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DOI: <http://dx.doi.org/10.4314/acsj.v25i2.5>



ECONOMIC PERFORMANCE OF COMMUNITY BASED BEAN SEED PRODUCTION AND MARKETING IN THE CENTRAL RIFT VALLEY OF ETHIOPIA

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(Received 8 June, 2016; accepted 8 May, 2017)

ABSTRACT

Limited access to seed of improved varieties is an impediment to agricultural productivity in sub-Saharan Africa. Researchers in the national and international agricultural research systems have been piloting a community based seed multiplication and marketing enterprises (CBSME) model, as an alternative to the formal seed systems, in order to increase availability and accessibility to quality seed of improved common bean (*Phaseolus vulgaris* L.) varieties by smallholder farmers. The objective of this study was to assess the profitability of CBSME as an enterprise for seed production and analyse factors that influence farmers' decisions to participate in it as seed producers or buyers of seed. Gross margins were computed to assess value addition at farm level; while Tobit and multivariate probit models used to respectively, analyse determinants of participation in community based seed multiplication enterprise and its use by producers as a seed source. The community based seed multiplication enterprises were found to be profitable, generating US\$792 as gross margins and accessible to farmers for the bean seed, along other seed sources, i.e. formal and informal seed systems. These three seed production and delivery models competed at farm level, but complemented each other in terms of reaching users in different social groups and locations. Community based seed multiplication enterprises as sources of seed were used by farmers located in rural areas and those in farmer organisations/cooperatives. However, seed production through this model is concentrated closer to urban areas, where individual seed producers are easily linked to the formal seed system. This, however, makes the marketing of seed reliant on big buyers for redistribution among remote farming communities.

Key Words: Community bean seed multiplication, Ethiopia, improved varieties, seed systems

RÉSUMÉ

L'accès limité aux semences de variétés améliorées est un obstacle à la productivité agricole en Afrique sub-Saharienne. Les chercheurs dans les systèmes nationaux de recherches agricoles sont entrain de tester des modèles d'entreprises communautaires de multiplication et de commercialisation (CBSME); comme une alternative aux systèmes semenciers formels, dans le but d'accroître la disponibilité et l'accessibilité aux semences de qualité de l'haricot commun (*Phaseolus vulgaris* L.) par les petits producteurs. L'objectif de cette étude était d'évaluer la rentabilité de CBSME comme une entreprise de production des semences et d'analyser les facteurs qui influencent les décisions des producteurs à y participer en tant que producteurs et acheteurs de semences. Les marges brutes

étaient calculées pour évaluer la valeur ajoutée au niveau de l'exploitation agricole, tandis que les modèles de Tobit et multivarié de Probit étaient utilisés respectivement, pour analyser les déterminants de participation à l'entreprise de multiplication des semences communautaires et son utilisation par les producteurs comme une source de semences. Les entreprises de multiplication des semences communautaires ont été identifiées rentables, générant des marges brutes de 792 US dollars et les semences de l'haricot sont accessibles aux producteurs, comparées à d'autres sources de semences, c'est-à-dire les systèmes semenciers formel et informel. Ces trois modèles de production et de distribution des semences se rivalisent à l'échelle de l'exploitation agricole, mais se complètent en atteignant différents groupes sociaux d'utilisateurs dans de localités différentes. Les entreprises de multiplication des semences communautaires comme sources de semences, étaient utilisées par les producteurs situés dans les milieux ruraux et ceux en organisations/coopératives paysannes. Néanmoins, la production des semences à travers ce modèle est plus concentrée dans les zones urbaines, où les producteurs individuels de semences entrent facilement en contact avec le système semencier formel. Ceci, cependant met la commercialisation de la semence en étroit contact avec les grands acheteurs pour la redistribution des semences entre les communautés paysannes isolées.

Mots Clés: Multiplication de semence communautaire d'haricot, Ethiopie, variétés améliorées, systems semenciers

INTRODUCTION

The world's demand for common bean (*Phaseolus vulgaris* L.) is increasing due to population growth and improvement in economies, especially in developing countries. This growth in bean demand provides trade opportunities for small scale growers to commercialise their bean production and improve their livelihoods. However, common bean production is highly susceptible to a number of biotic and abiotic constraints, notably, drought, diseases and low soil fertility (Buruchara *et al.*, 2011), which necessitate research to enhance adaptability of the crop to the ever increasing environmental stresses.

The major bean research thrust in Sub-Saharan Africa has been on developing bean varieties that are adapted to multiple constraints, as a strategy to reduce yield loss due to biotic and abiotic stresses. However, like other self-pollinated crops, access and use of research derived new bean varieties by the target beneficiaries is constrained by the fact that commercial private seed companies are hesitant to invest in seed business because seed demand is uncertain.

In Ethiopia, the government owned seed enterprise have for long been operating below capacity, and thus unable to supply adequate quantities of bean seed and/or provide a diversity of bean varieties (Rubyogo *et al.*,

2010). Besides, the Ethiopian Seed Enterprise (ESE) had difficulty in accessing remote areas, supplied in big packs that are less affordable to the poor farmers, charged high prices and failed to supply seed on time during sowing period (Crowford *et al.*, 2003; Rubyogo *et al.*, 2007; Langyintuo *et al.*, 2010; Katungi *et al.*, 2011).

These challenges that limited access to bean seed of new improved varieties by the poor farmers prompted researchers in the Pan Africa Bean Research Alliance (PABRA-see <http://www.pabra-africa.org>) to explore alternative options to strengthen the linkage between formal and informal seed systems. In 2003, the "Wider Impact Seed Dissemination approach" was initiated by CIAT and the Bean Research Programme at Melikassa Agriculture research center (MARC) to address barriers that constrained access and utilisation of improved bean varieties in Ethiopia (Teshale *et al.* 2006; Rubyogo *et al.*, 2010, Buruchara *et al.*, 2011).

This approach embraced a collaborative arrangement that builds on varied organisational strengths, to shift from a centralised to a decentralised and pluralistic seed systems for improved access to quality bean seed (Buruchara *et al.*, 2011).

New seed production and/or delivery models: small packs and community based seed multiplication models (CBSME) were

introduced and piloted under the auspices of the Tropical Legumes Project implemented through PABRA framework (Buruchara *et al.*, 2011; Habte *et al.*, 2011; Rubyogo *et al.*, 2016). These models are not mutually exclusive, but complement each other in ensuring that farmers access seed of new bean varieties of their choice.

The small (1-2 kg) pack approach enables farmers to purchase quality seed of new varieties and evaluate them for productivity and profitability; thereby reducing uncertainty about the superiority of the bean variety. The poor households can afford small packs and multiply the variety on their farms to accumulate the desired quantities of seed.

The CBSME builds on the advantages of the informal and formal seed systems to increase seed availability, accessibility and affordability by small holder farmers. The basic characteristics of CBSME are farmers' ownership of the enterprise, and their responsibility for independently operating it alongside the commercial system (Thijssen *et al.*, 2008).

Unlike the formal seed system, the CBSME has a decentralised structure, which allows farmers to avail seed in different places by involving farmers' unions, cooperatives, peasant associations and other NGOs. This enables the timely availability of seed for sowing in remote communities often not served by formal seed systems.

Since the introduction of the small pack approach and CBSME, the Ethiopian Agriculture Research Institute, through its bean research programmes at MARC, Regional agricultural Research Organisations (RARO) and CIAT, have invested significantly towards developing CBSME into specialised commercial sustainable enterprises. For example, individual farmers and farmer groups have been trained in seed production techniques, including plant protection, postharvest handling and business skills (Rubyogo *et al.*, 2016). Further support came in the form of breeder/basic seed loans, awareness creation and popularisation of

varieties through mass media, on-farm demonstrations and participatory variety selection models, to create demand (Rubyogo *et al.*, 2016).

Although there is considerable information about CBSME in Ethiopia, little is known about its economic performance in terms of value added to the farmer's investment and its use by the local non-participating farmers as their source of seed. This study was conducted to assess the profitability of CBSME in the Central rift valley of Ethiopia and examine factors that facilitate or constrain farmers' participation in the same. The study also investigates the use of CBSMEs by local farmers as their source of seed, factors that influence their choice of seed source and evaluates whether CBSME complements the formal seed systems.

MATERIALS AND METHODS

Study area. The study was conducted in the Central Rift Valley of Ethiopia, which is located between 1500 and 2300 metres above sea level. The dominant climate in the area falls between the longest tropical and sub-tropical agro-climate zones. The annual mean rainfall of the study area ranges between 90 and 1990 mm in two rainy seasons, *meher* (the shortest), and *kiremt* (the largest), respectively. Common bean is the second most produced crop, after maize, being used as food and cash crop by smallholders (Rubyogo *et al.*, 2011). It is cultivated during the *Kiremt* season, which starts in June and ends in September.

Data sources and sampling procedures. The study used primary data, complemented by secondary data from Oromiya Regional State official website, *woreda* (district) offices (i.e. Boset, Adamitulu judocombolcha and Shalla), Ethiopian Seed Enterprise, Central Statistics Agency, MARC and CIAT. A multi stage sampling procedure was used to cost effectively select households for inclusion in the analysis. First, three *woredas* (The number of *woredas* was limited to three due to budget

limitations) were randomly selected from the lists of all *woredas* in Central Rift Valley of Ethiopia. The *woredas* were: Boset, Adamitulu judocombolcha and Shalla, with a respective population of 34,888; 26,582 and 21,598, making a total of 83,068 people in 13,398 households. All these *woredas* were important producers of the three types of common bean; red, white and ranger. From each *woredas*, two *kebeles* (each equivalent of a village) were then randomly selected from a list of all *kebeles* in the *woreda*, making a total of 6 randomly selected *kebeles*. Households for the interview were selected randomly using a random start from a list of households in each *kebele*, obtained from *kebele* leaders. Because seed multipliers were few (less than 10 in a *kebele*), all seed multipliers in each *kebele* were identified with the help of *kebele* leaders and purposively included in the survey. A sample of 195 farming households, 50 of who were seed multipliers were surveyed in the six *kebeles*.

Primary data were collected through a survey of households conducted during *kiremt* season of 2012/13 by MARC in collaboration with CIAT. Well-trained enumerators conducted face to face direct interviews with household heads or their representatives, using a semi-structured pretested questionnaires. Data were gathered on: socioeconomic characteristics of the decision maker (such as age, education, gender and occupation) and those of the household (household size, wealth assets), type and sources of seed planted in the study season as well as detailed bean production inputs, their respective prices, quantities harvested and plot characteristics. Information was also gathered on bean grain and seed marketing, as well as the market characteristics including distance from the farm to seed source. Furthermore, information on the community was gathered through focus group discussions organised in each of the selected *kebeles*.

Data analysis. Descriptive as well as econometric techniques were used to analyse

the data in the Stata software, Version 13. Gross margin analysis was used to calculate the profitability of seed production, which is essential in understanding whether farmer-based seed system can be promoted as a profitable business as well as its prospect for expansion to new producers. Econometric analysis was then applied to identify factors that influenced the farmers' decision to participate in CBSMEs, their intensity of participation as well as those that have influence on the choice of seed source used by farmers at planting.

Gross margins. Gross margins obtained by seed multipliers involved in the CBSME and those who produced bean as grain were computed for each household as the difference between total revenue and total costs according to Upton (1964);

$$GM_i = TR_i - TC_i \dots\dots\dots \text{Equation 1}$$

Where:

GM_i = the gross margin, TR_i = the total revenue and TC_i = the total cost of production incurred by farmer i.

Revenue and total costs were normalised at hectare level. Total revenue was computed as the sum of the market value of the bean grain sold as seed or grain and the imputed value of bean crop residues. Although less common, bean crop residues in Ethiopia can either be used to feed livestock or sold to other farmers. For households where bean crop residues were not sold, the average market value of bean crop residues of US\$0.025 per kg was used following Funte *et al.* (2009). Total variable costs included the cost of inputs (i.e. seed, fertiliser, labour, pesticides), costs related with storage, transport and rented land. Since family labour is not traded, it was valued at the average wage rate for hired labour in each *kebele* and ranged from USD.1.85-3.15.

Estimation of farmer participation. In modeling the farmer's participation in CBSME, we followed Amare *et al.* (2012) and assumed that under imperfect market conditions and uncertainty, farmers allocate their resources to agricultural enterprises based on the objective of maximising the expected profits. The expected profit from seed multiplication is denoted by π_p ; while π_{NP} is the expected profit farmer i receives by not participating in CBSME but uses the resources in the production of grain. The intensity of participation in CBSME by farmer i , is observable when $\pi_p > \pi_{NP}$ and will remain unobserved if $\pi_p \leq \pi_{NP}$.

Participation in CBSME, measured as the amount of land in hectares allocated to seed multiplication enterprise in 2012/13 is a two-step voluntary decision making process. In the first step, the individual decides on whether or not to participate in CBSME. Then, the individual decides on the amount of land to allocate to seed multiplication conditioned on a positive decision to participate in the first step. This means that participation in seed multiplication is a censored variable observed as zero at the left corner and continuous above zero. From previous studies, censored limited dependent variables are commonly tackled using either Tobit or two stage Heckman model (Chukwuji and Ogisi, 2006; Akinola *et al.*, 2010; Bernard *et al.*, 2010). The basic difference between Tobit and Heckman models is the assumption each makes towards the simultaneity of decision to participation and level of participation.

The Tobit model assumes that participation and level of participation, in our case, the amount of land allocated to seed multiplication, are made simultaneously. On the other hand, the two stage Heckman model assumes that the two decisions are made separately and that the decision to participate influences the decision on the level of participation. This can cause a selection bias, leading results to be

inconsistent, if not accounted for in the econometric analysis.

To check for possible presence of selection bias, we first estimated the two stage Heckman model. The Heckman model uses the inverse mill's ratio (λ) to detect and control for the selection bias. The inverse mill's ratio is derived from the first stage and included in the second stage to test and control for selection bias. The lack of significance of the mills ratio provided evidence of no selection bias. Thus, a Tobit specification was considered to be more appropriate for analysing the data than the two stage Heckman model. According to Gujarati (2004), a Maximum Likelihood (ML) Estimator which is used in Tobit model is much more efficient than the estimators used in two stage Heckman model.

Following Gujarati (2004), the statistical model underlying a Tobit can be expressed as:

$$Y_i = \beta_i X_i + \mu_i \dots \text{if } \beta_i X_i + \mu_i > 0 \\ = 0 \text{ otherwise} \dots \text{Equation 2}$$

Where:

Y_i = the observed amount of land allocated to seed multiplication enterprises, X_i = a vector of explanatory variables; and β_i = a vector of coefficients to be estimated.

The vector μ_i contains the unobserved random error terms that are assumed to be independently and normally distributed with zero mean and constant variance. According to Tobin (1958), the expected value of participation and the amount of land allocated to seed multiplication enterprises across all observations can be estimated as:

$$E(Y_i) = X\beta F(z) + \sigma f(z) \dots \text{Equation 3}$$

Where:

$z = X\beta/\sigma$, $F(z)$ = the cumulative distribution function, $f(z)$ = the value of derivative of the

normal curve at a given point, z = the Z-score for the area under normal curve, β = a vector of Tobit maximum likelihood estimates, and σ = the standard error of the error term.

Each explanatory variable in the Tobit model has two effects; the effect on the probability to participate in CBSME and the effect on the intensity of participation. A McDonald and Moffitt decomposition technique (Maddala, 1983) was used to decompose the total effect of a change in the independent variable on a dependent variable, into its effect on the probability to participate (i.e. adopt) and the effect on the intensity of participation. Accordingly, the change in the probability of participating in CBSME as independent variable

X_i changes is estimated as:

$$\frac{\partial F(z)}{\partial X_i} = f(z) \frac{\beta_i}{\sigma} \dots\dots\dots (4)$$

Similarly, the change in intensity of participation defined as the amount of land allocated to seed production business with respect to change in an explanatory variable (X_i) among adopters is estimated by:

$$\frac{\partial E(Y|Y_i^* > 0)}{\partial X_i} = \beta \left[1 - z \frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)} \right)^2 \right] \dots\dots\dots (5)$$

The two effects can be aggregated later to determine the total marginal effect as a result of a change in each individual explanatory variable.

Estimation for choice of seed source. The dependent variable in this analysis is defined by the type of seed source used by the smallholder in the *kiremt* season of 2012/13, which was also the season selected for the study. Farmers used a combination of three

seed sources: (i) formal (formal seed source), (ii) informal (informal seed source) and (iii) CBSME. Given that farmers were at liberty to choose one, two or three out of the available seed sources, a multivariate Probit Model (MVP) was used to investigate the factors that facilitated or constrained bean producers who grew grain in these communities from choosing CBSME as their source of seed. A univariate model would leave out useful economic information about interdependence and simultaneous choice decisions.

We follow Teklewold *et al.* (2013) and specify a multivariate probit model for the choice of bean seed source by the Ethiopian bean growers as:

$$C_{ij}^* = \alpha_j D_i + \varepsilon_{ij}$$

$$C_{ij} = 1 \text{ if } C_{ij} = C_{ij}^* \text{ and; -- where } j = \text{formal, informal or CBSME}$$

$$C_{ij} = 0 \text{ if } \text{Otherwise} \dots\dots\dots (6)$$

Where:

Utility (C_{ij}^*) is the latent variable determined by observed (i.e. household, market and institutional) characteristics cast in vector, D_i and C_{ij} is the observed dependent variable defined as the choice of seed source j used by household i . Vector α_j consists of unknown parameter to be estimated while vector ε_{ij} contains the unobserved characteristics associated with the choice j made by the farmer i .

The unobserved characteristics were assumed to follow a multivariate normal distribution, with zero conditional mean and variance normalised to unity; $\varepsilon_{ij} \sim \text{MVN}(0, \delta)$. The diagonal of the covariance matrix of ε_{ij} are one, but what is useful are the non-zero off-diagonal elements of the matrix, which represent the unobserved correlation between the stochastic components of the different types of seed sources.

Thus, by adopting MVP model, we are able to simultaneously determine the influence of the set of explanatory variables on the choice of each of the different seed source; while allowing the unobserved and/or unmeasured characteristics to be freely correlated. The correlation may be positive (complementary) or negative (substitute) between different seed sources.

Definition of explanatory variables.

Variables included in the analysis were based on literature on adoption and seed enterprises, as well as documented information about the Ethiopian context (Bwire, 2008; Akinola *et al.*, 2010; Alemu *et al.*, 2011; Teferi, 2013). Empirical definitions of the explanatory variables and their descriptive statistics are presented in Table 1. Some of these variables were useful in testing the assumptions on positive complementarity of formal and CBSME regarding reach to users distinguished by wealth status and locations with respect to distance from main urban centre that underlie most interests in CBSMEs.

Household and farm characteristics. We included several characteristics of the household head (i.e. age, education, gender and occupation) and those of the household (i.e. household size and wealth assets). Gender of the household head captures the differences between household typologies with regard to resource endowments and type of social networks. Ethiopia is a patriarchal society that keeps women at a subordinate position while putting men at a comparative advantage in terms of accessing information, better pay and asset accumulation (Kassa, 2015). Such gender disparities in favour of men mean that men are more likely to learn about new business opportunities such as seed multiplication enterprises as well as purchase seed produced from CBSME as compared to women.

Age of the household head influences the accumulation of experience about seed quality that may be needed to participate in seed production and/or purchase seed from formal or CBSME. Younger individuals are also more likely to access information about new innovations, learn new skills needed in business

TABLE 1. Definition and summary statistics (standard deviation) of the variables used in the analysis

Variable	Total sample (N=195)	Seed multipliers (N=50)	Grain producers (N=145)	t-value/ chi-square
Age (years)	38.374	41.08(1.46)	37.44(0.82)	-2.21**
Formal education (years)	4.64	5.04(0.39)	4.49(0.24)	-1.16
Family size (Adult equivalent)	3.19	3.73(0.23)	3.00(0.13)	-2.87***
Livestock (TLU)	4.65	6.72(1.25)	3.74(0.57)	-2.79***
Number of agricultural equipment	10.94	14.44(1.79)	9.74(0.46)	-3.6***
Land owned (ha)	3.01	4.52(0.28)	2.52(0.16)	-6.24***
Distance to main district town (Km)	28.55	19.176(2.93)	31.78(1.33)	4.44***
Distance to tarmac road (Km)	9.19	2.77(0.63)	11.41(3.56)	1.42
Price (US\$/kg)	0.50	0.58(0.42)	0.48(0.35)	-3.15***
Male headed household (%)	87.69	86.00	88.27	0.18
Household participating in organization (%)	86.67	84.00	87.59	0.41
Respondents with Access to credit (%)	47.69	60.00	43.45	4.08**
Households participating in Off-farm income (%)	0.33	0.16	0.39	9.09***
Households using Agri-input (%)	93.33	96.00	92.41	0.768
Households visited by Extension worker (%)	89.74	96.00	87.59	2.85*

*, ** and *** denote are significant variables at 10, 5 and 1 percent level of significance, respectively

and take risk (Salim 1986; Feleke and Zegeye, 2006; Chukwuji and Ogisi, 2006). Thus, the expected sign of age on participation in CBSME or choosing it as a source of seed cannot be determined a priori. Similarly, education of the household head is linked to participation in CBSME through information acquisition and processing (Schultz, 1975).

Household wealth, represented by landholding, livestock ownership and agriculture equipment was expected to positively influence participation in CBSME and the probability that a household chooses CBSME and formal seed sources over informal seed sources. Farmers with larger land sizes can overcome liquidity constraints and have low opportunity cost of land under experimentation (Shiyani *et al.*, 2000; Bwire, 2008; Thapa, 2008; Sitomwe *et al.*, 2009; Teferi, 2013). Similarly, possession of a larger number of different agricultural equipment (such as cart, sickle, axe, hoe, knapsack sprayer and water carrier) reflects the household capacity to undertake and complete agricultural activities, which in turn, may influence uptake of new innovations. Different livestock types (i.e. cattle, pig, sheep, goat, and poultry) owned by a household were combined into a single continuous measure using the Tropical Livestock Unit (TLU) and is expected that households endowed with large size of livestock are likely to overcome financial constraints and afford seed from formal or CBSME source.

Other household characteristics assumed to influence the likelihood that a household participates in CBSME and chooses formal and CBSME seed sources were access to credit, off-farm income and having membership in farmer organisations. Off farm income is linked to participation in CBSME through two mechanisms (i.e. purchasing power or opportunity cost) that operate in opposite directions, thus its expected sign is indeterminate. Farmer associations in Ethiopia represent a form of social capital for members to access NGOS involved in disseminating seed to farmers (Alemu *et al.*, 2011).

Location and contextual factors. For contextual factors, proximity to town centers, presence of a market in the village and extension were included as proxies for market characteristics and information access. Households close to the district town were expected to face lower transaction costs involved in looking for a buyer of CBSME seed as well as that of acquiring initial seed for uptake of CBSME. On the other hand, households located in villages where a grain market is present were expected to face competition from the latter when selling their seed from CBSME and be discouraged from participating or obtaining seed from the CBSME. Contact with extension was expected to exert an influence on the access to information and skills necessary for started up of CBSME and choice of seed source (Feder *et al.*, 1985; Asfaw *et al.*, 2012).

RESULTS AND DISCUSSION

Profitability of CBSME. Results of gross margins obtained by bean farmers involved in the CBSME and those who produced bean as grain are presented in Table 2. The average total costs incurred by seed multipliers and grain producers were respectively, US\$608.38 and 334.94 ha⁻¹. The higher cost that accrued to seed multiplication through CBSME can be attributed to upward adjustment in input use by seed producers (Table 2).

Input adjustment for seed producers occurred in land quality, labour (especially during land preparation, weeding and sorting of seed) and amount of the DAP used. Because some farmers accessed land through renting, it was treated as a variable input unlike in Katungi *et al.* (2011), where the cost of land was treated as a fixed input.

Table 2 shows that the cost of land used for seed multiplication is valued at US\$200 per hectare and higher than that used for grain production (valued at US\$128 per hectare). The differences in the value of land could be because seed production is conducted on

TABLE 2. Descriptive statistics of the production costs and revenue of sale of bean seed by CBSME and bean grain, Central Rift valley of Ethiopia

Description of the cost (US\$)	Seed multiplication (N=50)			Grain production (N=157)		
	Mean (US\$ha ⁻¹)	SD	%	Mean (US\$ha ⁻¹)	SD	%
Total cost of land	200.41	289.04	32.94	127.8	107.88	38.16
Cost of seed	66.76	34.6	10.97	40.67	35.85	12.14
Total cost of Urea	3.83	24.28	0.63	4.11	12.64	1.23
Total cost of DAP	67.57	61.04	11.11	46.55	38.13	13.90
Total cost of paid labour	86.66	116.94	14.24	48.23	71.45	14.40
Total cost of unpaid labour	178.54	658.53	29.35	61.21	44.53	18.28
Total cost of anti-pest	1.26	10.73	0.21	0.21	1.35	0.06
Total cost of storage	0.07	0.02	0.01	0.02	0.24	0.01
Total cost of transport to individuals	0.10	0.20	0.02	0.19	0.22	0.06
Total cost of transport to crop	3.18	3.82	0.52	5.95	7.51	1.78
Total production cost	608.38		100.00	334.94		100.00
revenue from crop sales	1310.91	1367.61	93.59	936.23	850.61	93.74
Revenue from residue	89.86	56.42	6.41	62.57	36.20	6.26
Total production revenue	1400.76	NA	100.00	998.81	NA	100.00
Profit (US\$)	792.38	NA	NA	663.87	NA	NA
Gross margin	56.56	NA	NA	66.46	NA	NA

SD = standard deviation; NA = Not applicable

higher quality land in terms of fertility. In the bean seed production manual (David, 1998), farmers are advised to select high quality land for seed production to enhance yields. Using such seed production manuals, seed producers are usually trained by development workers on relevant business plans and the required best practices for successful seed production (Tebeka, 2016), thus influencing the type of land used for seed production.

Nevertheless, per hectare cost of seed production incurred by seed multipliers was lower than expected, considering that certified seed is used, perhaps reflecting the fact that part of seed used in CBSME is recycled. The costs of labour and fertiliser were also higher among seed multipliers than grain producers.

Labour, which, is mainly contributed by the household members accounts for the highest share of the total costs; 44 percent for seed multipliers and 33percent for grain producers (Table 2). Increase in labour costs is both a reflection of the higher productivity

of seed production plots that increases harvesting and post-harvest handling labour (Larochelle *et al.*, 2015); as well as additional seed quality control practices used by seed producers. Seed producers have been reported to increase efforts on sorting out poor-quality seeds, including those that are visibly diseased (Rubyogo *et al.*, 2009).

The total cost of fertiliser (US\$71.4) used in seed multiplication is higher than that used for grain (US\$50.7), which reflects differences in quantities used by the two groups. From Table 2, it can be deduced that an average seed multiplier used 60 kg ha⁻¹ of DAP and 3.83 kg ha⁻¹ of urea; while a grain producer used 46.55 kg ha⁻¹ of DAP and 4.11 kg ha⁻¹ of urea.

The cost of marketing included transport and packing (Table 2). However, these costs were dismal, accounting for just 0.54 and 1.84 percent of the total costs incurred by seed multipliers and grain producers, respectively. Transport costs are insignificant because most of the seed multipliers made transactions at

the farm gate; the average cost of storage accounted for only 0.01 percent of the total cost.

Table 2 also shows the total revenue from the sales of seed or grain and residue from bean crop. Combining the crop and residue sales, the respective per hectare total revenue for seed multipliers and grain producers were US\$1400.76 and US\$998.81. The average selling price for seed was US\$0.58kg⁻¹, statically higher than the price of grain US\$0.48kg⁻¹ in the same season (Table 1). Producers who sold seed late during the sowing period received as high as US\$0.9 kg⁻¹ compared to those who sold immediately after harvest (US\$0.3kg⁻¹). Also, selling to organisations such as MARC and the Catholic Missionary Church, attracted a higher price compared to selling directly to fellow farmers. The NGOs involved in seed dissemination also purchase seed in bulk at fixed prices; thus greatly influencing the revenue received (Alemu, 2015).

Comparing the average total revenue with the average total variable costs gave US\$792.38 ha⁻¹ as average gross margins for seed multiplication and US\$663.87 ha⁻¹ as gross margins for grain production. The gross margins for seed multipliers were higher than those of grain producers by US\$128.51 ha⁻¹. In relative terms, the profit margins from seed production constituted 56.57 percent of revenue, which were much higher than 36 percent reported for Kenya in 2011 (Katungi *et al.*, 2011); but lower than that received from grain production (66.46 percent) in the study area (Table 2).

The difference in revenue between seed producers and grain producers emanates from differences in selling price received; as well as yields associated with better management by the former. Accordingly, there was a difference of US\$511 in revenue between seed producers and grain producers, which was much higher than the respective difference between production costs (US\$273). This is evidence that though seed multiplication is accompanied by increase in production costs,

it is profitable when farmers gain skills in good management for seed production and the incentives in form of higher prices. However, producers who sold seed as grain benefited dismally, which is an indication that the performance of CBSME depends on the proportion of harvest that is marketed as seed. Thus, it is important to expand the demand for seed produced by CBSME for future sustainability of the model.

Farmers' participation in CBSME. Results from the Tobit estimation are presented in Table 3. The F-test statistic value of 4.55 (significant at 1 % level), confirms that the variables included in the model jointly explained variations in the CBSME participation decisions within the sample.

Results reveal that the smallholders' decisions to participate and their intensity of participation were determined by a number of factors, namely: sex of the household head, education of the household head, agricultural equipment possessed by the household, off farm income and land size (Table 3). Contrary to our expectations, participation in CBSME was higher among female-headed households than among their male counterparts. This result reflects the fact that under the CBSME project, there were efforts to increase women participation, which could have contributed to higher chances of the female-headed households participating in CBSME.

Education level positively influenced the size of land allocated to seed multiplication, but had no significant influence on the probability of participation in CBSME (Table 3). An increase in the formal education by one year increased the amount of land allocated to seed multiplication by 0.08ha. This is perhaps because education increases the individuals' ability to access and process information and might increase their profits from seed (Teklewold *et al.*, 2006; Foster and Rosenzweig, 2010).

Wealthier households in terms of land size and agriculture equipment were more likely to participate in seed multiplication, allocating

TABLE 3. Factors affecting participation in seed multiplication and amount of land allocated to it among smallholder producers in the Central Rift valley, Ethiopia

Variable	Coefficient	Change in probability of participation	Change in land allocated
Sex of household head (1=male)	-0.937** (0.456)	-0.061** (0.029)	-0.228** (0.112)
Age of household head	0.0106 (0.019)	0.001 (0.001)	0.003 (0.005)
Education in years	0.075* (0.044)	0.005 (0.003)	0.018* (0.011)
Family size	0.007 (0.114)	0.001 (0.007)	0.002 (0.028)
Total livestock unit	0.036 (0.023)	0.002 (0.002)	0.009 (0.006)
Farm size	0.336*** (0.095)	0.022*** (0.005)	0.082*** (0.024)
Distance to village market(Km)	0.065 (0.053)	0.004 (0.004)	0.016 (0.012)
Membership in cooperative	-1.110*** (0.367)	-0.073*** (0.026)	-0.270*** (0.084)
Extension	0.938 (0.741)	0.061 (0.052)	0.228 (0.179)
Access to credit	0.386 (0.261)	0.025 (0.016)	0.094 (0.062)
Off-farm income (1=yes)	-0.937** (0.361)	-0.062*** (0.021)	-0.22819** (0.088)
Agriculture equipment index	0.047*** (0.015)	0.003*** (0.001)	0.012*** (0.004)
_constant	-3.079***		
/sigma	1.355		
Number of observations	195		
Pseudo R2	0.243		
F(12, 183)	4.55		
Prob> F	0		

Numbers in parentheses are standard errors. *, ** and *** are significant variables at 10, 5 and 1 percent level of significance, respectively

larger land than poorer ones (Table 3). For one hectare increase in land holding, the probability that a household decided to participate in seed multiplication increased by 2.2 percent and the land allocated to the enterprise increased by 0.08 ha, respectively. The results are consistent with findings in the study conducted by Welelign (2008), which reported a significant and positive effect of land size on the household participation in farmer-based seed multiplication for a number of crops in the Southern region of Ethiopia. Similarly, the number of agricultural equipment had a positive and significant association with the probability that a bean producer decided to participate in seed multiplication and was found to increase the amount of land allocated to the seed multiplication (Table 3). Both results reflect the fact that the success in seed multiplication requires resources that might be limiting among majority of bean producers. For example, results show that grain producers owned about 2.25 ha and 9.74 agriculture equipment, which was much lower than respective land size (4.25 ha) and agriculture equipment (14.44) owned by seed producers (Table 1). This is suggestive that some grain producers who have not joined the CBSME model might be resource constrained. As observed by Bahadur (2004), resource constrained farmers are generally driven by food security objectives and might not respond to profitable opportunities.

Results also demonstrated that membership to organisations (such as cooperatives) is negatively associated with participation in seed multiplication. Being a member to organisations decreased the probability of participating in seed multiplication by 7.3%; while land allocated to the activity decreased by 0.27 ha. This is possibly because smallholders who participated in cooperatives and farmer organisations easily accessed improved seed compared to the ones who did not participate. Since cooperatives and farmer unions occasionally distributed free seed including that from the CBSME in Ethiopia (Alemu *et al.*, 2011), members might have been discouraged

from taking up seed multiplication as a private investment. This is evidence that NGOs that use farmer organisation networks as outlets for seed distribution (Alemu, 2015) crowd out the private participation in CBSME.

Having off-farm income was also negatively related with participation in seed multiplication and allocation of land to the activity (Table 3). The probability of participation in seed multiplication decreased by 6.2% when a respondent had an off-farm income. The amount of land allocated also decreases by 0.23 ha for those with off-farm income. This was perhaps associated with higher opportunity cost of time for individuals employed off-farm since CBSME members underwent intensive training and monitoring by public actors such as Research Organisations and/or, NGOs (Welu, 2015). Compared to grain producers (39 percent), seed multipliers were more dependent on farming, with only 16 percent participating in off-farm income activities (Table 1). Household heads who are involved in off-farm income might face high opportunity cost of time when required to attend training and meetings on seed production techniques supported under the project (Rubyogo *et al.*, 2016)

Choice of seed source demand-side of the seed system. Results indicate that the three sources of bean seed (formal, informal and CBSME) were used and that majority of bean growers in the study area simultaneously used more than one seed source (Fig. 1).

As expected, formal seed sources were prevalent among seed multipliers, and were used by 88 percent of interviewed seed multipliers. However, only 32 percent of seed multipliers exclusively planted seed from the formal seed sources; while 46 percent of the seed multipliers combined seed from the formal sources with seed from their previous harvest (Fig. 1).

A large number of grain producers used multiple sources (i.e. formal, informal and the community based seed multipliers) to meet

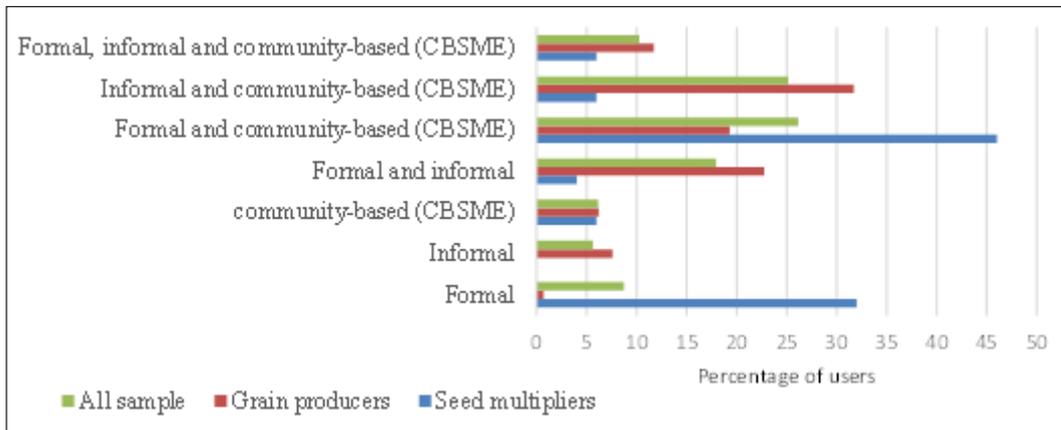


Figure 1. Proportion of farmers by seed source during 2012/13 *kiremt* production season in Central Rift valley of Ethiopia.

their seed demand (Fig. 1). The most popular combination of seed sources by this group was the informal+ CBSME (31.72%); followed by formal plus informal; used by 23 percent of the grain producers.

Choice of seed source. Factors that influence the choice of seed source together with the Wald test results, are presented in Table 4. Based on this diagnostic result, the null hypothesis of all coefficients in each equation being jointly equal to zero could not be accepted. The likelihood ratio test of the null hypothesis that there is no correlation between the error terms across equations was also rejected ($\chi^2(3) = 42.9947$, $\text{Prob} > \chi^2 = 0.0000$), which means that the alternative seed sources were not mutually exclusive. This confirms that a multivariate probit model was a suitable specification for the data analysis.

The model revealed a substitution effect between seed sources, with the formal and CBSME showing a relatively stronger negative correlation of 0.52, which implies that the two seed sources were close substitutes. On the other hand, the correlation between formal and informal was weak, (-0.443), perhaps because farmers tended to keep some grain from the previous harvest as supplement to the formal source. For the same reasons, the correlation

between informal and CBSME as source was observed to be weak (-0.243), but significant.

Results revealed that household characteristics as well as market access conditions influenced the seed source used by bean growers in the study area (Table 4). Older farmers were less likely to access seed from the formal seed source perhaps because as farmers advance in age, they devise effective methods for controlling quality of their own bean seed (Asfaw *et al.*, 2013) and develop trust in their own seed over other sources (CRS, 2014). This suggests that the perceived benefit of bean seed from formal sources might be lower for older farmers, which implies that targeting younger farmers for promoting formal sources will be more effective in resource use while creating longer term growth in demand for bean seed from formal sources.

Households with larger landholdings were more likely to choose a formal seed source over informal seed sources compared to those with smaller landholding (Table 4). In particular, results indicate that when the household landholding increased by one hectare, the probability that the producer would choose the formal sources of bean seed for planting increased by 15.8 percent; while that of choosing informal seed source reduced by

TABLE 4. Multivariate estimation of the factors affecting the choice of seed source by bean grain producers, Rift Valley of Ethiopia

Variables	Formal	Informal	Farmers based
Sex of HH [^]	0.383(0.357)	0.272(0.357)	0.199(0.338)
Age of HH [^]	-0.028*(0.015)	0.022(0.014)	0.020(0.015)
Formaleducation of HH [^]	-0.023(0.031)	0.032(0.031)	-0.039(0.032)
Family size inadulthequivalent	0.073(0.087)	-0.015(0.083)	-0.033(0.084)
Livestock (TLU)	0.003(0.015)	-0.001(0.015)	-0.009(0.014)
Farmsize (ha)	0.158*** (0.058)	-0.231*** (0.058)	0.021(0.057)
Participation in organization	-0.073(0.319)	-0.540(0.375)	1.715*** (0.347)
Extension visit	-0.007(0.008)	-0.004(0.008)	0.014*(0.008)
Credit Access	-0.133(0.221)	0.115(0.217)	0.083(0.216)
Distance to district town (Km)	-0.029*** (0.007)	0.010(0.006)	0.014** (0.007)
Participation in off-farm income	0.149(0.209)	0.198(0.212)	0.079(0.212)
_cons	0.902(0.642)	0.303(0.661)	-1.996*** (0.670)
rho21		-0.443***	
rho31		-0.521***	
rho32		-0.243**	
Number of observations		195	
Wald chi2(39)		96.06	
Prob> chi2		0.000	
Log likelihood		-299.83604	

Likelihood ratio test of $\rho_{21} = \rho_{31} = \rho_{32} = 0$: $\chi^2(3) = 42.99$ Prob> $\chi^2 = 0.00$; [^]HH=Household head
*, ** and *** denote significant variables at 10, 5 and 1 percent level respectively; Parenthesis are standard errors

23.1 percent (Table 4). Landholding is a surrogate for risk taking, access to information and credit, all of which are positively associated with adoption of new innovations (Feder *et al.*, 1985; Foster and Rosenzweig, 2010).

Neither, wealth nor education showed a significant effect on use of CBSME as the source of seed for bean (Table 4), suggesting that this type of seed source was neutral to social status. The poorer as well as the wealthier households, used CBSME. Similarly, households headed by less educated individuals and those headed by highly educated individuals were equally likely to choose CBSME as their source for seed.

Participation in Organisations, such as cooperatives, significantly influenced the choice of seed source (Table 4). Households who were members to organisations were likely to choose CBSME as the source for their seed requirements. Organisations serve as

information hubs and the channel for distribution of seed from CBSME (Rubyogo *et al.*, 2016). Similarly, extension visits help to reinforce the message and popularise the new innovations (Oladele, 2005). Since NGOs that are heavily involved in the distribution of seed from CBSME, also employ extension to provide training in general seed production (Alemu, 2015), it is also possible that NGOs supplied seed to their farmers along with information.

Market conditions represented in the analysis by distance to main district town were negatively related with use of formal seed source (Table 4). As expected, farmers who were far from the district (woreda) town were less likely to use formal seed sources due to limited accessibility. Most agro-input dealers, including Ethiopian Seed enterprise, were located in the main towns; meaning that rural based farmers who were far from district

(woreda) towns incurred higher transport costs to access seed (Minten *et al.*, 2013). On the other hand, distance from town to the village exerted a positive influence on the probability that a farmer would choose from CBSME. It was evident that the two models complemented each other in terms of geographical reach.

ACKNOWLEDGMENT

The authors are grateful for the financial support provided for this study by the Government of Ethiopia through EIAR-Melkassa, Bill & Melinda Gates Foundation through Tropical Legume II Project, Swiss Agency for Development and Cooperation (SDC) and Global Affairs Canada (formerly Canadian International Development Agency [CIDA]) through the Pan-Africa Bean Research Alliance (PABRA)/CIAT and the Eastern and Central Africa Bean Research Network (ECABREN).

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