received seeds. 98 households cultivated the received seeds, mostly out of curiosity. Insect damage, consumption of the seeds or taboo to plant them were reported as reasons for not planting the seeds. Households that did not receive information were significantly more likely to consume the seeds. The following tables present results from the experiment based on the initial assignment of households to the three groups, those who were assigned seeds and information, seeds only and the control group.

**Table 2: Adoption and main reason for adopting and not adopting**

| | **Seeds + info (n=106)** | **Seeds (n=72)** | **Controls (n=176)** | **Total (n=354)** |
|---|---|---|---|---|
| Cultivation | 52% | 47% | 5% | 28% |

| | **Seeds + info (n=55)** | **Seeds (n=34)** | **Controls (n=9)** | **Total (n=98)** |
|---|---|---|---|---|
| **Primary reason for adopting** | | | | |
| Consumption | 27% | 3% | 78% | 23% |
| Sales | 0% | 0% | 0% | 0% |
| Trial | 73% | 97% | 22% | 77% |

| | **Seeds + info (n=43)** | **Seeds (n=26)** | **Controls (n=10)** | **Total (n=79)** |
|---|---|---|---|---|
| **Reasons for not planting** | | | | |
| Consumption of seeds | 30% | 62% | 30% | 41% |
| Insects destroyed seeds | 58% | 31% | 60% | 49% |
| Other | 12% | 8% | 10% | 10% |

The impact of the received information on yield is shown in table 3. The achieved yield is given in Kapoaka (kpk) and ranged from 1-100 kpk. More than 50% of those who cultivated the seeds did not achieve any yield. There was no significant difference in yield between the households that received information and the ones that did not receive information. Nine households that did not receive seeds and information from interviewers, received seeds from

other sources (neighbor, family, friends) and achieved a significantly higher yield. This hints to the fact that those households that received seeds and could or did not want to cultivate them, gave it to households of whom they knew that they are experienced in bean cultivation. Control group households perceived the cultivation of PDC compared to other legumes significantly easier than the households that received bean seeds.

**Table 3: Cultivation and yield**

| | **Seeds + info (n=55)** | **Seeds (n=34)** | **Seeds from other sources (n=9)** | **Total (n=99)** |
|---|---|---|---|---|
| Evaluation of seed quality | 3.5 | 3.6 | 3.7 | 3.6 |
| Evaluation of seeding | 3.1 | 3.4 | 3.8 | 3.4 |
| Evaluation of cultivation | 3.3 | 3.4 | 3.8 | 3.3 |
| Cultivation compared to other legumes | 3.1 | 3.2 | 3.8 | 3.2 |
| Harvest compared to other legumes | 3.4 | 3.3 | 3.8 | 3.4 |
| Yield compared to other legumes | 3.0 | 2.7 | 3.8 | 3.0 |
| Yield in kapoaka | 6.7 (15.8) | 9.4 (19.1) | 29.3 (32.3) | 9.7 (19.8) |

98% of the households reported to have consumed their harvested beans. Seven households reported to have saved seeds for the next cultivation period and two households to have sold part of the harvest. No significant differences between the three groups could be detected.

### Information dissemination

Households were asked if the given information was useful and sufficient. 54% said that the information was ‘very useful’ and 47% stated that it was ‘very sufficient’. 16% of the households stated that the information was ‘not at all useful’ or ‘not useful’. Only 5% responded that the given information was ‘not sufficient’. Households that did not receive information on storage and cultivation of the bean seeds were expected to ask for information from others who received information. Table 4 shows the percentage of households that received information from other sources besides the interviewer. Out of the households that received information from the interviewers, 20% of households asked for additional information on the bean seeds from other sources. Out of the households that received seeds but no information, 12 households (17%) obtained information from other sources. Control group households informed themselves significantly less (7%). Most reported information sources were family (49%), neighbors (43%) and friends (8%).

**Table 4: Information received from other sources**

| | Seeds + info (n=106) | Seeds (n=72) | Controls (n=185) | Total (n=354) |
|---|---|---|---|---|
| Received information from other than interviewer | 20% | 17% | 7% | 12% |

As shown in Table 5, significantly more households that had received information planted the bean seeds on flooded fields, as included in the information given. Overall compliance with information given is low, more households planted the seeds on a normal field or next to the house. Yet the plantation locations had no significant difference on the reported bean yield. Three households reported to have replaced other legumes, the rest of the households said to have cultivated the seeds in addition.

**Table 5: Cultivation**

| | Seeds + info (n=55) | Seeds (n=34) | Controls (n=9) | Total (n=354) |
|---|---|---|---|---|
| Planted on "baiboho" | 46% | 27% | 0% | 35% |

## Consumption

Table 6 shows if households had consumed PDC in the 12 months prior to the interview and legumes in general in the week prior to the interview. As mentioned earlier, PDC were sold on the local market in the time between the survey in 2013 and 2014. 45% of the 354 household stated that they had tried the beans in the past year, with significant differences between treatment and control group. However, no significant differences could be detected when looking at legume consumption and diet diversity.

**Table 6: Consumption**

| | Seeds + info (n=106) | Seeds (n=70) | Controls (n=176) | Total (n=354) |
|---|---|---|---|---|
| PDC (past 12 months) | 62% | 65% | 26% | 45% |
| Consumption of legumes (Dummy) | 0.9 | 0.9 | 0.8 | 0.8 |
| Consumption of legumes (number of times, past week) | 3.3 | 3.5 | 3.2 | 3.3 |
| Consumption of legumes from own production (past week) | 71% | 77% | 66% | 70% |
| Expenditures for legumes (in Ariary, past week) | 309 | 374 | 433 | 384 |
| Diet diversity (WFP, with weights, 7 days) | 10.7 | 10.8 | 10.8 | 10.8 |

Table 7 shows where the beans were obtained. 38% of the households stated that they had purchased the beans on the market and 30% of the households consumed the distributed seeds. 28% of the 159 households had consumed the beans from their own production, with significant differences between the groups. A trader on the market confirmed that after the seeds had been distributed he sold PDC on the market, originating from the region of Toliara. This might explain the high percentage of control group households having consumed PDC.

**Table 7: Purchase of PDC**

| | **Seeds + info (n=66)** | **Seeds (n=47)** | **Controls (n=46)** | **Total (n=159)** |
|---|---|---|---|---|
| **Source** | | | | |
| Market | 27 | 30 | 63 | 38% |
| From other farmers/friends | 0 | 0 | 9 | 3% |
| Own production (from distributed seeds) | 38 | 26 | 15 | 28% |
| The distributed seeds | 35 | 45 | 9 | 30% |
| Other | 0 | 0 | 4 | 1% |

When asked about the perceived quality in terms of taste, handling while cooking, visual impression and overall quality compared to other beans, an overall positive attitude can be observed. Control group households rated the quality of the PDC beans compared to other legumes significantly better.

**Table 8: Evaluation of quality of PDC beans**

| **Evaluation from 1 (worst) to 5 (best)** | **Seeds + info (n=105)** | **Seeds (n=71)** | **Controls (n=160)** | **Total (n=158** |
|---|---|---|---|---|
| Taste | 4.5 | 4.5 | 4.6 | 4.5 |
| Cooking | 4.5 | 4.6 | 4.5 | 4.5 |
| Appearance | 4.3 | 4.4 | 4.4 | 4.4 |
| Texture | 4.5 | 4.6 | 4.5 | 4.5 |
| Quality compared to other legumes | 3.6 | 3.5 | 3.9 | 3.7 |

### Seeds

58% of the farmers stated that they usually produce their own legume seeds, 30 % of the farmers said they usually buy their seeds at the market, 10% buy them with other farmers and the rest mostly received seeds from family members. In total, at least once in the last 5 years, 49% of all households cultivating legumes reported to have bought seeds, 64% to have produced their own seeds and 21% bought with other farmers in the village.

Table 9 shows the importance of different seed traits for the households.

**Table 9: Improved seeds – importance for seed selection, % of households**

| | Importance | | | | | |
|---|---|---|---|---|---|---|
| | Not at all | Not | Little | Important | Very | Don't know |
| Yield | 0.3 | 0.3 | 3.8 | 40.1 | 55.3 | 0.3 |
| Resistance against pests | 8.5 | 17.7 | 26.5 | 43 | 4.1 | 0.3 |
| Drought resistance | 7.9 | 14.6 | 30.1 | 42.4 | 4.1 | 0.3 |
| Cultivation aspects | 1.2 | 6.1 | 17 | 47 | 29.3 | 0 |
| Taste | 0.3 | 0.3 | 8.5 | 52.1 | 38.6 | 0.3 |
| Possibility of selling | 5.3 | 1.5 | 5.3 | 25.8 | 48.5 | 13.8 |

Farmers were then asked if they plan to grow/regrow or buy PDC for consumption in the future. As shown in table 10, 40% of the households stated that they would purchase PDC for consumption on the market, 49% said they were interested in cultivating the beans. Those households that received information are significantly more likely to buy and cultivate PDC than the other two groups. Some households indicated that they would plant the seeds if they were given to them for free.

**Table 10: Future cultivation intentions**

| | **Seeds + info (n=105)** | **Seeds (n=71)** | **Controls (n=160)** | **Total (n=336)** |
|---|---|---|---|---|
| Purchase intention | 50% | 37% | 35% | 40% |
| Cultivating intention | 58% | 47% | 44% | 49% |

The majority of households prefers to buy the seeds in March (217), February (54) and April (31). This might reflect storage problems like insect damage. The majority of households would prefer the option to buy the improved seeds at the local market over buying with other farmers and the extension service.

When the households were asked which importance they would attribute to certain traits, yield (53% stated yield as 'very important'), the possibility to sell the beans (47% stated it to be 'very important') followed by taste and mode of cultivation (difficulty of cultivation, if it is easy to cultivate a product or if certain complicated steps have to be adhered to) were named. Surprisingly pest and disease resistance and drought tolerance do not seem to play a very important role to most households. Results from the household survey and focus group discussions show that the majority of households were unaware of the existence of improved seeds and therefore also of the possibility of breeding more resistant and tolerant seeds. In

focus group discussions they stated that improved seeds are properly sorted, i.e. the biggest, not damaged seeds.

### Willingness to pay

According to focus group discussion and information from traders on the market, the price for bean seeds range between 500-600 Ar/kpk, therefore the reference value of 550 Ar was chosen for comparison. The mean WTP of all 350 households amounts to 942 Ar/kpk which is 171% of the price for beans which can be purchased on the local market (premium of 42% compared to the average bean price). The WTP for improved bean seeds of the distributed seeds (PDC) and the most common traditional variety (Tsaramaso) is shown in Table 11. Interviewees stated a higher mean WTP for Tsaramaso seeds, 952 Ariary compared to 878 Ariary for PDC seeds, however the difference is not significant.

**Table 11: Mean WTP for improved bean seeds of distributed and traditional variety**

| WTP (in Ariary) | Mean | Standard Deviation | Minimum | Maximum | Observations |
|---|---|---|---|---|---|
| Overall | 942.17 | 224.43 | 300 | 1550 | 350 |
| Tsaramaso | 952.16 | 189.18 | 500 | 1550 | 303 |
| PDC | 877.81 | 377.24 | 300 | 1475.50 | 47 |

Table 12 shows that there was no significant difference in mean WTP between treatment and control groups.

**Table 12 WTP for distributed seeds – Differences between groups**

| WTP (in Ariary) | Seeds + info | Seeds | Controls | Total |
|---|---|---|---|---|
| Overall WTP (Ariary) | 918 (237) | 922 (204) | 965 (224) | 942 (224) |
| Tsaramaso | 960 (182) | 916 (189) | 962 (193) | 952 (189) |
| PDC | 718 (351) | 961 (303) | 984 (395) | 878 (377) |

When households where asked to indicate their personal estimation of the likelihood that improved bean seeds would be offered on the market in Fenoarivo, the mean answer was “likely” (4 out of 5, median 4). ). Almost 70% of the respondents thought it was very likely that they could afford the beans at the stated price (mean 3.9 out of 5, median 5). The likelihood that the improved bean seeds would be offered at the household’s stated price, the mean answer was 3.8 out of 5 (median 4). No differences between treatment and control group could be detected.

Table 13 shows the impacts of seed distribution on PDC yield, WTP for improved beans and diet diversity. In all three models, a significant impact on PDC yield is observed. For ITT and LATE, which take selection bias into account, a significant negative impact on WTP is observed. There is no significant impact of seed distribution on legume consumption and diet diversity.

**Table 13 Impact of seed distribution on PDC yield, WTP and diet diversity**

| | PDC yield (n=353) | WTP (n=350) | Diet diversity (n=354) |
|---|---|---|---|
| **ATT** | 5.28*** (1.16) | -35.76 (24.00) | -0.031 (0.23) |
| **ITT** | 2.47** (1.19) | -45.21* (23.90) | -0.065 (0.23) |
| **LATE** | 3.13** (1.47) | -57.75* (30.54) | -0.083 (0.30) |

Additional controls added show that next to seed distribution, willingness to take risks is a significant predictor of yield. Significant predictors for WTP are cultivated land area, workforce within the household and access to mutual help, if the household knows the agricultural extension service, risk aversion and expenditures for legumes, whereas for diet diversity education of the household head, crop diversity and public employment are significant positive predictors.

## 4 Discussion

Results show that improved seeds can be distributed at low cost if project or survey infrastructure and baseline data are available. With the help of randomized distributions in controlled settings improved seeds could be distributed in a much faster rate than public extension service is able to achieve, for a much higher percentage of the population and recommendations for scaling-up can be given. Yet, in this study, seed distribution did not increase WTP for improved bean seeds and diet diversity and legume consumption. In terms of the achieved impacts, this seed distribution was not effective. In the following discussion possible reasons and recommendations for achieving higher impacts will be given.

During seed distribution in 2013, 88% of households that received PDC seeds stated they would cultivate them. In 2014 only 54% of households stated to have cultivated the seeds. The households were told that a lottery decided who is going to receive the seeds. Some households nonetheless might have stated to cultivate the seeds in order to ensure that they receive them. Results from focus group discussions and from personal interviews with the representative of the extension service in the village showed that some households have fadys against beans and therefore might not have been willing to cultivate, eat or talk about it. Some households rejected to accept seeds, others stated they cannot cultivate them but wanted to keep them for consumption or giving them to others. Due to the ongoing household survey seeds were distributed already in November, six months from sowing time. Long storage time and limited storing possibilities might have led to the high number of 39 households which reported that their seeds were destroyed by insects. Households that did not receive information were more likely to consume the seeds already at the beginning of the lean season and not take the risk of keeping the seeds until the planting season. Households that received information might have kept the seeds with the intention to plant them, which points to the importance of information.

Other than that, information on storage and cultivation had no significant impacts on the outcomes like yield. Reasons for the low mean yield of 8 kpk could be the time difference between distribution and cultivation, households might not have remembered the cultivation techniques explained by the interviewers or might have deliberately chosen to stick to their known cultivation technique. 63% of households that cultivated legumes estimated climatic

conditions for cultivating legumes in 2014 ‘much worse’ or ‘worse’ compared to the past 5 years. Based on the result that households prefer traditional to new varieties it is recommended to disseminate improved seeds of known bean varieties before introducing unknown varieties.

As illiteracy is still widespread in the region, information was given verbally only, thus households were not able to look up information which they might not have remembered at sowing time. The beans have not been planted before in the villages, there was no local contact person to ask questions and the nearest place to get information was in the district capital Ambalavao. The expected information exchange between the villagers (asking for and passing on the information about storage and cultivation) did not take place as hypothesized. According to the representative of the extension service, many villagers are not willing to share information and knowledge and many believe that old and proven techniques are better than new ones. Seed quantity distributed to households was small and only 92 households had cultivated the PDC seeds. Fields are scattered and people might not have seen the plants growing on the field and thus not noticed the cultivation and not talked about it. In future studies more emphasis could be put on different kinds of information diffusion, like videos or visual aid, containing pictures and short sentences with information about proper storage, how to sow effectively, the cultivation method, weeding and when and how to harvest. Dissemination of information could be improved by training more local representatives about storage and cultivation techniques and given as contact persons for households in case they have questions or encounter problems. Several alternatives like local markets, farmer-to-farmer information provision (see e.g. Vasilaky, 2015), or by the extension service could be tested.

As the cultivation techniques explained included application of cow dung and irrigation, which involves some fadys, households might have been discouraged to apply the explained cultivation techniques and stick to the traditional way of cultivating beans. Work on a nearby large-scale Jatropha plantation did not have significant effects on yield. Households that work there might have learned new techniques like applying cow dung or might have had access to information as the plantation management is also cultivating other crops and beans. However, cow dung on the plantation is only applied for Jatropha, which is different in cultivation, preventing spill-overs. Social pressure concerning fadys for cow dung application might further prevent the use of cow dung. These results are comparable to Minten et al. (2009), who found that compost and chemical fertilizer application in vegetable cultivation in Madagascar was significantly affected by supervision from the contracting firm – the more supervision the more compost was applied. Due to fadys, some households might have stated other reasons for not cultivating since they might not wanted to talk about PDC or consulted opinion leaders in the village later. The adoption process of Voanjobory showed that it might take some years until fadys are overcome. Further research could look at long-term effectiveness of seed distributions. It would be interesting to see if PDC experience a similar adoption process.

The insect damage might explain why a majority of the households said they would prefer to buy the seeds in March or April, just before the planting season. This result is contrary to what Duflo et al. (2008) found, namely that farmers in Kenya in an experimental setting were willing to buy fertilizer at harvest time when they had cash available and store it to be used

several months later. Reasons might be that seeds are more difficult to store than fertilizer and the hypothetical character of the question on the preferred buying time. In further studies, the time when seeds are provided and when farmers have to pay could be varied between groups and effects on the resulting demand estimated (see Duflo et al., 2008). Distribution of packaged seeds could avoid problems like insect damage.

In all three stages of bean cultivation, women had the major share. Women are also responsible for preparing food. This is similar to other settings, as in Larochelle and Alwang (2014), who found that in Rwanda beans are mainly cultivated by women, which had a positive effect for diet diversity as women might have control over bean sales and therefore might be in a better position to influence household nutrition outcomes. To achieve a bigger impact of seed distribution and bean cultivation it is suggested to include women in training and enable them to contribute their knowledge and ideas, as well as training and informing women on nutrition characteristics of beans and investigate impacts of this information on household nutrition. Katungi et al. (2011b) found a need for well-adapted varieties and multi-attribute breeding like a reduction in cooking time. They argue that this less-tangible information should be included in the dissemination of new bean varieties to increase adoption.

To overcome the criticism that randomized control trials are not able to understand the processes which determine the impacts, Ravallion (2008) suggests the use of intermediate indicators additionally to outcome indicators. If the adoption and cultivation process is more closely monitored, compliance with information given, inputs used or problems reported in cultivation could be used as intermediate indicators.

Mean WTP for improved bean seeds was estimated at 171% of the market price for traditional seeds or at a premium of 42% compared to traditional seeds. This result is comparable to other studies. Kaguongo et al. (2014) who valued certified potato seeds in Kenya found that farmers on average were willing to pay 190% of the price for farmer seeds compared to certified seeds and 170% compared to clean seeds. Chelang'a et al. (2013) assessed the WTP for African leafy vegetables, they found that consumers prefer them to exotic leafy vegetables and are willing to pay an average premium of 79% for African leafy vegetables. This considerable difference in premium might be due to the fact that in the study of Chelang'a et al. (2013) consumers already knew the good in question.

An interesting result is that 87% of the households answering the WTP question chose the familiar Tsaramaso bean seeds over the distributed PDC variety, when asked which of the two they prefer to buy or which of the two they would buy if offered at the same price. Mean WTP for Tsaramaso seeds was higher than for PDC seeds. An explanation for this can be that households selecting PDC were significantly more willing to take risks, independent if they were successful in cultivating the seeds or might have been disappointed by their experience. Risk aversion was also associated with a significantly lower WTP for weather-index insurance in Ethiopia (Hill et al., 2011). Fady for the PDC might also have played a role, due to social pressure households might stick to already cultivated, non-fady bean varieties. This confirms the results from Moser and Barrett (2003) who found that social conformity limits adoption of new varieties and technologies. Chelanga et al (2013) found a significant and positive influence of years households' had consumed African leafy vegetables. When

compared to the adoption process of Voanjobory, households might need more than one season to observe cultivation of others and after seeing that nothing bad happened start cultivating themselves.

Households that evaluated the seed quality of a private input seller as a proxy for knowing their seed quality reported a significantly higher WTP. This compares to Kaguongo et al. (2014), who found farmers' awareness of quality seeds had a positive impact on WTP. Cultivated land per capita as a proxy for wealth, and expenditures for legumes have a significant positive effect on the WTP. Ulimwengu and Sanyal (2011) also found in their study estimating farmers' WTP for agricultural services, that the size of land owned by farmers increased WTP. Adepoju and Oyewole (2014) studied the WTP of consumers for bread with varying degrees of cassava flour inclusion and also found household income and share of bread in total household food expenditure as significant influencing variables on WTP.

Village did not have an influence on WTP. This compares to the study of Kaguongo et al. (2014), suggesting that remoteness to markets does not result in a lower WTP, neither does proximity to markets increase WTP. Moreover no further statistical influence could be found when controlling for gender and years of education of the household head as well as household size, achieved yield. This is contrary to the study of Chelang'a et al. (2013), who found a significant and positive influence of years of education of household head and the number of children below the age of 18 living in the household. Education is also an influencing variable on WTP in the study of Okello et al. (2014).

Antony and Rao (2010) found that factors which influence consumers' WTP in CVM studies might often be unobserved, resulting in inadequate explanatory power of the regression models and potentially biased parameters. One potential restriction with CVM is hypothetical bias, the difference between stated and revealed values, shown by Murphy et al. (2005) by comparing stated and actual values. As in this study there is no possibility to compare these results with actual purchasing behavior, a hypothetical bias cannot be ruled out. In order to minimize hypothetical bias, another difficulty was to set the lower bound of the payment card, but at the same time trying to keep a realistic range which households could choose from. Households were given the information that the yield of improved bean seeds would be roughly the double of normal beans. Therefore it seemed reasonable to set the lower bound at 1000 Ariary, which is a little less than double the amount paid for normal beans. Furthermore other benefits like higher pest and disease resistance and higher drought tolerance were given. Another shortcoming of this research is the difference between the WTP selected within the payment card range and the one stated below the payment card. From the payment card mean interval values where used, whereas the values below the payment card are a self-picked value below 1.000 Ariary. Assuming a household did not select an amount from the payment card, but declared to be willing to pay 800 Ariary maximum, then it cannot be determined if the 800 Ariary were from the interval of 750-800 Ariary or 801-850 Ariary. Therefore it is not possible to measure nuances and it is problematic to find a solution to apply to regression analysis. Compared to open questions the payment card has the advantage that it offers respondents a visual aid for the choice. Yet it does not overcome the problem of biased understatements, which some respondents might have given, trying to influence the final price. Therefore it might be possible that the determined mean WTP value of 942 Ariary/kpk

in this research is subject to understatement as some respondents might have tried to influence the final price.

Interviewer bias is another potential influence on the stated WTP amount. It is possible that some interviewers explained the WTP question in a more understandable way for the interviewees and had a greater ability to empathize. Himelein (2015) studied interviewer effects in quantitative data collection and found effects especially in the event of sensitive and subjective questions. The WTP question is considered to be subjective and sensitive and thus might be subject to interviewer effects. It is strongly advised by Himelein (2015) to consider traditional cultural norms for topics apart from standard objective questions in surveys. Yet according to her findings respondents' characteristics explain the variations in answers. Even though the interviewers were trained together and role plays were conducted beforehand so that every interviewer would ask the questions in the same manner, differences might have occurred in personality, empathy, establishing trust during the interview, and the mode of explaining and posing the questions. Due to the biases and potential influences on the WTP for improved bean seeds it might have been more helpful to assess WTP for different traits of the improved bean with conjoint analysis seeds instead of the seeds in general. This was discarded during the questionnaire pretest, as respondents had difficulties in distinguishing between different traits of the seeds due to the non-existence of improved seeds.

Contrary to the findings of Bates et al (2012) receiving a product or a service for free can even increase peoples' likelihood to buy or WTP for it later, in this study the control group reported a higher willingness to pay. Reasons can be the insect damage, the low yield due to climatic conditions which households evaluated worse than in other years and due to the inability of following the cultivation recommendations.

The WTP estimated in this study can be useful for the extension service having the objective of distributing their improved bean seeds to farmers. Descriptive results show that the majority of farmers are well informed about availability and selling points of seeds. However, they lack knowledge about technologies and possible benefits. Information on seeds was disseminated mainly through family members. In the adoption of Bambara groundnut a nearby large-scale bioenergy plantation plays a significant role. Net maps compiled during the focus group discussions turned out to be a very helpful and easy-to-implement tool, as in the process participants learned about the breeding program of the Ministry of Agriculture and the possibility of obtaining improved seeds with the extension service. The training of a local farmer in the commune has shown to be an effective means of disseminating knowledge about improved inputs from the extension service to the village. These results strengthen the importance and the need for public extension service in rural Madagascar. However according to the focus group discussions and the household survey it became evident that the majority of households do not know the extension service or how they can benefit from it. Therefore we conclude that having a representative in the commune is not enough and too bureaucratic to foster the use of improved inputs among farmers. To make seeds more easily accessible in remote regions the extension service could cooperate with private input sellers who could take over the marketing. In addition of targeting male and female farmers, we suggest cooperation of the extension service with schools. Educating children in agricultural production processes and the agricultural market might lead to long-term benefits and might

also lead to more participation of the rural population in development programs. More participatory programs which match farmers' needs could focus not only technological problems but also allow the consideration of social processes which might hinder innovations. Given the evidence that only a small fraction of the seed demand is supplied by the public sector and that private enterprises are lacking in the seed sector, future research should also look at seed production by farmers or farmers' associations (see e.g. Tin et al., 2011).

## Sources


Abimbola, O. 'Households' Perception and Willingness to Pay for Bread with Cassava Flour Inclusion in Oshogbo Metropolis, Osun State, Nigeria', *Int.J.of AgriScience,* vol. 4/no. 2, (2014), pp. 127-139.

Alemayehu. 'Reinvigorating Bean Seed System in Ethiopia: Role of Farmers and Social Institutions', *Seed Info,* no. 36, (2009), pp. 11; 11-16; 16.

Antony, Jubin, and Aruna Rao. *Contingent Valuation: A Review with Emphasis on Estimation Procedures,* (2010).

Banerjee, A. V., and E. Duflo. *The Experimental Approach to Development Economics,* (2008).

Barrett, Christopher B. 'Poverty Traps and Resource Dynamics in Smallholder Agrarian Systems', *Economics of Poverty, Environment and Natural-Resource use,* (2008), pp. 17-40.

Barrett, Christopher B., and Michael R. Carter. 'The Power and Pitfalls of Experiments in Development Economics: Some Non-Random Reflections', *Applied Economic Perspectives and Policy,* vol. 32/no. 4, (2010), pp. 515-548.

Bates, Mary Ann, Rachel Glennerster, Kamilla Gumede, et al. 'The Price is Wrong', *Field Actions Science Reports. The Journal of Field Actions,* Special Issue 4, (2012).

Beaman, Lori A., Dean Karlan, Bram Thuysbaert, et al. *Profitability of Fertilizer: Experimental Evidence from Female Rice Farmers in Mali,* (2013).

Breidert, Christoph, Michael Hahsler, and Thomas Reutterer. 'A Review of Methods for Measuring Willingness-to-Pay', *Innovative Marketing,* vol. 2/no. 4, (2006), pp. 8-32.

Carletto, Gero, Marie Ruel, Paul Winters, et al. 'Farm-Level Pathways to Improved Nutritional Status: Introduction to the Special Issue', *The Journal of Development Studies,* (2015).

Carson, Richard T., and W. Michael Hanemann. 'Contingent Valuation', *Handbook of Environmental Economics,* vol. 2 (2005), pp. 821-936.

Chelang'a, PK, GA Obare, and SC Kimenju. 'Analysis of Urban Consumers' Willingness to Pay a Premium for African Leafy Vegetables (ALVs) in Kenya: A Case of Eldoret Town', *Food Security*, vol. 5/no. 4, (2013), pp. 591-595.

Chilton, Susan M., and W. George Hutchinson. 'Do Focus Groups Contribute Anything to the Contingent Valuation Process?', *Journal of Economic Psychology*, vol. 20/no. 4, (1999), pp. 465-484.

Dalton, T. J., M. Yesuf, and Lutta Muhammad. 'Demand for Drought Tolerance in Africa: Selection of Drought Tolerant Maize Seed using Framed Field Experiments', no. 103712, (2011), .

De Steur, Hans, Xavier Gellynck, Shuyi Feng, et al. 'Determinants of Willingness-to-Pay for GM Rice with Health Benefits in a High-Risk Region: Evidence from Experimental Auctions for Folate Biofortified Rice in China', *Food Quality and Preference*, vol. 25/no. 2, (2012), pp. 87-94.

Deaton, Angus. 'Instruments, Randomization, and Learning about Development', *Journal of Economic Literature*, (2010), pp. 424-455.

Duflo, E., M. Kremer, and J. Robinson. 'Nudging Farmers to use Fertilizer: Theory and', *American Economic Review, 101(6): 2350–90.*, (2011), .

Duflo, E., R. Glennerster, and M. Kremer. Using Randomization in Development Economics Research: A Toolkit', in *Handbook of Development Economics*, Volume 4, 3895-3962.

Filières de l'Agriculture, de l'Elevage et de la Pêche, et Actions du Ministère de l'Agriculture, de l'Elevage et de la Pêche: Filière Grain Secs, Sommaire. Fiche n° 106. Available at http://inter-reseaux.org/IMG/pdf_106_Filiere_Grains_secs.pdf

Geil, Patti Bazel, and James W. Anderson. 'Nutrition and Health Implications of Dry Beans: A Review.', *Journal of the American College of Nutrition*, vol. 13/no. 6, (1994), pp. 549-558.

Gibson, R. 'How Sweet Potato Varieties are distributed in Uganda: Actors, Constraints and Opportunities', *Food Security*, vol. 5/no. 6, (2013), pp. 781-791.

Haab, T. C., and K. E. McConnell. , *'Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation'*, Edward Elgar Publishing, 2002.

Hill, Ruth Vargas, John Hoddinott, and Neha Kumar. 'Adoption of Weather-Index Insurance: Learning from Willingness to Pay among a Panel of Households in Rural Ethiopia', *Agricultural Economics*, vol. 44/no. 4-5, (2013), pp. 385-398.

Hounkonnou, Dominique, Dansou Kossou, Thomas W. Kuyper, et al. 'An Innovation Systems Approach to Institutional Change: Smallholder Development in West Africa', *Agricultural Systems*, vol. 108/(2012), pp. 74-83.

Imbens, Guido W. *Better LATE than Nothing: Some Comments on Deaton (2009) and Heckman and Urzua (2009)*, (2009).

Kabunga, Nassul, Shibani Ghosh, and Jeffrey K. Griffiths. 'Can Smallholder Fruit and Vegetable Production Systems Improve Household Food Security and Nutritional Status of Women? Evidence from Rural Uganda', (2014).

Kaguongo, Wachira, Gladys Maingi, Ian Barker, et al. 'The Value of Seed Potatoes from Four Systems in Kenya', *American Journal of Potato Research*, vol. 91/no. 1, (2014), pp. 109-118.

Kassie, Girma T., Awudu Abdulai, John MacRobert, et al. 'Willingness to Pay for Drought Tolerance (DT) in Maize in Communal Areas of Zimbabwe', no. 169747, (2014).

Katungi, E., D. Wozemba, and JC Rubyogo. 'A Cost Benefit Analysis of Farmer Based Seed Production for Common Bean in Kenya', *African Crop Science Journal*, vol. 19/no. 4, (2011), pp. 409-415.

Katungi, Enid, Louise Sperling, David Karanja, et al. 'Relative Importance of Common Bean Attributes and Variety Demand in the Drought Areas of Kenya', *Journal of Development and Agricultural Economics*, vol. 3/no. 8, (2011), pp. 411-422.

Larochelle, C., J. Alwang, GW Norton, et al. 'Impacts of Improved Bean Varieties on Poverty and Food Security in Uganda and Rwanda', *Crop Improvement, Adoption and Impact of Improved Varieties in Food Crops in Sub-Saharan Africa*, (2015), pp. 314.

Mahieu, Pierre-Alexandre, Pere Riera, and Marek Giergiczny. 'The Influence of Cheap Talk on Willingness-to-Pay Ranges: Some Empirical Evidence from a Contingent Valuation Study', *Journal of Environmental Planning and Management*, vol. 55/no. 6, (2012), pp. 753-763.

Minten, Bart, Jean-Claude Randrianarisoa, and Christopher B. Barrett. 'Productivity in Malagasy Rice Systems: Wealth-differentiated Constraints and Priorities', *Agricultural Economics*, vol. 37/no. s1, (2007), pp. 225-237.

Minten, Bart, and Christopher B. Barrett. 'Agricultural Technology, Productivity, and Poverty in Madagascar', *World Development*, vol. 36/no. 5, (2008), pp. 797-822.

Minten, B., B. Koru, and D. Stifel. 'The Last Mile(s) in Modern Input Distribution: Pricing, Profitability, and Adoption', *Agricultural Economics*, vol. 44/no. 6, (2013), pp. 629-646.

Mitchell, Robert Cameron, and Richard T. Carson. , *'Using Surveys to Value Public Goods: The Contingent Valuation Method'*, Resources for the Future, 1989.

Moser, Christine M., and Christopher B. Barrett. 'The Disappointing Adoption Dynamics of a Yield-Increasing, Low External-Input Technology: The Case of SRI in Madagascar', *Agricultural Systems*, vol. 76/no. 3, (2003), pp. 1085-1100.

---. 'The Complex Dynamics of Smallholder Technology Adoption: The Case of SRI in Madagascar', *Agricultural Economics,* vol. 35/no. 3, (2006), pp. 373-388.

Moursi, M. M., M. Arimond, K. G. Dewey, et al. 'Dietary Diversity is a Good Predictor of the Micronutrient Density of the Diet of 6- to 23-Month-Old Children in Madagascar', *The Journal of Nutrition,* vol. 138/no. 12, (2008), pp. 2448-2453.

Rodríguez, Elsa Mirta M., María Victoria Lacaze, and Beatriz Lupín. 'Contingent Valuation of Consumers' Willingness-to-Pay for Organic Food in Argentina', (2008).

Schiffer, Eva, and Jennifer Hauck. 'Net-Map: Collecting Social Network Data and Facilitating Network Learning through Participatory Influence Network Mapping', *Field Methods,* vol. 22/no. 3, (2010), pp. 231-249.

Sperling, Louise, H. David Cooper, and Tom Remington. 'Moving Towards More Effective Seed Aid', *The Journal of Development Studies,* vol. 44/no. 4, (2008), pp. 586-612.

Sperling, Louise, and Shawn McGuire. 'Understanding and Strengthening Informal Seed Markets', *Experimental Agriculture,* vol. 46/no. 02, (2010), pp. 119-136.

Stifel, David, Marcel Fafchamps, and Bart Minten. 'Taboos, Agriculture and Poverty', *Journal of Development Studies,* vol. 47/no. 10, (2011), pp. 1455-1481.

Stifel, David, and Bart Minten. 'Isolation and Agricultural Productivity', *Agricultural Economics,* vol. 39/no. 1, (2008), pp. 1-15.

Tin, H. Q., N. H. Cuc, T. T. Be et al. 'Impacts of Seed Clubs in Ensuring Local Seed Systems in the Mekong Delta, Vietnam', *Journal of Sustainable Agriculture,* vol. 35/no. 8, (2011), pp. 840-854.

Vandercasteelen, J., M. Dereje, B. Minten, et al. *Scaling-Up Adoption of Improved Technologies: The Impact of the Promotion of Row Planting on Farmers' Teff Yields in Ethiopia*, (2013), .

Vasilaky, Kathryn. 'Female Social Networks and Farmer Training: Can Randomized Information Exchange Improve Outcomes?', *American Journal of Agricultural Economics,* vol. 95/no. 2, (2013), pp. 376-383.

Whittington, Dale. 'Administering Contingent Valuation Surveys in Developing Countries', *World Development,* vol. 26/no. 1, (1998), pp. 21-30.

Zapata, Samuel D., and Carlos E. Carpio. 'The Theoretical Structure of Producer Willingness to Pay Estimates', *Agricultural Economics,* vol. 45/no. 5, (2014), pp. 613-623.