ICARDA

Science for resilient livelihoods in dry areas

Faba bean seed system landscape in the highlands of Ethiopia: Smallholders' varietal adoption, preference, and seed commercial behavior

Zewdie Bishaw, Dawit Alemu

October 2019

WORKING PAPER 2019-3

ISBN: 978-92-9127-531-1

Keywords: adoption, varietal preferences, seed commercial behavior, faba bean, Ethiopia

Working Papers
Working Papers are one of ICARDA's global public goods; they capture and share knowledge and learning from projects and research partnerships. Each paper is internally reviewed as part of the Center's publishing process.

Suggested citation
Bishaw, Z., and D. Alemu. 2019. *Faba bean seed system landscape in the highlands of Ethiopia: Smallholders' varietal adoption, preference, and commercial seed behavior.* Working Paper 2019-3. Lebanon, Beirut: International Center for Agricultural Research in the Dry Areas (ICARDA).

About ICARDA
Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is a non-profit, CGIAR Research Center that focusses on delivering innovative solutions for sustainable agricultural development in the non-tropical dry areas of the developing world.

We provide innovative, science-based solutions to improve the livelihoods and resilience of resource-poor smallholder farmers. We do this through strategic partnerships, linking research to development, and capacity development, and by taking into account gender equality and the role of youth in transforming the non-tropical dry areas.

Address
Dalia Building, Second Floor, Bashir El Kasser St, Verdun, Beirut, Lebanon 1108-2010.
www.icarda.org

CGIAR
A CGIAR Research Center
cgiar.org

Contents

List of tables

List of figures

Acronyms

AI	attainment index
ARARI	Amhara Regional Agricultural Research Institute
ARC	agricultural research center
CSA	Central Statistical Agency
DI	demand index
EIAR	Ethiopian Institute of Agricultural Research
ESE	Ethiopian Seed Enterprise
MoA	Ministry of Agriculture
NARS	national agricultural research system
NSPDC	National Seed Production and Distribution Committee
OARI	Oromia Agricultural Research Institute
SARI	Southern Agricultural Research Institute
SI	supply index
SNNPR	Southern Nations, Nationalities, and Peoples' Region
Std	standard deviation
TLU	tropical livestock unit

Acknowledgments

This Working Paper was supported by the CGIAR Research Program on Dryland Systems and partial funding of the ICARDA-USAID project, "Deployment of Malt Barley and Faba Bean Varieties and Technologies for Sustainable Food and Nutritional Security and Market Opportunities in the Highlands of Ethiopia." The authors are grateful for the financial support, without which, this study would not have been possible.

The authors would also like to thank several institutions for providing the valuable information needed to produce this Working Paper. These include the Ministry of Agriculture; the Ethiopian Institute of Agricultural Research and the regional agricultural research institutes of Amhara, Oromia, Southern Nations, Nationalities and Peoples', and Tigray regions; and federal (the Ethiopian Seed Enterprise) and regional (the Amhara Seed Enterprise and the Oromia Seed Enterprise) public seed enterprises. Special thanks go to the kind and generous Ethiopian faba bean farmers who contributed their time and provided information to this study.

The views and opinions expressed in this Working Paper are purely those of the authors and do not necessarily reflect the views of their employers.

Executive summary

Faba bean is the most important crop among pulses in Ethiopia in terms of area allocation, production, and the number of smallholder farmers involved in its production. In addition to its role as food and a nutritional security crop in the highlands, it has become in recent years one of the main agricultural export commodities.

This Working Paper documents the varietal adoption, preferences, and seed commercial behavior based on primary data collected in the 2014 cropping season from 549 randomly selected faba bean growers in four major crop-producing regional states: Amhara, Oromia, Southern, and Tigray. The results indicate that the national average yield (1.8 tons/ha in 2014) is 44 and 50 percent lower than the yield achieved on research stations and in farmers' fields with improved varieties and recommended practices, respectively. This reflects the poor performance of the seed system, extension services, and other input delivery systems.

About 29 improved faba bean varieties have been developed and released for different recommended domains, including the mid- and high-altitude agro-ecologies and Vertisols (waterlogged areas) up until 2014. Of faba bean growers, 19 percent are full adopters (all plots use improved varieties), 1.9 percent are partial adopters (one or more plots use improved varieties), and the remaining 79.1 percent are non-adopters (all faba bean plots use local varieties). However, only six improved varieties are recognized by some of the adopting farmers. The weighted average age of the improved varieties under use is 20.5 years although there are a number of recently released varieties with better performance.

The improved faba bean varieties demonstrate higher attainment indices for most of the key varietal attributes: grain size, number of pods per plant, and number of seeds per pod. However, it will be important for breeding programs to consider improving varietal traits such as early maturity, cooking ability, and taste because local varieties show higher attainment indices for these traits.

The seed commercial behavior of faba bean producers indicates that only 6.4 percent purchase certified seed, whereas the remaining 18.5 percent purchase non-certified seed from a local market, and 75.1 percent use their own saved seed. The difference in the average seed renewal rate by adoption category is not significant, indicating an average of two years for variety renewal for all categories of adoption, although most non-adopters do not renew their seeds.

The overall revealed demand for certified seed is low and there is also a considerable gap in the supply of demanded seed, with only 45.9 percent of the revealed demand supplied, which could only cover 3.97 percent of the total faba bean area in the 2014 cropping season. The limited engagement of the formal sector seed actors is associated with the lower commercial attractiveness of faba bean compared to other crops like maize, which has a high grain to seed price ratio. In 2014, the estimated grain to seed price ratio for faba bean was 67 compared to 27 percent for hybrid maize. The limited amount of certified seed is often produced by public seed enterprises, primarily the Ethiopian Seed Enterprise. These results indicate the potential for increasing the productivity and production of faba bean in the country by strengthening the seed delivery system through better access to and use of seed of improved varieties.

1. Introduction

Grain legumes play a crucial role in Ethiopian agriculture, representing 12.2 percent of the total land cultivated and 10.4 percent of total grain production (CSA 2016). Faba bean is the most important crop among legumes, being first in terms of area allocation (27 percent), production (31 percent), and number of farmers involved (44 percent) in the 2016 production season (CSA 2016). Ethiopia is a major producer of faba bean, second only to China (EIAR 2017). Agro-ecologically, faba bean is produced in the highlands under rainfed conditions. Apart from contributing to household food and nutritional security, it recently became one of the country's main agricultural export commodities. The volume and value of faba bean exports increased from less than 10,000 tons[1] with an average value of less than US$7 million a decade ago to about 40,000 tons with a value of close to US$20 million in 2014 (ERCA 2014).

Faba bean production, however, is highly constrained by the inherently variable and low yield of the crop and by adverse conditions for crop production imposed by biotic (diseases, insects, and weeds) and abiotic stresses (moisture deficit, soil acidity, and waterlogging). The national agricultural research system (NARS) has developed and released several improved varieties along with associated integrated crop management practices to address these challenges.

Despite the availability of improved varieties and appropriate crop management practices, availability, accessibility, and affordability of these technologies are still limited—resulting in low productivity. The yield gaps between research-managed yields and national yield levels are still very high across all crops and agro-ecologies, including faba bean (Spielman et al. 2010). Likewise, performance of the formal seed sector also varies considerably by crop type and agro-ecology, with legume seed supply in general and faba bean in particular being very weak. The formal seed sector better serves the mid-altitude agro-ecologies where maize and wheat are predominant. Accordingly, the bulk of certified seed supplied for these two crops often represents more than 72 percent of the total formal sector seed supply in the country (Lakew and Alemu 2012; Alemu and Bishaw 2015). However, evolution of the seed system and the dynamics of market demand for different crops dictate an increase in production of certified seed for diverse crops where the research system has released better performing varieties.

The adoption of improved crop varieties is reportedly low in Ethiopia (Yirga and Alemu 2016). This can be related to the inherent attributes of the improved varieties themselves as perceived by the farmers and the prevailing seed system constraints (Alemu and Bishaw 2015). Under Ethiopian conditions, there is a mismatch between the demand and supply of seed of improved varieties (Alemu 2011). Assessment of effective seed demand is often associated with farmers' subjective preferences and perceptions of the attributes of the varieties (Alemu and Bishaw 2016).

This paper presents the faba bean seed system landscape in the highlands of Ethiopia, with reference to smallholder farmers' adoption of improved varieties, their preferences, the demand and supply relations for certified seed as the performance indicator of the formal seed sector, the commercial behavior of smallholders concerning faba bean seed, and overall implications for the development of the faba bean seed sector.

2. Methodology

2.1. Sampling and sample size

The study was conducted in four major faba bean-producing regional administrative states. Based on the importance of faba bean production, six zones (West Shewa, North Shewa, Arsi, West Arsi, Bale, and South West Shewa) from Oromia; four zones (North Gondar, South Wolo, North Shewa, and East Gojjam) from Amhara; two zones (East and South Tigray) from Tigray; and one zone (Gurage) from the Southern Nations, Nationalities, and Peoples' Region (SNNPR) were selected. By allocating a sample size to each district based on its proportion of the population of faba bean growers, a total of 370 faba bean-producing farmers were selected from 19 districts in 13 zones of the four regions (Figure 1). In addition to household-level information, plot-level data of seed use for faba bean were collected. The data were collected using a pre-

[1] Metric tons are used throughout.

tested questionnaire through individual interviews of household heads.

2.2. Estimation of adoption

The adoption rates were estimated based on three approaches: (i) household-level, where households were categorized into non-adopter, partial adopter, and full adopter, which represents the degree of adoption; (ii) land allocated for improved faba bean varieties, which represents the intensity of adoption; and (iii) number of plots per household allocated to improved varieties. Since data were collected at plot level, the household-level adoption rate was estimated based on three categories of adoption: non-adopters, partial adopters, and full adopters. Non-adopters were households who did not use any improved faba bean variety in any of their plots; partial adopters used both local and improved faba bean varieties in one or more plots; and full adopters used improved varieties in all plots.
The adoption rates based on land allocation were estimated from the proportion of total land allocated to improved faba bean varieties over the total land allocated for faba bean by all sample households:

$$BA = \frac{\sum_{i=1}^{n} BPI_{ij}}{\sum_{j=1}^{N} BP_j}$$

where:
BA = adoption rate of improved faba bean varieties
BPIij = size of faba bean plot "i" of farmer "j"
BPj = size of all plots of faba bean fields of farmer "j"
n = number of plots with seed of improved faba bean varieties
N = number of farmers growing faba bean

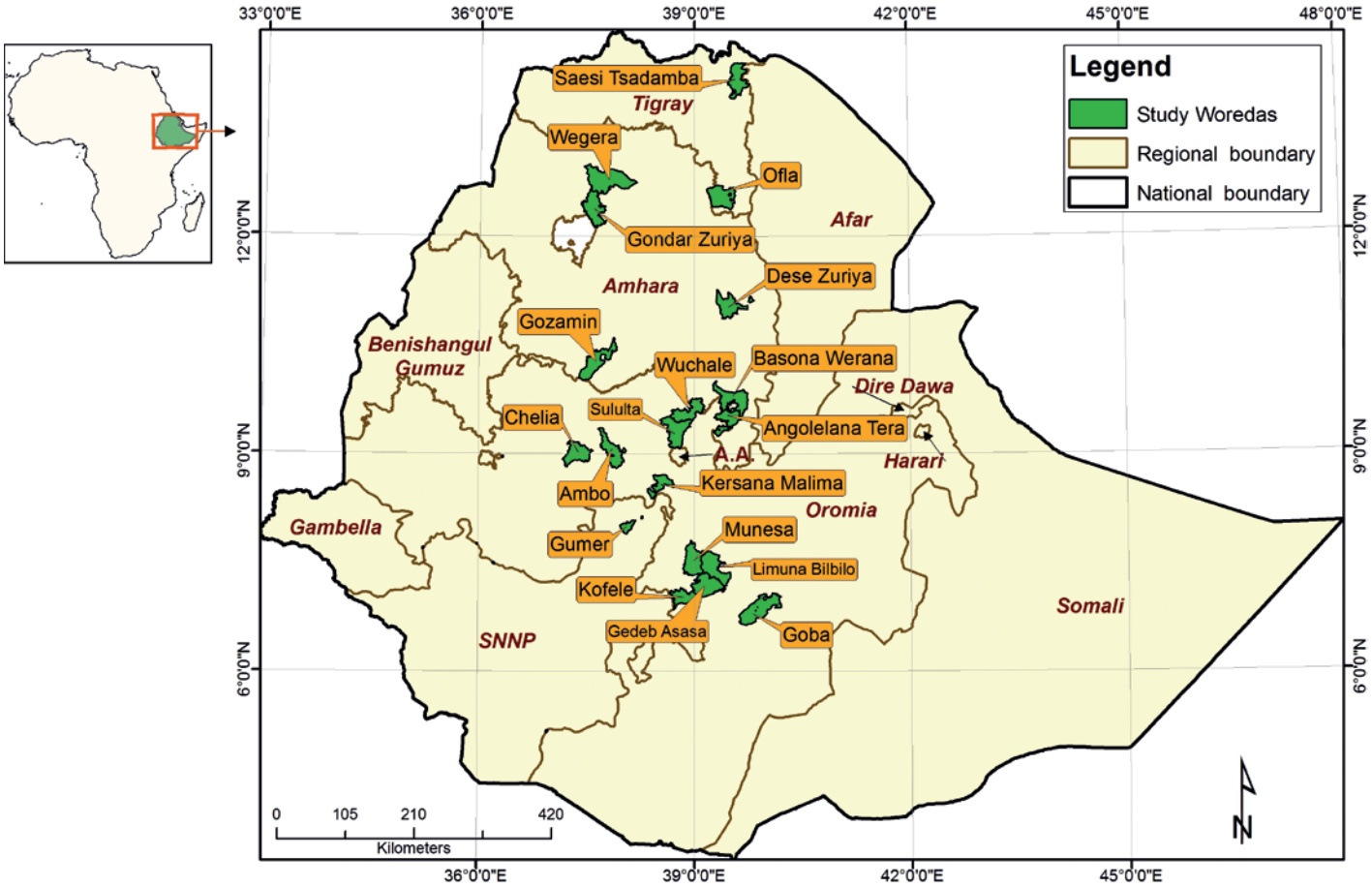

Figure 1. Distribution of sample districts

2.3. Estimation of varietal preferences

To elicit farmers' faba bean varietal preferences, we followed two steps. First, we identified the list of attributes that helped farmers to characterize the different faba bean varieties. These attributes included grain yield, grain size, number of pods per plant, number of seeds per pod, stem strength, chocolate spot resistance, rust resistance, rot resistance, germination and stand, early maturity, cooking ability, taste, and marketability. Second, we elicited farmers' perceptions using these attributes for local and improved faba bean varieties currently grown by the farmers themselves.

Farmers' perceptions about different faba bean varieties using the above attributes were elicited using an empirical approach applied by Sall et al. (2000). This approach uses an index that shows how well attributes of a variety meet farmers' preferences. It involves the application of quasi-arbitrary ordinal weights in which farmers rank the importance of each attribute and how well these attributes are embodied in different varieties. Accordingly, each farmer was asked to judge each attribute of the faba bean variety on two scales: first, the importance of a given attribute to the farmer (very important, important, and not so important); and, second, the quality of the attribute presented by a variety (very good, good, and poor). Thus, the response matrix for N farmers, each ranking the characteristics according to their importance and quality, is shown in Table 1. Each entry in the matrix, n_{ij}, represents the number of farmers who ranked a particular attribute based on their perception of its importance, j, and their satisfaction with the quality provided by the variety, i. The bottom row entries, C_j, are the total number of farmers who ranked the characteristic according to its importance. The row total, r_i, is the total number of farmers who ranked the characteristics as embodied in a variety at a certain level of satisfaction. Given the above description, the following must hold:

$$\Sigma C_j = \Sigma r_i = \Sigma \Sigma n_{ij} = N$$

The weighting matrix is presented in Table 2. The row totals (S_i) present the supply weights, which are weights assigned to farmers' perceptions of how well a specific attribute is embodied in a given variety. The column totals (d_j) present the demand weights, which are assigned to the farmers' perceptions of how important the specific attribute is. Each cell in the matrix is then calculated as:

$$W_{ij} = S_i d_j$$

Reed et al. (1991) and Sall et al. (2000) propose certain restrictions to be imposed on the weights, so that the following inequalities hold:

a) $w_{1j} > w_{2j} > w_{3j}$ for all j. This implies that regardless of how important a characteristic is, the more favorably the farmer perceives that characteristic being present in the evaluated variety, the higher the weight is.
b) $w_{i1} > w_{i2} > w_{i3} > 0$ for all i which is rated good or better. This inequality implies that whenever a characteristic embodied in a variety is rated as good or better, the weight should be positive and increase in value as its level of importance increases.
c) $w_{i1} < w_{i2} < w_{i3} < 0$ for all i which is rated poor. This implies weights for characteristics rated as poor should be negative and decreasing as their importance increases.

Table 1. The response matrix of farmers' perceptions of varietal attributes

	Attribute			
Variety	**Very important**	**Important**	**Not so important**	**Row total**
Very good	n_{11}	n_{12}	n_{13}	r_1
Good	n_{21}	n_{22}	n_{23}	r_2
Poor	n_{31}	n_{32}	n_{33}	r_3
Column total	c_1	c_2	c_3	N

d) The above inequalities imply the following restrictions when constructing the supply and demand weights: $S_1 > S_2 > 0 > S_3$ and $d_1 > d_2 > d_3 > 0$.

All demand weights (d_i) are positive, and the supply weight for a characteristic ranked as poor is negative. The stated weighting scheme ensures that the highest weights are given to those characteristics considered to be very important and very well embodied. Likewise, the lowest weights will be given to those characteristics considered least important. Given the response weighting matrices, the following indices can be calculated as follows:

$$D = \frac{1}{d_1 N} \sum_{j-1}^{3} d_j c_j$$

The demand index (DI) is a measure of how important the farmers perceive a characteristic to be. A value of 1 indicates that all farmers perceive the characteristic to be very important. The minimum value of the index is $(d_3/d_1) > 0$, and is attained when all farmers perceive the characteristic to be of little importance.

$$SI = \frac{1}{s_1 N} \sum_{j-1}^{3} s_i r_i$$

The supply index (SI) is a measure of the farmers' perceptions of how well a characteristic is embodied in a variety. A maximum value of 1 indicates that all farmers perceive the characteristic supplied as being very good quality. The minimum value is attained if all farmers perceive the quality of the characteristic being supplied as poor.

$$AI = \frac{1}{w_{11} N} \sum_{j=1}^{3} \sum_{i=1}^{3} w_{ij} n_{ij}$$

The attainment index (AI) provides a measure of how well farmers' perceptions of the importance of the characteristic match their perceptions of how well it is supplied in the variety. The maximum value of W is 1, which implies a perfect match. In such a situation, all farmers rank a particular attribute as very important and rank the quality supplied by the variety as very good. The minimum value of the index depends on the supply weight, S_i, chosen and is calculated to be $(s_i/s_1) < 0$.

2.4. Estimation of yield gaps

The yield gaps were assessed among the yields achieved on research stations, in farmers' fields with improved varieties and farmers' practices, and the average national yield by considering secondary data from different sources and making comparisons. The yield estimates at research stations were based on data from the national variety register for recently released varieties, and yields in farmers' fields with research-recommended practice were estimates from either demonstrations or popularization events, which are commonly reported in the variety register. In this study, estimates are from the variety register. The national yield estimate is from the estimates of the annual crop production reports of the Central Statistical Agency (CSA).

3. Results and discussion

3.1. Characteristics of faba bean producers and production

Table 3 presents the socio-demographic characteristics of faba bean producers. Most faba bean producers were

Table 2. The weighting matrix of farmers' perceptions of varietal attributes

	Attribute			
Variety	**Very important**	**Important**	**Not so important**	**Row total**
Very good	w_{11}	w_{12}	w_{13}	s_1
Good	w_{21}	w_{22}	w_{23}	s_2
Poor	w_{31}	w_{32}	w_{33}	s_3
Column total	d_1	d_2	d_3	

male-headed households with an average family size of about six individuals. In terms of resource ownership, a household on average owned 11.6 tropical livestock units (TLU) and 1.94 ha of land. Most faba bean producers reported access to major services: 98 percent reported that they have access to extension services, about 73 percent to cooperative services, and about 63 percent access to credit.

In terms of the importance of faba bean, farmers on average allocated 0.34 ha of land for faba bean, which is about 21.2 percent of the total land cultivated. Most farmers produced faba beans in one plot (about 90 percent) and about 8 percent of farmers produced in two plots.

3.2. Varieties, adoption, and perceptions of varietal attributes

3.2.1. Availability of improved faba bean varieties

Faba bean research is nationally coordinated by the Holeta Agricultural Research Center (ARC) of the Ethiopian Institute of Agricultural Research (EIAR). The ARCs involved in faba bean improvement are Holeta and Kulumsa ARCs of EIAR; Adet, Debre Berhan, and Sirinka ARCs of the Amhara Regional Agricultural Research Institute (ARARI); Fedis and Sinana ARCs of the Oromia Agricultural Research Institute (OARI); Hawasa ARC of the Southern Agricultural Research Institute (SARI); and Mekele University. Among the international agricultural research centers, the crop improvement program closely works mainly with ICARDA.

According to Keneni et al. (2006), faba bean breeding commenced with objectives to improve grain yield, seed size, and resistance to important diseases, particularly chocolate spot (*Botrytis fabae*). Several improved faba bean varieties have been developed and released for different recommendation domains, including the mid- and high-altitude agro-ecologies and the waterlogged Vertisol areas (Tolessa et al. 2015). Up until 2014, a total of 29 faba bean varieties were released in the country since the first release of CS-20-DK in 1977 by Holeta ARC (Table 4). Among these, some were released for waterlogged Vertisol areas where black root rot is a major problem (Dagm, Hachalu, and Walki), whereas others provided resistance to chocolate spot and rusts (Dosha) or had a large seed size (Gora). A review of

Table 3. Characteristics of faba bean producers and production

Category	Variable	Indicator	Estimates
Demographic characteristics	Gender (%)	Male Female	93.50 6.50
	Marital status (%)	Single Married Divorced Widowed	6.00 88.90 2.40 2.70
	Age of household head (years)	Mean Std	45.88 14.41
	Education level of head of household (years of formal education)	Mean Std	4.47 4.18
	Family size	Mean Std	6.08 2.66
Resource ownership	Livestock owned (TLU)*	Mean Std	11.58 8.55
	Own land cultivated (ha)	Mean Std	1.43 1.08
	Total land owned (ha)	Mean Std	1.94 1.15
Faba bean production characteristics	Size of land allocated for faba bean (ha)	Mean Std	0.34 0.25
	Proportion allocated from total operated land (%)	Mean Std	21.21 16.41
	No of plots allocated (%)	One Two Three Four	90.5 7.9 1.1 0.5
Access to services	Access to credit	%	63.7
	Membership in agricultural cooperatives	%	73.4
	Access to extension	%	98.10

Source: Own survey, 2014
Note: Std, standard deviation; * TLU estimated using conversion factors (Chilonda and Otte 2006)

three decades of faba bean improvement (1977–2007) showed low progress in grain yield and resistance to chocolate spot compared to seed size, calling for better strategies to address these challenges (Tolessa et al. 2015).

3.2.2. Varietal adoption

The results indicate that 19.6 percent of the faba bean growers were full adopters—all plots were covered with improved varieties; 1.9 percent were partial adopters—more than one of the plots were covered with improved varieties; and the remaining 78.5 percent were non-adopters—all faba bean plots used local varieties (Table 5). However, the adoption rate of faba bean based on the number of plots allocated to improved varieties is estimated at 18.93 percent, and based on the proportion of land allocated to improved varieties this is 22.38 percent. The data show a significant difference, with the average size of plots allocated to improved varieties at 0.37 ha compared to plots with local varieties at 0.30 ha. This indicates that plots allocated to improved varieties are on average larger than those with local varieties.

Of the 29 released varieties, only six varieties were identified by 8 percent of adopters: CS-20-DK (with 2.54 percent of adopters, released in 1977), Degaga (2.23 percent, 2002), Gabelcho (1.66 percent, 2006), Moti (0.63 percent, 2006), Kassa (0.59 percent, 1980), and Shallo (0.39 percent, 1999). The other 14.34 percent of adopters could not name the improved variety they grew. Some of the identified varieties, like CS-20-DK, are more than 40 years old and show exceptionally low varietal replacement rates in farmers' fields. The weighted average age of the improved varieties being used is 20.5 years.

The observed trends in the limited adoption of improved varieties and associated agronomic practices have resulted in low national yields. In this regard, productivity levels achieved at the national level, on farm under

Table 4. Faba bean varieties released by NARS: 1977–2014

Institute	Agricultural research center	No. of varieties	Released varieties
EIAR	Holetta	18	Tumsa, Hachalu, Dosha, Walki, Obse, Moti, Gabelcho, Selale, Wayu, Degaga, Holetta, Tesfa, Messay, Bulga 70, Kassa, Kuse, NC-58, CS-20-DK
	Kulumsa	2	Dide'a, Gora
ARARI	Adet	1	Adet-Hanna
	Debre Berhan	1	Lalo
	Sirinka	1	Dagm
OARI	Sinana	2	Mosisaa, Shallo
SARI	Hawassa	3	Bobicho-05, Bule-04, Angacha-1
Haromaya University		1	Gachena
Total		**29**	

Source: MoA (2014)

farmers' practice or under recommended practices, and on station at research stations may serve as yield gap indicators of availability and access to technologies, information, and knowledge. In general, they reflect the performance of a seed system, extension services, and other input delivery systems (Spielman et al. 2010; van Ittersuma et al. 2013).

The results indicated a clear yield gap in faba bean production due to varietal adoption and the application of recommended crop management practices. The national average yield, which was 1.8 tons ha^{-1} in 2014, is 44 and 50 percent lower than the yield achieved for farmers' fields using improved varieties and recommended practices and for research stations, respectively. These figures indicate the potential of narrowing the yield gap through improved access to varieties, quality seed, and recommended agronomic practices along with adequate extension services (Table 6).

3.2.3. Farmers' perceptions of faba bean varieties

We estimated the demand index (DI), SI, and attainment index (AI) for improved and local varieties based on the methodology discussed above (Table 7). The aggregation of the varieties into two categories is mainly associated with the limited number of farmers who knew the name of the improved varieties. Unlike other crops, farmers do not have given names for local varieties, and simply call them A(H)besha, meaning of Ethiopian origin or a landrace.

Accordingly, the results indicate that (i) yield and grain characteristics, disease resistance, earliness, and cooking ability are the attributes preferred most among all attributes; (ii) the relatively higher SI values of most of the attributes for improved varieties indicates that what the farmers demand is met more by improved varieties than by local landraces. However, the value of the SI for taste was far higher for local compared to improved varieties, indicating better perceived taste for local varieties; (iii) the high AI values for the improved varieties shows how the demanded characteristics are embodied more in improved compared to local varieties; and (iv) on average, local varieties show better AIs for early maturity, cooking ability, and taste, which implies the need to consider these attributes in the national faba bean breeding program so that improved varieties will have at least the same or better AIs compared to local varieties for maturity, cooking ability, and taste.

Yield and grain characteristics: Farmers' perceptions of grain characteristics (grain yield, grain size, number of pods per plant, and number of seeds per pod)

Table 5. Estimated adoption of improved faba bean varieties in Ethiopia

Approach	Adoption status	Estimated adoption (%)
Households (no. of farmers)	Full adopters	19.6
	Partial adopters	1.90
	Non-adopters	78.5
Plots (no. of plots)	Adopters	18.93
	Non-adopters	81.07
Area (ha)	Adopters	22.38
	Non-adopters	77.62

Source: Own survey, 2014

Table 6. Yield gaps in faba bean production in the highlands of Ethiopia

Category	Use of technologies and practices	Yield range (tons ha^{-1})*
Research field on station	■ Improved variety ■ Recommended practices, and ■ Researcher managed	2.3–5.0 (~3.6)
Farmers' fields with research-recommended practice	■ Improved variety ■ Recommended practices, and ■ Farmer managed	2.0–4.4 (~3.2)
National average yield	■ National production system	11.18–18.83 (~1.5)

Source: MoA (2014) and CSA (2014)
Note: * The ranges show recorded yield level and figures in parentheses are average yields

show considerable differences between local and improved faba bean varieties. The improved varieties demonstrated better AIs for grain size, number of pods per plant, and number of seeds per pod. This implies that the claimed better yield by breeders is not perceived by farmers as much as for the other attributes.

Field establishment, earliness, and crop stand: Improved faba bean varieties demonstrated better AIs for stem strength compared to local varieties. However, in terms of germination, emergence and crop establishment, and earliness, the local varieties presented better AIs compared to improved varieties. This result indicates the need to consider improvement of these attributes in faba bean breeding programs.

Disease resistance: Farmers consider that varieties embody resistance to important faba bean diseases such as chocolate spot, rust, and root rot. Accordingly, improved varieties demonstrated better AIs compared to local varieties. However, magnitudes of AIs for the three disease-related attributes are very low, implying the need to strengthen research for disease resistance. This confirms the recent trend of wider incidence of these diseases, which seriously affect production in faba bean growing areas.

Food quality and marketability: The estimated AI for taste clearly indicates farmers' preferences for local compared to improved faba bean varieties. However, the similar values of AI for marketability indicate that both improved and local varieties have good acceptance in markets. Similarly, the AIs for cooking ability are similar for both improved and local varieties.

3.3. Performance of the formal faba bean seed sector

Mirroring the national seed system setting generally, the faba bean seed system is composed of both the formal and informal sector. Although its contribution in terms of volume of seed is small, the formal sector plays a critical role in making released varieties available to end users. The NARS develops new faba bean varieties and supplies source seed (breeder, pre-basic, and basic seed); public seed enterprises or private seed companies

Table 7. Demand index (DI), supply index (SI), and attainment index (AI) for improved and local faba bean varieties

		Improved			Local		
Category	**Varietal attributes**	**DI**	**SI**	**AI**	**DI**	**SI**	**AI**
Yield and grain characteristics	Grain yield	0.932	0.847	0.793	0.950	0.736	0.706
	Grain size	0.888	0.823	0.743	0.868	0.587	0.517
	No. of pods per plant	0.863	0.719	0.625	0.843	0.585	0.502
	No. of seeds per pod	0.843	0.606	0.527	0.853	0.562	0.492
Field establishment, stand, and earliness	Stem strength	0.839	0.679	0.561	0.821	0.558	0.449
	Germination and stand	0.771	0.590	0.461	0.829	0.660	0.551
	Early maturity	0.831	0.518	0.448	0.845	0.545	0.472
Disease resistance	Chocolate spot resistance	0.837	0.480	0.398	0.816	0.323	0.287
	Rust resistance	0.811	0.349	0.305	0.809	0.288	0.259
	Root rot resistance	0.811	0.365	0.297	0.773	0.308	0.286
Food quality and marketability	Cooking ability	0.815	0.663	0.548	0.812	0.639	0.547
	Taste	0.779	0.655	0.533	0.862	0.854	0.735
	Marketability	0.876	0.823	0.739	0.917	0.801	0.738

Source: Own survey, 2014

produce certified seed; cooperatives are involved as seed distributors; and regulators ensure the quality of seed used.

The NARS is responsible for early generation seed (breeder, pre-basic, and basic seed) production of their released varieties along with the Ethiopian Seed Enterprise (ESE), which is involved in pre-basic and basic seed production of some crops including faba bean. Among the 30 released varieties, basic seed for only 10 varieties was produced in the 2014 production season. Of the total 112.7 tons of basic seed produced for the 10 varieties, about 85 percent was for CS-20-DK by the ESE. This indicates not only the limited availability of source seed for production of certified seed (Table 8) but also the mismatch between basic and certified seed production (Tables 8 and 9) in terms of the list of varieties and amount of seed demanded, produced, and supplied. This clearly demonstrates a lack of demand-driven seed production and marketing with no alignment between early generation seed and certified seed production.

The trend in revealed demand and supply of certified seed has interesting features: (i) there is an increasing trend in revealed demand for seed over the years although there is some inconsistency which dropped in 2014; (ii) the proportion of seed supplied is considerably lower than revealed demand, showing limited engagement of formal sector actors; and (iii) the amount of seed distributed is far less than the total amount supplied, showing considerable carry-over seed in some years (Figure 2) due to a mismatch between varieties demanded and those supplied, reducing the total supply where only 20–45 percent of the demand is supplied.

The main actors in certified seed supply of faba beans are public seed enterprises. Given the limited commercial interest in the crop, private sector engagement is lacking in terms of seed produced and varietal coverage. The data for the 2014 production season indicates a considerable seed supply gap compared to demand (Figure 2 and Table 9).

In 2014, the revealed certified seed demand of 5,752 tons is estimated to cover only 8.65 percent of the total faba bean area (0.44 million ha); however, only 45.9 percent of demand was supplied (2,638 tons), which would cover only 3.97 percent of the total faba bean area (Table 9). Moreover, the data shows a mismatch between varietal choice and certified seed supplied—of the eight varieties, only certified seed of four varieties was supplied: Moti, Bulga, CS-20-DK, and Messay. This implies that very few farmers were served by the formal sector despite demand for quality seed. Moreover, seed of old commercial varieties is supplied by the formal sector.

Given its considerable outcrossing nature, seed production of faba bean requires isolation to maintain varietal purity and identity. Farm-saved seed of faba bean

Table 8. Amount of faba bean basic seed produced by NARS and ESE (2014)

Variety	Year released	Area allocated (ha)	Basic seed produced (tons)	Producers
CS-20-DK	1977	58.00	95.586	EIAR, ESE
Lalo	2002	1.25	1.00	EIAR
Degaga	2002	1.79	2.148	ESE
Dagm	2002	1.00	0.80	ARARI
Gabelcho	2006	4.00	5.00	OARI, ESE
Obse	2007	3.10	4.23	EIAR, ESE
Walki	2008	2.00	2.70	OARI, ARARI
Hachalu	2010	0.50	0.75	EIAR
Mosisaa	2013	0.40	0.34	OARI
Hashenge	2015	0.25	0.20	TARI
Total		**72.29**	**112.754**	

Source: National Seed Production and Distribution Committee (2014)

is vulnerable to contamination by varieties in a given production area and with pollinator activity. This implies the more frequent need to use certified seed compared with self-pollinated crops.

3.4. Commercial behavior in seed use and varietal renewal patterns

For various reasons farmers may use seed from different sources (Bishaw 2004). Understanding the commercial behavior of smallholder farmers in relation to seed helps gauge the seed market and plan promotions to create demand and ensure supply (Bishaw et al. 2011; Alemu and Bishaw 2015).

The assessed commercial behavior of faba bean producers is presented in Table 10. Of the 19.6 percent of farmers who are full adopters of improved faba bean varieties, only 5.4 percent purchased certified seed, whereas 4.8 percent purchased seed from local sources, and the remaining 9.4 percent used their own saved seed. Of the partial adopters, 0.5 percent used their own saved seed and the others purchased certified seed: 1.1 percent from the formal sector and 0.3 percent from local markets. Among the non-adopters, 13.4 percent used seed purchased from local sources and 65.1 percent used saved seed (Table 10). These results indicate that a large proportion of both adopters or non-adopters of improved varieties depend on using saved or locally purchased faba bean seed, showing the predominance of the informal sector.

Official statistics appear to show a huge demand for certified faba bean seed, indicating the potential market for faba bean seed. However, the limited engagement of both the public and the private sector in certified seed production has resulted in a limited supply of certified seed, which has directly led to the low adoption levels of improved varieties. However, engaging non-adopters has potential to boost adoption rates and create a bigger faba bean seed market, if adequate demand creation as well as associated supply of certified seed of the demanded improved varieties is ensured. Of the 28.4 percent of faba bean producers who purchased non-certified seed, 24.32 percent are non-adopters of improved varieties.

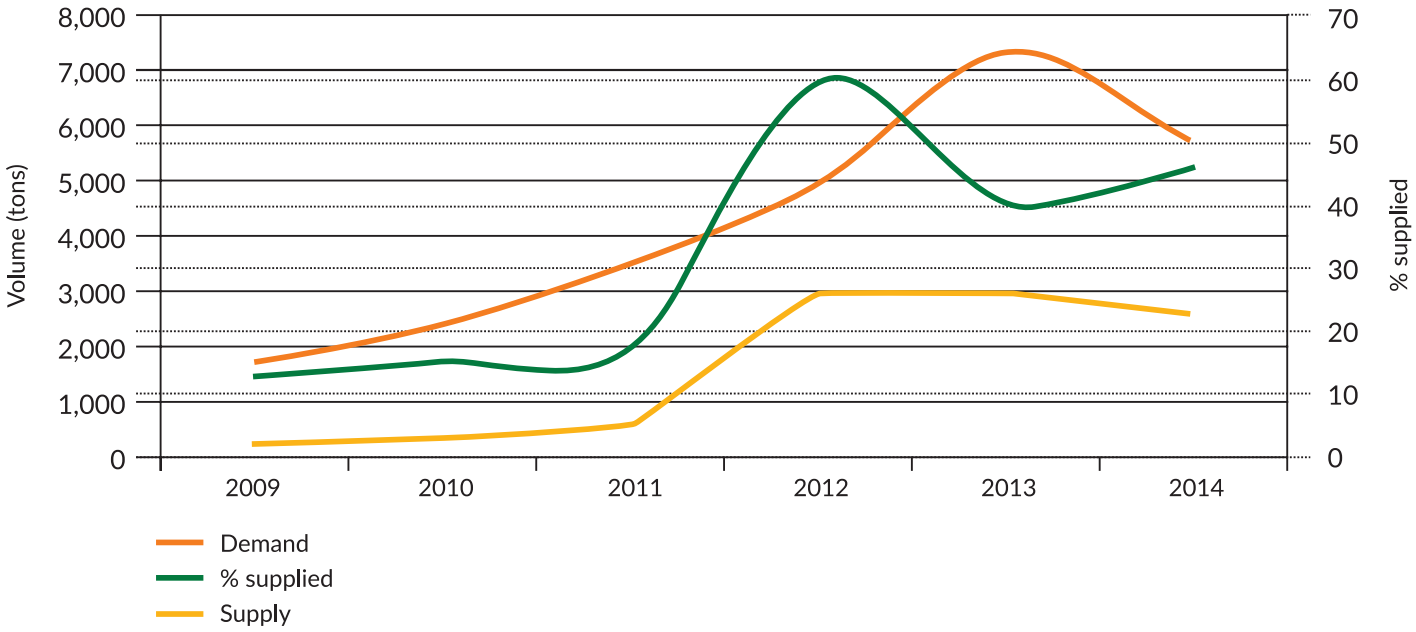

Figure 2. Faba bean seed demand, supply, and distribution (2009–2014)

Source: National Seed Production and Distribution Committee (2014)

Table 9. Faba bean certified seed demand and supply in Ethiopia (2014)

Varieties	Year released	Demand (tons)	Proportion of total demand (%)	Supply (tons)	Demand supplied (%)
CS-20-DK	1977	4762.4	82.8	2,599.37	54.6
Bulga	1995	130.72	2.3	6.18	4.7
Messay	1996	81.12	1.4	4.93	6.1
Tesfa	1996	12.58	0.2	-	-
Lalo	2002	457.62	7.96	-	-
Dagm	2002	148.99	2.6	-	-
Moti	2006	62.18	1.1	27.51	44.2
Walki	2008	96.37	1.7	-	-
Total		**5,752**	**100**	**2,637.99**	**45.9**

Source: National Seed Production and Distribution Committee (2014)
Note: - denotes no supply

The limited engagement of actors in the formal seed system is also reported to be associated with the limited commercial attractiveness of faba bean seed compared to seed of other crops such as maize in terms of grain to seed price ratio. The estimate of the grain to seed price ratio in 2014 for faba bean was 67 percent compared to 27 percent for maize (hybrid maize). The limited amount of certified seed is often produced by public seed enterprises, primarily the ESE.

The pattern indicated in Table 11 shows the need to consider the promotion of alternative approaches to boost better adoption and varietal renewal, such as local seed businesses (Thijssen et al. 2015), farmers' research groups (Alemu and Shiratori 2016), and farmers' seed schools (Yagi et al. 2014), which have demonstrated better use of quality seed of preferred varieties and facilitation of the transition to a formal seed system.

The seed renewal pattern varies by adoption category. Among the 78.6 percent of non-adopters (n = 293) of improved faba bean varieties, around 54 percent (n = 159) reported that they do not renew their seed stock and the remaining 24.32 percent reported renewing their seed stock by purchasing non-certified seed. Of the 19.6 percent of full adopters, 8.40 percent reported that they do not renew their seed stock, 4.46 percent renew using both certified and non-certified seeds, 4.09 percent renew through the purchase of non-certified seed, and the remaining 2.65 percent renew using certified seed (Table 11). The average seed renewal rate according to adoption category did not significantly differ, indicating renewal on average after every two years for all categories of adoption.

4. Conclusions and recommendations

In addition to its contribution to household food and nutritional security, faba bean has become one of the main agricultural export commodities in Ethiopia. In this regard, its increased importance demands boosting productivity and production of the crop by addressing key challenges. The results of this study focused on varietal adoption, preferences, and the commercial behaviors of smallholders in seed use of faba bean, and demonstrate the following key challenges and future areas of attention:

- Faba bean is a food security crop in the highlands, where there is limited crop diversity. Low adoption rates and old commercial varieties characterize the formal sector showing low rates of adoption and varietal replacement. Promotion of newly released improved faba bean varieties to create demand for

Table 10. Commercial behavior in seed use according to adoption type

	Commercial behavior (% of faba bean producers)			
Adoption	**Purchased certified seed**	**Purchased non-certified seed**	**Own saved seed**	**Total**
Full adopter (n = 73)	5.4	4.8	9.4	19.6
Partial adopter (n = 7)	1.1	0.3	0.5	1.9
Non-adopter (n = 293)	-	13.4	65.1	78.6
Total (n = 373)	**6.4**	**18.5**	**75.1**	**100.0**

Source: Own survey, 2014

seed and better varietal adoption and replacement is critical for increased productivity and production to ensure food and nutrition security in the country.

- Although improved faba bean varieties demonstrated higher AIs for most key varietal attributes, it is important for breeding programs to consider improving the varietal attributes related to early maturity, cooking ability, and taste because local varieties show higher AIs for these.
- The size of revealed demand for certified seed is very small compared to the total land allocated for faba bean production. Moreover, better seed demand assessment considering farmers' demand shifts in response to emerging production and marketing challenges is critical. There is a need for demand creation concerning certified seed and newly released varieties.

Table 11. Patterns in faba bean seed renewal by adoption category

			Adoption category				
Renewal	**Renewal mechanism**	**Indicator**	**Full adopters**	**Partial adopters**	**Non-adopters**	**Total**	**Chi-square/ F-value**
Renewal pattern	Purchase of both certified and non-certified seed	%	4.46	1.31	-	5.70	133.85***
	Purchase of non-certified seed	%	4.09	-	24.32	28.40	
	Purchase of only certified seed	%	2.65	-	-	2.65	
	Do not renew at all	%	8.40	0.59	54.26	63.25	
	Total	%	19.6	1.9	78.6	100.0	
Average number of years for renewal	Purchase of certified seed	Years Std	2.31 1.01	1.75 0.96	- -	2.25 1.01	1.10
	Purchase of non-certified seed	Years Std	2.12 1.017	3.25 1.26	2.41 1.898	2.35 1.69	1.01

Source: Own survey, 2014
Note: *** indicates significance at P<0.01

- The commercial behavior of farmers indicates the dominance of their own saved or locally purchased seed even among adopters of improved varieties. This implies the need to promote an optimum seed replacement rate given faba bean's outcrossing nature. Given the limited performance of the formal seed sector for faba bean, and the level of local seed purchase, it will be important to promote an integrated seed system where farmer-based seed enterprises can contribute to the use of quality seed of preferred improved varieties.

References

Alemu, D. 2011. The Political Economy of Ethiopian Cereal Seed Systems: State Control, Market Liberalisation and Decentralisation. *IDS Bulletin* 42 (4): 69–77.

Alemu, D. and Z. Bishaw. 2015. Commercial Behaviours of Smallholder Farmers in Wheat Seed and its Implication for Seed Demand Assessment in Ethiopia. *Development in Practice* 26(6): 798–814.

Alemu, D. and Z. Bishaw. 2016. Commercial Behaviour, Varietal Preferences and Wheat Seed Markets in Ethiopia. Working Paper 30. Beirut, Lebanon: International Center for Agricultural Research in the Dry Areas (ICARDA).

Alemu, D. and K. Shiratori. 2016. Overview of Farmer Research Group-based participatory research in Ethiopia. *In* Farmer Research Groups Institutionalizing Participatory Agricultural Research in Ethiopia, (eds. D. Alemu, Y. Nishikawa, K. Shiratori, and T. Seo), 13–24. Rugby, UK: Practical Action Publishing.

Bishaw, Z. 2004. Wheat and Barley Seed Systems in Ethiopia and Syria. PhD dissertation, Wageningen University, the Netherlands.

Bishaw, Z., P.C. Struik, and A.J.G. van Gastel. 2011. Wheat and Barley Seed Systems in Syria: Farmers' Varietal Perception, Seed Sources and Seed Management. *International Journal of Plant Production* 5(4): 323–347.

Chilonda, P. and J. Otte. 2006. Indicators to monitor trends in livestock production at national, regional and international levels. *Livestock Research for Rural Development* 18(6).

CSA (Central Statistical Agency). 2014. Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season). Agricultural sample survey 2013/2014 (2006 E.C.). Statistical Bulletin 532. Addis Ababa, Ethiopia: CSA.

CSA (Central Statistical Agency). 2004–2014. Reports on Area and Production of Major Crops. Agricultural Sample Survey. Statistical Bulletins. Addis Ababa, Ethiopia: CSA.

EIAR (Ethiopian Institute of Agricultural Research). 2017. Pulses Research Strategy (2016–2030). Addis Ababa, Ethiopia: EIAR.

ERCA (Ethiopian Revenues and Customs Authority). 2015. Import–Export Data. Addis Ababa, Ethiopia: ERCA.

Keneni, G., M. Jarso, and T. Welabu. 2006. Faba Bean (*Vicia faba* L.) Genetics and Breeding Research in Ethiopia: A Review. *In* Food and Forage Legumes of Ethiopia: Progress and Prospects. Proceedings of a Workshop on Food and Forage Legumes. September 2003, Addis Ababa, Ethiopia, (eds. K. Ali, G. Keneni, S. Ahmed, R. Malhotra, S. Beniwal, K. Makkouk, and M.H. Halila). Aleppo, Syria: ICARDA.

Lakew, T. and D. Alemu. 2012. Approaches and Procedures of Seed Demand Assessment in the Formal Seed Sector, 1-8. *In* Seed Demand Assessment: Practices, Challenges, and Options. Proceedings of the FRG II project Seminar series: Empowering Farmers' Innovation Series No. 5. EIAR/ Farmers' Research Group Project No. II, (eds. A. Teklewold, D. Alemu, S. Kiyoshi, and A. Kirub). Addis Ababa, Ethiopia: EIAR.

MoA (Ministry of Agriculture). 2014. Crop Variety Register. Issue No 17. Addis Ababa, Ethiopia: Plant Variety Release, Protection and Seed Quality Control Directorate, MoA.

Reed, G.V., M.R. Binks, and C.T. Ennew. 1991. Matching the Characteristics of a Service to the Preferences of Customers. *Managerial and Decision Economics* 12: 231–240.

Sall, S., D. Norman, and A.M. Featherstone. 2000. Qualitative Assessment of Improved Rice Variety Adoption: Farmers' Perspective. *Agricultural Systems* 66: 129–144.

Spielman, D., D. Byerlee, D. Alemu, and D. Kelemework. 2010. Policies to Promote Cereal Intensification in Ethiopia: The Search for Appropriate Public and Private Roles. *Food Policy* 35: 185–194.

Thijssen, M., G. Borman, K. Verhoosel, A. Mastenbroek. and W. Heemskerk. 2015. Local Seed Business in the Context of Integrated Seed Sector Development. *In* Community Seed Production. Workshop Proceedings, 9–11 December 2013, Addis Ababa,

Ethiopia, (eds. C.O. Ojiewo, S. Kugbei, Z. Bishaw, and J.C. Rubyogo), 39–45. Rome and Addis Ababa: FAO and ICRISAT.

Tolessa, T.T., G. Keneni, and H. Mohammad. 2015. Genetic Progresses from Over Three Decades of Faba Bean (*Vicia faba* L.) Breeding in Ethiopia. *Australian Journal of Crop Science* 9(1): 41–48.

van Ittersuma, M.K., K.G. Cassman, P. Grassini, J. Wolf, P. Tittonell, and Z. Hochman. 2013. Yield Gap Analysis with Local to Global Relevance—A Review. *Field Crops Research* 143: 4–17.

Yagi, K., K. Shiratori, D. Alemu, and A. Bekele. 2014. Seed Farmers' School (SFS): Experiences of Quality Seed Promotion Project. *In* Quality Seed Promotion Project, Ministry of Agriculture, Farmers' Research Group Project, Ethiopian Institute of Agriculture, and Japan International Cooperation Agency (JICA).

Yirga C. and D. Alemu. 2016. Adoption of Crop Technologies Among Smallholder Farmers in Ethiopia: Implications for Research and Development. *Ethiopian Journal Agricultural Science*. EIAR 50th Year Jubilee Anniversary Special Issue: 1–16.

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is a non-profit, CGIAR Research Center that focusses on delivering innovative solutions for sustainable agricultural development in the non-tropical dry areas of the developing world. We provide innovative, science-based solutions to improve the livelihoods and resilience of resource-poor smallholder farmers. We do this through strategic partnerships, linking research to development, and capacity development, and by taking into account gender equality and the role of youth in transforming the non-tropical dry areas.
www.icarda.org

CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to reducing poverty, enhancing food and nutrition security, and improving natural resources and ecosystem services. Its research is carried out by 15 CGIAR centers in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector.
www.cgiar.org