Strategies and Innovative Approaches for Food Legumes Seed Delivery in Ethiopia

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Abstract

Seed is the only vehicle in crop technology promotion, adoption and impact enhancement. Legumes play an important role in food and nutritional security of smallholder farmers and sustainability of farming systems in Ethiopia. The national agricultural research systems (NARS) in partnership with the international agricultural research centres (IARCs) have developed several improved varieties and integrated crop management technologies for legume production in the country. Currently about 201 legume varieties have been released by NARS from the federal and regional agricultural research institutes. However, the adoption of improved varieties and agronomic management practices are constrained by lack of information, skills and knowledge and inadequate availability, access and use of inputs by most farmers. The paper reviews the status, challenges and opportunities of the legume seed sector and suggests strategies to enhance seed delivery within the Ethiopian context.

Key words: Food legumes, scaling, seed delivery, farmer-based seed production, Ethiopia

Introduction

Legumes play a significant role in the integrated crop-livestock farming systems and provide multiple benefits to the smallholder farmers in Ethiopia. They are important sources of protein, micro-nutrients and vitamins ensuring food and nutritional security; improve soil fertility and health fixing N from the atmosphere and as break crops for rotation ensuring sustainability of farming systems; increase farm incomes improving rural livelihoods and reducing poverty as cash crops in the domestic and international markets earning foreign currency for the country. Legumes are also known for their low carbon foot print and help in mitigation of climate change. In 2015/16 crop season, both highland and lowland legumes collectively occupied 1.7 million ha (13.24% of crop area) with production of 2.8 million t (10.38% of crop production) at an average productivity of 1.68 t ha^{-1} (CSA, 2016). The main grain legumes produced include faba bean, field pea, chickpea, grasspea, lentil, fenugreek and lupine in the highlands; and haricot bean, soybean and mung bean in the lowlands. CSA has no statistics yet on

adzuki bean, *Dekoko* (*Pisum sativum* var. *abyssinicum*),
cowpea and pigeon pea production (CSA, 2016).

Table 1 shows substantial area expansion, increase in grain production and progress in crop productivity particularly during the last one and half decade (2001-2016). The overall area expansion for all legumes was 63% with the range from the highest of 198% for haricot bean to the lowest of 20% for faba bean (except soya bean). Similarly, grain production had increased by 171% for all legumes with range from 448% (haricot bean) to 90% (faba bean). The productivity increase was 68% with the range of 133% (highest for soya bean) and 35.4% (the lowest for lupine) followed by faba bean (58%) and grasspea (64%). For some crops productivity is the main source of increase in production compared to area expansion. The minimum productivity increase of grasspea and lupine is understandable given little or no agricultural research on both crops even though they are hardy and low input crops, with better N fixation (Atnaf *et al.*, 2015) and human health benefits (Foyer *et al.*, 2016) and long history in the traditional farming systems of smallholder farmers in the country.

This review examines the achievements made in legume seed system development over the last decades and identifies major challenges constraining the availability and access to seeds of legumes in Ethiopia. The review concludes with opportunities and way forward to enhance the development of legume seed systems in the country.

Table 1. Area, production and productivity changes of legumes in Ethiopia: 2001-2015

Crop	Area in ha (000)			Production in t (000)			Yield t ha^{-1}		
	2001	2016	Increase (%)	2001	2016	Increase (%)	2001	2016	Increase (%)
Faba bean	369.15	443.97	20.3	447.06	848.65	89.8	1.21	1.91	57.8
Field pea	175.22	221.42	26.4	147.27	323.39	119.6	0.84	1.46	73.8
Chickpea	184.80	258.49	39.9	179.82	472.61	162.8	0.97	1.83	87.9
Grass pea	83.52	159.11	90.5	92.34	287.67	211.5	1.11	1.81	63.5
Lentil	60.14	100.69	67.4	38.43	133.93	248.5	0.64	1.33	108.2
Lupine	7.25	16.79	131.6	5.97	18.72	213.6	0.82	1.11	35.4
Fenugreek	15.05	29.84	98.3	10.03	35.65	255.4	0.67	1.19	79.3
Haricot bean	119.88	357.30	198.1	98.67	540.24	447.5	0.82	1.51	83.7
Soya bean	1.77	38.17	2056.5	1.62	81.24	4914.8	0.92	2.13	132.5
Mung bean	-	27.09	-	-	27.16	-	-	1.00	-
Total (legumes)	**1016.78**	**1652.86**	**62.56**	**1,021.21**	**2,769.26**	**171.2**	**1.0**	**1.68**	**68**

Source: CSA, 2001 &2016

State of Food Legumes Research

Agricultural research is crucial to generate new and better crop technologies that address the challenges of food and nutritional security and economic growth and development while maintaining and conserving the natural resource base of the country. The beginning of agricultural research has relatively a long history linked to the establishment of agricultural schools and colleges almost 70 years ago. EIAR (ex IAR/EARO) was later established as a sole public national agricultural research center in 1966. Since 1990s the agricultural research landscape has changed tremendously with the establishment of the regional agricultural research institutes (RARIs).

Institutional Arrangements

In Ethiopia, to date, NARS (National Agricultural Research System) constitute one federal and seven regional public agricultural research institutes (RARIs), 25 public higher learning institutes (HLIs), few private companies and NGOs (https://agriknowledge.org/downloads/1n79h429p). Apart from NARS, legume research is also augmented by the CGIAR centres such as CIAT, ICARDA, ICRISAT and IITA supporting research for development projects of chickpea, lentil, faba bean, beans, grasspea in partnership with the NARS. However, the private sector research on legume crops is very little, if any where they may introduce varieties for testing and release through the public NARS. Effective coordination will avoid duplication of activities and accountability among the Ethiopian NARS at the federal, RARIs and HLIs to facilitate the effort in generating, promoting and delivering new and better agricultural technologies but also the research-extension-farmer linkages. The establishment of NARC in 2014 (Kassa and Alemu, 2017) to undertake overall coordination of agricultural research is expected to address some of these critical issues in the country's national agricultural research system.

In Ethiopia, both cool season (faba bean, field pea, chickpea, lentils and grasspea) and tropical (common bean, pigeon pea, mung bean and soya bean) legumes are grown extensively integrated with cereal crops. Faba bean and field pea are dominant in the barely-livestock farming systems in the highlands; chickpea, lentil and grasspea are common in the wheat-teff based cropping systems in the mid-highlands; and beans (haricot bean, soya bean and mung bean) are dominant in the lowlands where maize and sorghum are the major crops. Almost all grain legume research is coordinated by the federal NARS with few exceptions. Holetta ARC coordinates research on highland legumes such as faba bean, field pea and lupine, Deber Zeit ARC handles chickpea and lentil and Melkasa ARC is responsible for haricot beans. These centres are responsible for development of legume technologies in

collaboration with federal and regional ARCs and breeder and pre-basic seed production. However, like cereals, early generation seed production of legumes is constrained by lack of clearly defined roles and responsibility with accountability.

Current Production Constraints of Food Legumes

A considerable number of constraints and challenges were reported in grain legumes along the value-chain from production to utilization in Ethiopia (Atnaf *et al.*, 2015). Compared to cereals, legumes have low investments in crop improvement, management and input use. Grain legumes productivity is far below the potential due to low input use, lack of awareness of improved varieties, limited availability of quality seed, limited use of improved crop management practices, and poor extension services (Atnaf *et al.*, 2015; Kelemework, 2015; Tefera, 2013). Non-availability, high price, and lack of credit facilities have been some of the constraints related to use of inputs such as seeds, fertilizers and agro-chemicals. Poor seed bed preparation and use of marginal land is also identified as production constraints (Abate *et al.*, 2011; IFPRI, 2010). Moreover, weeding is rarely done and little or no fertilizer is applied in legume production.

Weak seed system of grain legumes is often cited as critical constraints to provide quality seed of improved varieties in adequate quantities and price (Abate *et al.*, 2011; Bishaw and Louwaars, 2012; Husmann, 2015; IFPRI, 2010). Poor infrastructure not only exacerbate the quantity and quality of grain legume marketing (IFPRI, 2010) but also hinders the access to inputs and the intensity of technology adoption.

Development of Food Legume Technologies

Variety development and release

The overriding research objectives in grain legumes have been on high grain yield and quality and adaptive traits to diverse production environments in the country (Fikre, 2016). NARS has released 108 highland and 93 lowland legume varieties during the last five decades as shown in Table 2 (MoANR, 2016). All the varieties have been developed for adaptation, productivity, preference and economic traits compared to contemporary standard checks. For example, faba bean varieties tolerant to waterlogging on Vertisols and partially resistant to Orobanche were released for production. Lentil varieties released with resistance to rusts resurrected lentil production in the highlands of Ethiopia.

In terms of varietal releases, haricot bean has the highest (about 1.3 variety per year) followed by field pea (0.8), faba bean (0.7) and chickpea (0.5). However, given variations in total crop area in the country, the number of varietal releases adjusted to per million

hectares of crop area is suggested as a useful indicator for comparison (Lantican *et al.*, 2014). Accordingly, the number of varieties released per million ha of cultivated land is the highest for soya bean followed by haricot bean, field pea and lentil owing to the smaller total area under cultivation compared to other legumes.

Table 2. Number of grain legume varieties released in Ethiopia: 1973-2015

Crops	Number of released varieties	Year of first release (variety)	Varieties released in 2015
Highland grain legumes			
Faba bean	31	1977 (CS-20-DK)	Ashebeka, Hashenge
Field pea	35	1979 (FP DZ)	Bursa
Dekoko	2	2015 (Raya 1, Raya 2)	Raya1, Raya 2
Chickpea (Desi)	12	1974 (DZ-10-11, DZ-10-4)	
Chickpea (Kabuli)	11	1999 (Arerti, Shasho)	
Lentil	11	1984 (Checole)	Jiru
Grass pea	1	2005 (Wasie)	
Fenugreek	3	2005 (Chala)	
Lupine*	2	2014 (Vitabor, Sanabor)	
Sub-total	**108**		
Lowland grain legumes			
Haricot bean	57	1973 (Mexican 142)	Ado, Tafach
Soybean	25	<1981 (Crawford, Williams)	Gazale, Pawe 01, Pawe 02
Mung bean	4	2008 (Borda)	
Adzuki bean	1	2015 (Erimo)	Erimo
Cowpea	6	2001 (Bekur)	
Sub-total	**93**		
Total	**201**		

Source: MoAN (crop variety register, issue no 19; 2016Addis Ababa Ethiopia); *Forage crops

Development of integrated crop management technologies

Improved crop varieties should be accompanied by an integrated crop management (ICM) practices to achieve maximum and economic yield. Detailed production package for faba bean, field pea, chickpea, lentil, haricot bean, and soybean were published in Amharic by EIAR (2007) on seed bed preparation; sowing rate, method, and time; irrigation management; weed and disease management; and field and storage insect pest management. However, production packages for grasspea were not specific and there were none for lupine, pigeonpea, fenugreek and mung bean in this guide.

The EIAR report (africasoilhealth.cabi.org/wpcms/wp-content/.../330-EIAR-Biofertlizer-manual.pdf), indicated commercially available rhizobia inoculants for faba bean, field pea, chickpea, soybean, lentil, haricot bean, and cowpea; and the opportunity for better products from the on-going research (Argaw *et al.*, 2015; Mnalku *et al.*, 2009). A study on native rhizobial strains compared to commercial EAL-029 and control showed that inoculation improved grain yield of chickpea in range of 17-

42% over the control across locations and chickpea varieties (Alemu, 2016). Strain ICRE-03 and ICRE-05 significantly improved chickpea grain yield by 15.5% and 21.4%, respectively, over EAL-029 at Debre Ziet but no significant difference at Wolayta Sodo. This result implies the potential to develop location specific alternative rhizobial strains to EAL-029 depending on economies of scale and capacity.

Rhizobia inoculants technology is 10 times cheaper compared to 50 kg ha^{-1} application of Urea fertilizer for production of grain legumes (africasoilhealth.cabi.org/wpcms/wp-content/.../330-EIAR-Biofertlizer-manual.pdf). The continuous use of rhizobia inoculants can help improve the soil fertility for subsequent crops and is useful for Ethiopian soils where 85% are reported to have low levels of N. The preliminary study on inoculation method by phosphorus application rates on productivity of soybean suggested that soybean needs application of 20 kg P ha^{-1} when produced without *Bradyrhizohium* inoculation, and no fertilization is required under inoculated condition on Acrisols in south western Ethiopia (Kenea, 2011). However, this result needs further validation across years and locations to reach a conclusive recommendation.

Fikre (2016) reported that legumes-cereals rotation saves 30% of N fertilizer need for the next crop. Such findings are useful to integrate grain legumes with cereals which demand high and expensive fertilizer application for smallholder farmers who may not afford high and rising input costs.

Faba bean gall disease (*Olpidium viciae)* has become the single most important yield limiting threat since 2010 and has reached epidemic levels in Amhara and Tigray Regional States (Abebe *et al.*, 2014; Hailemariam *et al.*, 2016; Hailu *et al.*, 2014). Bitew and Tigabie (2016) reported integrated approaches reduced disease incidence and severity which resulted in improved productivity. Integration of three sprays (at seedling, flowering and podding stages) of Baylaton WP 25 (Triadimefon 250 g kg^{-1}) at the rate of 0.7 kg ha^{-1} with relatively tolerant varieties and improved cultural practices (sowing time, crop rotation, soil fertility) was recommended. Improved varieties were relatively tolerant because of their vigorous early growth than local varieties; and cultural practices which enhances early vigorous growth also contributed to the relative disease tolerance.

The research to control the parasitic weed has enabled to reintroduce faba bean production in previously abandoned hot spot areas of Amhara and Tigray regions of Ethiopia. The ICARDA and NARS cooperative research program (www.mktplace.org/site/images/documents/ID524FinalReport.pdf) revealed that integrating partially resistant cultivar *Hashenge* (Abebe *et al.*, 2015) and one to two sprays of sub-lethal glyphosate at flowering stages were

found to be effective in managing Orobanche (*O. crenata*) in faba bean and increased grain yield up to 3 t ha^{-1}. Faba bean and lentil genotypes were also identified for further evaluation and release of partially resistant varieties. The integrated faba bean gall disease management and integrated parasitic weed management have been aggressively promoted and being scaled up/out since 2015 by ICARDA in collaboration with NARS and district Offices of Agriculture through USAID funded project.

There are many recent crop management studies which need to be validated and integrated in useable forms for promotion and scaling to reach smallholder farmers producing highland and lowland grain legumes.

Adoption and Performance of Food Legume Technologies

Agricultural research and technological improvements are crucial to increase agricultural productivity to meet demand for food and nutritional security and improve farmers livelihoods and thereby reduce rural poverty. However, these innovations must meet farmers' needs, minimize their risks and ensure predicted income to justify adoption.

Varietal adoption

Several adoption studies of grain legumes have found significant adoption rates of improved varieties and associated technologies such as fertilizers and herbicides among small-scale farmers in Ethiopia. Bishaw and Atilaw (2016) summarized grain legume adoption in Ethiopia, ranging from 44% for bean to 2% for field pea. Yirga and Alemu (2016) reported adoption rates of improved varieties of chickpea, faba bean and lentil was 19.4%, 15.6%, and 11%, respectively. Alemu and Bishaw (2017) however reported that old varieties tend to dominate faba bean varietal adoption. Farmers' knowledge and perception of existing improved varieties, household wealth (land and livestock) and availability of active labor force are major determinants for adoption of improved technologies (Asfaw *et al.*, 2011). Significant variation in adoption however was found between geographic regions and high and low potential areas across the country.

Among crop technology adopters, it was most frequently found that annual gross income of a household positively and significantly influenced crop technology adoption; thus, higher income resulting in a greater adoption of technologies. The impact of adopting new chickpea varieties on household welfare is reported from Ethiopia (Verkaart *et al.,* 2017).

Yield gaps

In Ethiopia, the major outstanding and persistent reason for yield gap is the low adoption of improved technologies by smallholder farmers (Asfaw *et al.*, 2011). Many extension approaches including the recent 'model farmers approach' have been tried for scaling

up and out of improved technologies to increase production and productivity (Tefera *et al.*, 2016) but the study also found that the productivity and adoption of the technologies and practices by smallholder farmers remains low. The overwhelming number of farmers across four regions (Amhara, Oromia, SNNP, and Tigray) responded that seed unavailability was the first major factor that hinders use and adoption of improved varieties. On the other hand the major constraint for pesticide use is high cost and unavailability. In most study regions, famers practiced hand weeding instead of herbicide. A recent review of agricultural research and extension linkages by Kassa & Alemu (2017) also reported that many farmers are not aware of the existence of technologies developed by research because of limited capacity of actors responsible for technology multiplication and delivery systems. Partial adoption and sub-optimal application of technological packages by smallholder farmers are also another factor limiting productivity.

Productivity gaps of improved varieties on-station and on-farm conditions are indicated in the crop variety register which is published annually to register and notify the agro-ecological adaptation and the merits of newly released varieties. The national average yield of each crop across different varieties, management practices and agro-ecologies are also reported annually based on the sample survey of the Central Statistical Agency. Figure 1 summarized from these sources, showed that the productivity gaps between potential yield, achieved yield and national average yield by smallholder farmers is very huge.

A combination of genetic improvement coupled with best agronomic management practices has improved grain legumes productivity reaching 3 to 5 tonnes ha^{-1} in favourable agro-ecologies (Fikre, 2016), while the national average grain yield is still 1.64 tonnes ha^{-1} in 2015/16 cropping season (Figure 1). This shows that there is huge potential to bridge the yield gap by making available and accessible improved legume technologies to smallholder farmers.

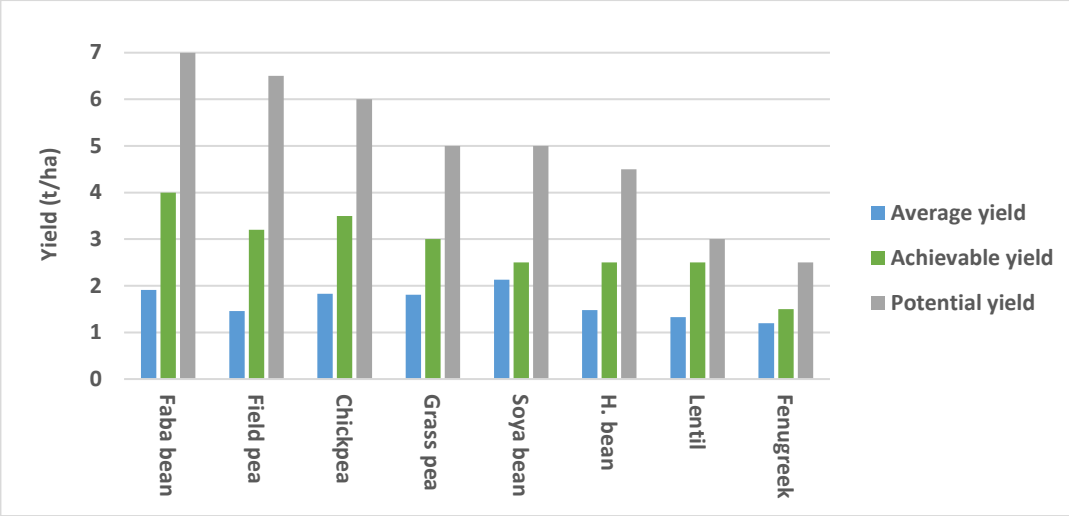

Figure 1. Potential, achievable and national average yield of grain legumes in Ethiopia
Source: Fikre (2016); CSA (2016)

State of Food Legume Seed Delivery

In Ethiopia, the organized seed sector is now operating for almost close to four decades. It went through several structural and organizational changes although its overall performance has shown mixed results particularly for grain legumes.

Institutional Arrangements

Currently, a mix of large public seed enterprises (one federal and 4 regional); several small to medium domestic private seed companies (35); and a wide range of licensed or non-licensed semi-informal (intermediate) farmer-based seed production supported by NARS, NGOs or projects are operating in the country (Bishaw and Atilaw, 2016). Most of the domestic private companies started as private farms where seed is not a core business, thus lack the knowledge and experience in managing a seed enterprise. Among 22 seed companies who are members of the Ethiopian Seed Association (ESA, 2015) only seven include legumes as part of their product portfolio (one is a forage legume). From another 13 seed companies with no company or product profile, four PSEs are known to be involved in seed production of at least one or more legumes. A multinational seed company, Pioneer Hi-bred Ethiopia, and a pan African company Seed Co are involved in maize hybrid seed only. In general, reliable data on seed producers and suppliers and their performance in terms of the quantity and quality of seed produced and distributed and the geographic location of their operation is limited. In the next section we will present the performance and experiences of the formal, semi-formal (intermediate)and informal sectors in legume seed delivery.

Performance of Formal Seed Sector

The Ethiopian formal seed sector is still dominated by the public enterprises and mostly engaged in cereal seed delivery particularly wheat and maize (Bishaw and Atilaw, 2016; Bishaw and Louwaars, 2012). From the outset, however, legumes specifically haricot bean and to a lesser extent soya bean have been part of formal seed delivery by the ESE, the sole public seed producer and supplier in the country until the 1990s (Bishaw and Atilaw, 2016; Bishaw *et al.,* 2008). Most of the common bean and soya bean seed produced were used as part of rotation crops for the state farms, the major contractual maize and sorghum seed producers for ESE. Gradually faba bean, field pea, chickpea and lentil seed production came into picture, but remain insignificant due to mechanization problems and as rapeseed is primarily used for rotation by state farms instead of legumes in the highlands.

Haricot bean seed supply is more consistent over the years compared to other legumes. It is difficult to get reliable and credible data from literature as seed production often mixed up with seed distribution and may not also include all legume crops. In some instances, recycled certified seed by farmers are reported as certified seed 2, contrary to standard protocols of seed certification, which inflate the formal sector performance. However, data compiled from different sources on legume seed demand, supply and distribution is presented in Figure 2. In recent years, there is escalation in seed demand for legumes although there is no significant change in actual seed supply. These figures showed that seed demand for legumes did not yet cross the 25,000 tonnes and the seed supply did not exceed 15,000 tonnes per year. More importantly, a closer look into the disaggregated formal seed sector delivery data revealed that, quite often few and relatively old legume varieties are produced and distributed.

Most grain legumes are strictly self-pollinated except faba bean with partial cross pollination where significant out-crossing is expected from adjacent fields, if farmers are growing different varieties. For grain legumes which are self-pollinated, farmers can retain and use the certified seed once they access the improved variety with little loss on purity and identity, if they follow proper agronomic practices. Farmers are not required to replace the legume seed every year unless a hybrid seed technology is available like in pigeon pea. In Turkey, for example a three-year seed replacement rate (SRR) is used for chickpea and lentil. Therefore, applying the rule of thumb of SRR, farmers may be required to replace seed of faba bean every 2-3 years and for other self-pollinated legumes every 4-5 years.

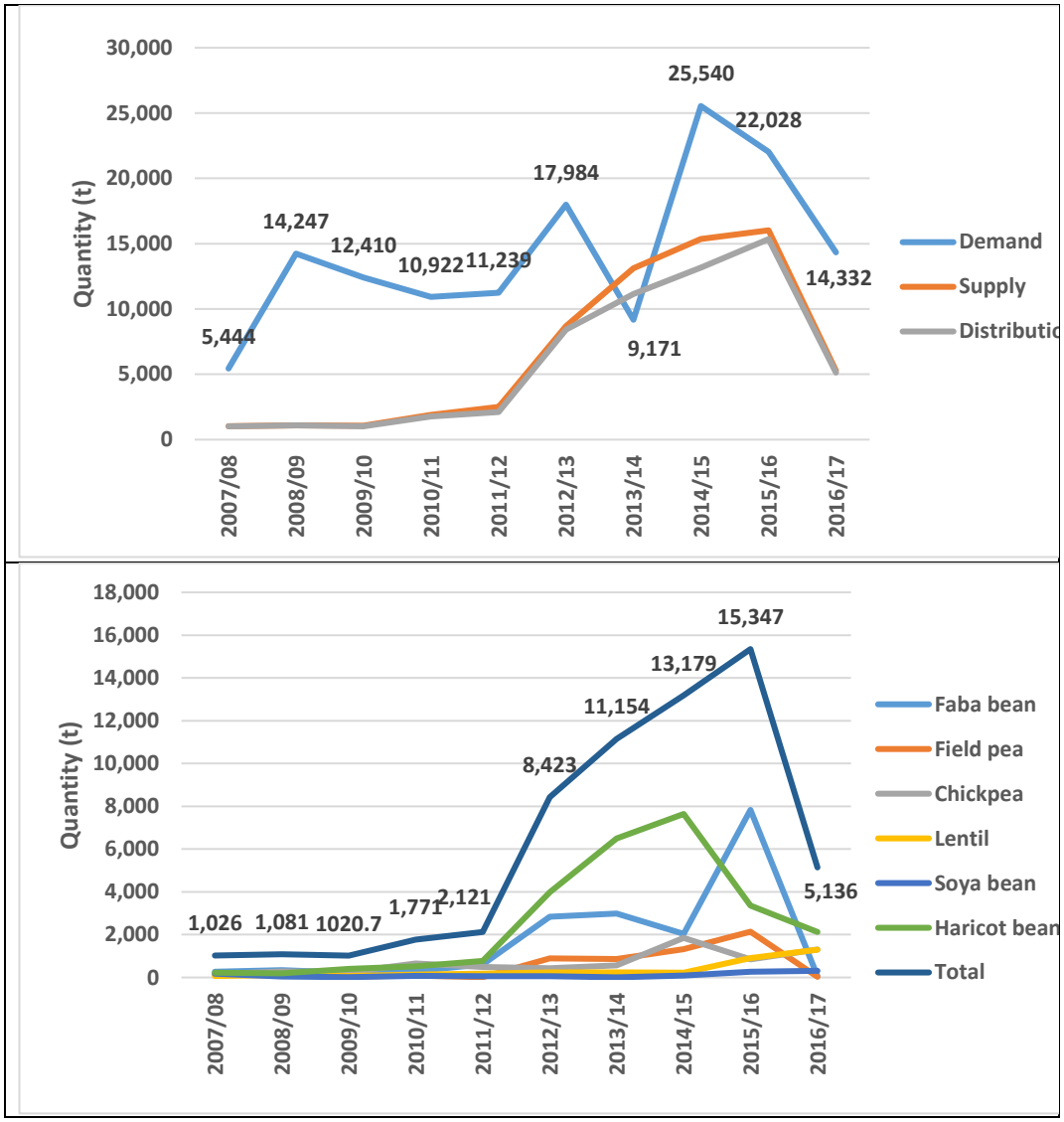

Figure 2. Performance of legume seed sector: a) Seed demand, supply and distribution (top); and b) Seed distribution (bottom)

Analysis of more realistic crop wise legume seed demand and supply based on area under cultivation and average SRR of 33% (every 3 years) for faba bean and 25% (every 4 years) for other legumes is proposed as presented in Table 3. During 2016/17 crop season, ten legume crops were planted on 1,549,912 ha and based on average seed rate (which may vary with seed size) will potentially require an estimated 214,475 tonnes of seed for planting an entire legume area in the country. However, considering the realistic SRR, the amount of certified seed required would be 60,747 tonnes whereas only 5,136 tonnes of certified

seed were supplied by the formal sector, which is 8.5% of certified seed required (based on SRR of 25%) or 2.4% of potential seed required for all legumes in the country. The certified seed supplied based on SRR varies from 61% for lentil to 0.2% for faba bean but the long-term trend is erratic and remain below 5% for all legumes compared to the potential seed requirement. Understanding the realistic demand and developing a road map for legume seed supply will help to sharpen the focus and allocate resources in promoting new varieties and improving the quantity of seed supplied with quality and yield enhancing treatments such as rhizobia inoculants.

Table 3. Amount of legume seed required and supplied in 2016/17 crop season

Crop	Area (ha)	Average seed rate (t)	Potential seed required (t)	SRR (years)	Certified seed required (t)	CS supplied (t)	% of CS required	% of potential seed required
Faba bean	427,697	0.2	85,539	3	28,513	60	0.2	0.1
Field pea	212,531	0.15	31,880	4	7,970	35	0.4	0.1
Chickpea	225,608	0.1	22,561	4	5,640	1,302	23.1	5.8
Lentil	113,685	0.075	8,526	4	2,132	1,299	60.9	15.2
H. bean	290,202	0.1	29,020	4	7,255	2,130	29.4	7.3
Soya bean	36,636	0.08	2,931	4	733	311	42.4	10.6
Grass pea	151,269	0.08	12,101	4	3,025	-	-	-
Mung bean	37,774	0.5	18,887	4	4,722	-	-	-
Lupine	19,908	0.1	1,991	4	498	-	-	-
Fenugreek	34,603	0.03	1,038	4	260	-	-	-
Total	**1,549,912**		**214,475**		**60,747**	**5,136**	**8.5**	**2.4**

Note: Area is based on CSA data (CSA, 2017); CS=certified seed

In 2016/17 crop season, eight cereal crops were planted on 10,219,444 ha and grown by about 16,326,448smallholder farmers, each farmer cultivating on average about 0.626 ha. Cereals covered 81.27% of the cultivated area and produced by 93.61% of the farming population. In contrast, during the same year, ten legume crops were planted on 1,549,912 ha and produced by about 9,062,008 smallholder farmers, each farmer cultivating on average 0.171 ha. Legumes occupied 12.33% of the total cultivated area and produced by 51.96% of farming population. A close observation on the population dependent on farming showed that a substantial number of farmers (over 50%) are dependent on legumes as in cereals, though area wise it seems to be significantly low. Hence legumes should get the attention they deserve in the development planning given their importance in the livelihoods of smallholder farmers in ensuring food and nutritional security, farming systems sustainability and other environmental and health benefits.

Performance of Farmer-based Seed Production

Experiences in Ethiopia or elsewhere showed that the formal seed system, the

public or private sector, were unable to make seed of improved grain legume varieties available and accessible in sufficient quantity, quality and affordable price to smallholder farmers. The formal sector lacks the incentive to participate in the grain legumes seed delivery due to lack of reliable demand and small size of seed markets. Most reviews reported that the formal legume seed delivery showed reaching less than 10% of the farming communities (CARE, 2011; CSA, 2011). Therefore, efforts have been made to make use of a variety of farmer-based seed production initiatives for seed delivery which is semi-formal or informal. Farmer-based seed production is one of the innovative strategies by which legume seed could be produced and become available and accessible to smallholder farmers in a relatively affordable price.

Farmer-based seed enterprises (FBSEs) are not a new concept to Ethiopia. Sahlu *et al.* (2008) summarized the experiences, achievements, constraints and the typology of FBSEs in the country. FBSEs are diverse form of enterprises and sit at the intersection between formal and informal sectors with some similarities to the formal or the informal sectors based on product profile, organizational structure and operations. However, reviews from Ethiopia (Sahlu *et al.*, 2008) and elsewhere in Africa and Asia (Ojiewo *et al.*, 2015) seem to suggest lack of common framework in defining what constitute the FBSEs and the variation that exist among the practitioners. In Ethiopia, seed producer cooperatives (SPCs) emerge as *force de majeure* of farmer-based seed production and recognized as an intermediate sector (ATA,2015) where they all play an important role in seed delivery filling the seed demand gap of the formal sector. Some SPCs, evolved from farmer research groups established for adaptive research, participatory variety selection, pre-extension technology demonstration or pre-scaling up/out activities by NARS while others were established by public seed enterprises for contractual seed production or by NGOs and projects for local seed production. Hence, SPCs are not homogeneous entities and as diverse as their origin and vary in terms of structure, membership, governance, legality, crops, capital, capacity, facilities, geographic coverage and more.

The Agricultural Transformation Agency has recently started organizing and legalizing the formation of seed unions. According to Sisay (2017) about 327 SPCs are engaged in seed production and marketing and about two legally registered seed unions are operating in the country in 2016. The introduction of Quality Declared Seed (QDS) scheme provided an ample opportunity and space for the SPCs to engage in seed delivery. The following section presents some of farmer-based seed production experiences from NARS and development practitioners in Ethiopia.

Experiences of NARS in Ethiopia

Ethiopian NARS has initiated the farmer research groups (FRGs) as part of adaptive research or for pre-extension technology demonstration and pre-scaling-up/out of research results to reach farmers. Some of the FRGs were overtime transformed into farmer seed producer's associations. The EIAR affiliated agricultural research centers particularly Debre Zeit and Melkassa ARC have played a significant role in dissemination of chickpea and lentil and common bean technologies in central, north western, eastern and southern Ethiopia. Debre Zeit ARC (1998-2002) and the EIAR (2009-2010) managed to disseminate seed of improved chickpea varieties to cover an area of 4021.4 ha with the participation of 10462 smallholder farmers distributing about 518.8 tonnes of seed in Amhara, Oromia, SNNPR, and Tigray regions (Eshete *et al.*, 2015). Similarly, the achievement for lentil was 1557.25 ha with the participation of 3905 smallholder farmers who received about 120 tonnes of seed during the same period. Similar approaches and experiences of informal seed production and pre-scaling-up/out activities by NARS were reported for faba bean, chickpea, lentil and haricot bean (Teklewold *et al.*, 2012).

The framework for scaling crop technologies using seed as entry point was implemented for three consecutive years (2009-2011), spearheaded by EIAR in collaboration with RARIs, MoA and local administration to mitigate technology and seed gaps (http://edr.eiar.gov.et:8080/xmlui/handle/123456789/2147). It was integrated approach combining technology, seed systems, knowledge and information and development.

Experiences of ISSD-Ethiopia

The Integrated Seed Sector Development (ISSD)-Ethiopia Project introduced the concept of local seed business (LSB) where through scoping studies farmer research groups, farmer extension groups or cooperatives were identified, organized and trained to become licensed seed producer cooperatives (SPCs) in four regional states (Amhara, Oromia, SNNPR and Tigray) of Ethiopia. Moreover, the SPCs, have been supported in organization and management of seed production, seed marketing, business and finance and linked to input and service providers.

During 2009-2015, about 273 SPCs were organized and supported to engage in seed business in potential Agricultural Growth Program (AGP) districts, moisture stress areas in Productive Safety Net Project (PSNP) districts and in non-AGP and non-PSNP districts (Table 4). Among these, 98 SPCs have been engaged in grain legume seed production.

Table 4. Number of SPCs established and engaged in legume seed production in 2015

Region	AGP		PSNP		Non AGP/PSNP		Total	
	Total	Legumes	Total	Legumes	Total	Legumes	Total	Legumes
Amhara	16	8	16	6	40	4	72	18
Oromia	30	22	43	28	46	12	119	62
SNNPR	7	0	19	2	8	7	34	9
Tigray	4	1	7	8	37	0	48	9
Total	**57**	**31**	**85**	**44**	**131**	**23**	**273**	**98**

Note: The number of SPCs may increase with expected increase in AGP districts in 2016

Table 5 shows region, crop and year wise distribution of grain legume seed production. The SPCs in Oromia region were involved in seed production of more grain legumes followed by those in Amhara and Tigray regions. SPCs in SNNPR are primarily focus on haricot bean seed production. Chickpea and faba bean were mostly produced in Amhara and Oromia regions, while haricot bean is produced in Oromia and SNNPR (Table 5). Seed production of fenugreek, groundnut and soybean is in Oromia only. Legume seed production increased from 743 tonnes in 2012 to more than three times to 2301 tonnes in 2015. A total of 8676.1 tonnes of seed of different legume crops was produced over the five-year period. About 42.2% of legume seed production was of chickpea followed by lentil (22.4%), haricot bean (14.5%) and faba bean (12.2%) during 2012-15 crop season.

Table 5. Grain legumes seed production by SPCs during 2012-2015

Region	Crop	Quantity of seed produced (t)				
		2012	2013	2014	2015	Total
Amhara	Faba bean	0	42.0	24.0	24.5	90.5
	Field pea	0	0	6.0	0	6.0
	Chickpea	58.6	160.0	57.8	68.5	344.9
	Lentil	75.0	31.3	0	0	106.3
	Sub-total	**133.6**	**233.3**	**87.8**	**93.0**	547.7
Oromia	Faba bean	96.6	308.4	315.2	131.5	851.7
	Field pea	54.4	114.9	95.3	63.5	328.1
	Chickpea	152.0	851.0	952.5	1327.7	3283.2
	Lentil	37.5	743.0	451.1	605.2	1836.8
	Haricot bean	13.5	23.9	241.3	1.9	280.6
	Soybean	0	40.0	59.3	7.0	106.3
	Groundnut[1]	52.1	93.8	90.6	57.3	293.8
	Fenugreek	0	0	0	13.9	13.9
	Sub-total	**406.1**	**2175.0**	**2205.3**	**2208.0**	6994.4
SNNPR	Faba bean			9.8		9.8
	Haricot bean	201.8	234.9	538.3	0	975.0
	Sub-total	**201.8**	**234.9**	**548.1**	**0**	984.8
Tigray	Faba bean	0.8	61.9	43.8	0	106.5
	Field pea	0.7	3.3	2.4	0	6.4
	Chickpea	0	17.0	19.3	0	36.3
	Sub-total	**0.8**	**61.9**	**43.8**	**0**	106.5
	Total	**743.0**	**2725.4**	**2906.7**	**2301.0**	**8676.1**

Note: [1]Ground nut is classified as oil crop in Ethiopia

Experiences with CGIAR Centers

Apart from supporting agricultural research in developing improved grain legumes varieties, CGIAR centers such as ICARDA, ICRISAT and CIAT are involved in scaling out activities of their mandate crops using a combination of formal, intermediate or informal approaches. CIAT and ICRISAT implemented Tropical Legume (TL) projects funded by Bill and Melinda Gates Foundation (BMGF). ICARDA has recently involved in scaling faba bean and chickpea technologies in strengthening the seed sector.

Chickpea seed delivery with ICRISAT

Abate *et al.* (2012) summarized the achievements on chickpea and common bean under TL projects supported by the BMGF during 2007-2011 across a wide range of activities including among them a variety of seed delivery approaches employed to reach farmers. Working with broad range of partners, the project was able to produce 175 t of basic seed and 7780 t of quality declared seed through decentralized production and reaching 464,831 farmers (during phase 1) for common bean whereas 234 t of EGS and 3353 t of certified seed was produced for chickpea reaching a wide of small farmers directly or as spillovers. Under successive TL project, ICRISAT in partnership with EIAR was able to produce and distribute quality seed of chickpea working with seed producer cooperatives particularly in Eastern Shoa Zone. The project was able to disseminate new improved chickpea technologies (Table 6). It should be noted that however, once again seed of few and relatively old varieties dominated the intermediate sector as in formal sector where the top three varieties (over 12-15 years) captured 81, 10 and 7% of chickpea seed supply, respectively.

Table 6. Community based chickpea seed produced under TL projects in Ethiopia

	Amount of certified/quality seed produced (t)								
Variety	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Total**
Arerti (2000*)	500	859	1192	1283	1714	1900	2620	1726	**11794**
Shasho (2000*)	88.5	129.6	120.8	186	239.6	217	396.7	54.1	**1432.3**
Habru (2004*)	38	69.4	66	111	148.1	194.9	233	208.6	**1069**
Ejere (2005*)	1.5	2	2.5	6.2	6.7	9.3	6.4	78.6	**113.2**
Monino (2009*)				2.6	3.3	4.5	8.8	65	**84.2**
Teji (2005*)	1.5	2	2.5	6.1	4.9	6.8	6.4		**30.2**
Natoli (2007)				1.7	2.3	2.8	4.4	4.2	**15.4**
Kutaye (2005)	1			3.6	5.2	3.8	6.8	1.6	**22**
Chefe (2004*)	0.5	2.5	3	4		5			**15**
Mariye (1985)	0.2	0.3	0	3	1.8	1.3	2.9		**9.5**
Minjar (2010)						1.8	4.4	1.7	**7.9**
Teketay (2013)								6.6	**6.6**
Dalota (2013)								8.2	**8.2**
Akuri (2011*)								3	**3**
Mastewal (2006)								1.5	**1.5**
Total	**631.2**	**1065**	**1387**	**1608**	**2126**	**2347**	**3290**	**2159**	**14612**

Note: *Kabuli chickpea

Common bean seed delivery with CIAT

Several common bean varieties that are potentially suitable for a wide range of ecologies of Ethiopia were released through partnership between Ethiopian NARS (EIAR and RARIs) CIAT and Pan African Bean Research Alliance (PABRA). However, availability and access to seed of new improved varieties remain a major constraint for adoption. According to Tumsa *et al*. (2015), using community seed production, the Ethiopian National Bean Research Program in partnership with a broader range of organizations managed to increase access to seed of market demanded varieties from less than 20% to about 68% across major common bean growing areas during 2004-2011. During the same period, the area under beans production was also increased by 44.3% while the yield was increased by more than two folds. However, it is difficult to ascertain and attribute all these achievements ignoring the role of partnerships with the formal sector. The work on haricot bean is addressed elsewhere in this proceeding and hence not included to avoid duplication.

Faba bean and chickpea seed delivery with ICARDA

Since 2015, ICARDA has been implementing two USAID funded projects with the overall goal of increasing the productivity and production of faba bean[1] and chickpea[2] as well as improving the livelihoods of smallholder farmers. It has been involved in scaling out improved varieties and integrated crop management technologies to reach new potential areas for legume production and most farmers to compliment the limited performance of the formal seed sector. Anchored on ICARDA's experience in deploying rust resistant wheat varieties in Ethiopia and elsewhere (Bishaw *et al*., 2016) these projects aimed at strengthening some of the key components of the seed value chain working with a broad range of partners and stakeholders from federal (1) and regional (12) NARS; federal (1) and regional (3) PSEs; zonal and district Bureaus of Agriculture (BoA) and extension offices. In 2016, the project was operating in 62 districts for faba bean and 47 districts for chickpea across four regional states which are major producers of these legume crops including AGP, PSNP, non-AGP and non PSNP districts. These projects undertook massive demonstration and popularization of improved varieties and integrated crop management technologies to create awareness and demand among farmers; accelerated early generation seed production (including off-season) to produce sufficient amount of breeder, pre-basic and basic seed with NARS and certified seed production through formal public or private sectors; and small seed pack distribution for on-farm seed

[1]Deployment of malt barley and faba bean varieties and technologies for sustainable food and nutritional security and market opportunities in the highlands of Ethiopia

[2]Better livelihoods for small holder farmers through knowledge-based technology interventions in the highlands of Ethiopia: Increasing the productivity of chickpea in wheat-based cropping system

production by mobilizing existing or newly established seed producers cooperatives or farmer groups; and capacity development of project partners and stakeholders including farmers in providing facilities for NARS and seed producers and training to upgrade knowledge and skills. The project is unique in demonstrating and distributing rhizobia inoculants of faba bean and chickpea in partnership with the private sector (Menagesha Biotech Industry PLC).

A combination of formal, intermediate and informal sectors was used in multiplying the crop technologies for scaling out involving a broad range of partners and stakeholders (Figure 3). NARS are implementing partners and are responsible for technology generation, demonstration and multiplication of early generation seed (EGS) as well as technical support for on-farm seed production and facilitation of linkages with district BoA. NARS are responsible for early generation seed including basic seed with SPCs and make available the seed for further multiplication to certified or quality seed. Public seed enterprises (PSEs), having access to basic seed, are responsible for certified seed production and marketing by themselves. SPCs produce certified seed or quality seed, respectively, and market it formally or sell or exchange locally. BoAs facilitate demonstrations, organize field days and mobilize and provide technical support to SPCs or farmer groups and implement the 'revolving seed fund' scheme. The regional seed laboratories inspect and ensure the quality of seed produced to be marketed as certified seed through formal sector or through direct marketing or exchange by seed producers.

Farmers who are members of existing SPCs or newly identified and organized farmer groups are provided with seed of improved varieties and enter a contractual agreement with BoA to produce and market all the seed and return in kind the amount of seed received through the support of the projects under the 'seed revolving scheme'. The cooperatives or farmer groups will produce the seed under the technical support of NARS and supervision of BoA. The seed produced is inspected and certified through the regional seed laboratories and marketed through different channels. Farmers, after returning the revolving seed and retaining part of the seed for their own use, are free to market the seed collectively through the seed unions to public or private seed suppliers, on-going development projects or sell directly to farmers on cash or through lateral farmer to farmer exchange. About 37 licensed and seven newly formed non-licensed SPCs were involved in faba bean and/or chickpea seed production across four regions. The BoA will recover and use the 'revolving seed fund' and provide to other group of new farmers who did not access the technology as part of scaling out improved crop varieties.

NARS were able to produce 78.7 t of breeder seed, 268.54 t of pre-basic seed and 805.91 t of basic seed during 2015

and 2016. These include 38.75 t of breeder seed, 102.97 t of pre-basic seed and 306.67 t of basic seed of faba bean and 39.95 t of breeder seed, 165.57 t of pre-basic seed and 499.24 t of basic seed of chickpea. NARS produce part of the basic seed with SPCs to have sufficient quantity of early generation seed. NARS also supplied part of the pre-basic/basic seed to public or private sector for further multiplication and marketing through their own channels.

The amount of certified seed/quality seed produced through SPCs during 2015-16 is presented in Table 7. The project was able to produce collectively 3386.45 t of certified seed/quality seed of faba bean and chickpea which is sufficient to plant 28,224.2 ha and directly benefitting about 154,331 households. About 1316.1 t of faba bean seed was produced which would cover 7,520.54 ha of land, directly benefiting 60,650 farm households in Amhara, Oromia, SNNP and Tigray Regional States. Similarly, 2070.35t of certified/quality seed of chickpea was produced which would cover 20,703.5 ha of land, directly benefiting 93,681 farm households (Table 7) in Amhara, Oromia and Tigray Regional States. The coverage will be more than two folds as more seed will be injected by the projects in 2017. This show case that availability and access of improved technologies such as seed could be enhanced if concerted efforts continue and complemented by affirmative policy supports.

In summary, the review of both formal and informal sectors showed that the performance did not reach the desired level of legume seed delivery. From the case studies of NARS, ISSD and CGIAR, the SPCs have made significant contribution to legume seed delivery compared to the public seed enterprises or private seed companies. They were able to introduce improved varieties and produce and distribute quality seed at relatively lower cost serving as a bridge between formal and informal sectors. Given initial public support in seed business development, SPCs can grow into viable local seed business, serving seed supply of crops that are not adequately handled by public or private sector. However, the anarchic situation of farmer-based seed production we observe today need to be streamlined not to undermine the development of the nascent legume seed sector.

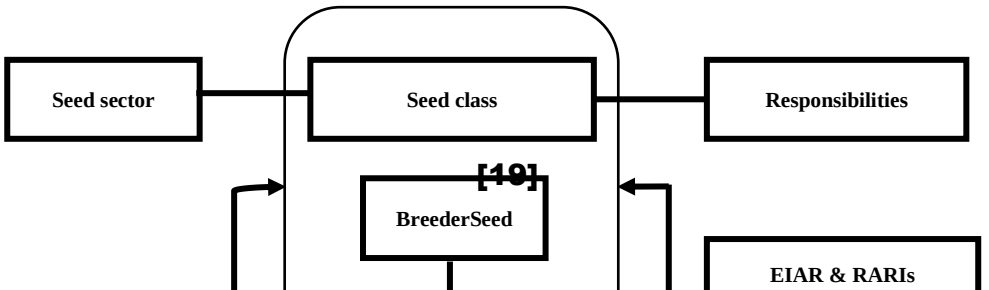

Figure 3. Approaches in seed multiplication for scaling out fab bean and chickpea technologies by ICARDA

Table 7. Faba bean and chickpea certified/quality seed produced and distributed during 2015-16

Region	Crop	2015	2016	Total	Area planted (ha)	Farmers reached (no.)
Amhara	Faba bean	39.0	296.87	335.87	1916.4	15455
	Chickpea	431.0	728.85	1159.85	11598.5	52482
	Sub-total	**470.0**	**1025.72**	**1495.72**	**13514.9**	**67937**
Oromia	Faba bean	288.1	588.43	876.53	5008.7	40393
	Chickpea	176.4	602.0	778.4	7784	35222
	Sub-total	**464.5**	**1190.43**	**1654.93**	**12792.7**	**75615**
Tigray	Faba bean		104.2	104.2	595.4	4802
	Chickpea	1079.5	241.5	132.1	1321	5978
	Sub-total	**107.95**	**128.35**	**236.3**	**1916.4**	**10780**
	Total	**1042.45**	**2344.5**	**3386.95**	**28224**	**154332**

Source: ICARDA project reports, 2015 & 2016

Are there Lessons from Developed and Developing Countries?

In developed countries, like Australia and Canada, cool season food legumes such as chickpea and lentil are recent introduction for diversifying the cereal

dominated agricultural production systems. Both countries became successful chickpea and lentil producers and competitors in global grain legume markets. According to Gareau *et al.* (2000) in countries like Australia and Canada, and members of European Union (e.g. France) producer associations gather levies from farmers to support research and seed delivery through public-private partnership.

On the other hand, traditional legume producers and exporters became net importers (e.g. Morocco, Turkey, etc) and less competitors in global markets due to decline in area for legume production, low productivity, marketing and pricing. Some countries like Algeria, Egypt and Tunisia are trying to revive grain legume production through government programs. In Turkey, area and production of chickpea and lentil reached the highest level with cereal-fallow replacement program during 1982-1991 targeting about 1.4 million ha in the Central Anatolia and Transitional Zones of the country. However, grain legume area and production showed sharp decline after the program due to marketing and pricing issues. Currently Turkey is paying subsidies both to the seed producers and seed user farmers to boost domestic grain legume production (Keser, 2016).

Legume production appears to be susceptible to domestic and international markets, leading to volatility in acreage, production and price. India, a major producer, consumer and importer of grain legumes, initiated a national drive for self-sufficiency and boost domestic production to meet the rising demands. The government introduced a minimum support prices to stabilize the acreage, production and prices and related policies to encourage the cultivation of legumes in the country (Subramanian, 2016). Such policies may boost and stabilize grain legume production in Ethiopia too.

Byerlee and White (2000) attributed the success and rapid expansion in soybean production to investments in research, wide-scale extension programs, supporting producer prices, encouraging the agro-processing industry and export markets. Similar efforts may be needed for other legumes in developing countries. Some of the characteristic of legume production and seed delivery in developed and developing countries are presented in Table 8.

Table 8. Legume production in developed and developing economics

Developed Economies	Developing Economies

Legumes introduced as part of crop diversification program	Legumes are part of traditional farming systems
Market-oriented and/or export-led commercial legume production	Subsistence agriculture with focus for domestic production
Strong public-private sector partnership supporting the legume sector (e.g. Australia)	Inconsistent government support for the legume sector (e.g. Turkey)
Private sector and farmers play leading role in seed production and marketing	Private sector lacks the capital and willingness to invest in seed sector
Government will match funds from the private sector to support grain legume research (e.g. Australia)	Introduce minimum support price for grain legumes to boost domestic production (e.g. India)

Source: Bishaw *et al. (*2008)

Strategies for Food Legume Seed Delivery

Bishaw *et al.* (2008) reviewed the major policy, regulatory, technical, institutional, organizational and socio-economic constraints for the development of an effective and efficient legume seed industry in Central and West Asia and North Africa (CWANA) region including Ethiopia. Some of these issues are still relevant today and applies to the national seed sector in general (Bishaw and Atilaw, 2016) and legume seed sector (Bishaw and Pandey, 2016) in Ethiopia. Some of these and other options which are relevant today are presented and discussed in more depth below.

Demand Driven Agricultural Research for Legumes

NARS have played a major role in developing improved technologies with significant contribution to the growth in productivity and production of legumes. Despite impressive achievements over the last five decades of agricultural research there are emerging challenges such as climate change and its ramifications i.e. emerging threats of new pests, increasing temperature, frequent droughts, etc with serious consequences on the agricultural sector (Bishaw and Atilaw, 2016). A ten-year research strategy for pulse crops have been prepared on the occasion of the International Year of Pulses in 2016 to provide future direction in research for development (Sivasankar *et al.*, 2016) which is relevant to Ethiopia too. There is also a legume research strategy developed by EIAR for the next 15 years (2016-2030).

Development of diverse varieties

Grain legumes as diverse as they are also produced in diverse farming systems and agro-ecologies and have multiples uses as nutritious food for human consumption, valuable feed for livestock or break crop for cereal rotation enhancing soil fertility and health or cash crop for domestic or international markets. Farmers require niche varieties that are suitable to their farming systems and production environments (e.g. early or short maturing varieties for late

planting), grain quality attributes for consumer preferences (e.g. colour, taste, cooking time) and export markets for certain grain quality attributes (e.g. seed colour, seed size) for premium prices in international markets. Tolessa *et al.* (2015) found a dramatic progress in breeding for seed size while increase in yield is more modest for faba bean during the last 33 years of crop improvement in Ethiopia. Legumes are exposed to suite of abiotic (drought, heat) and biotic stresses (ascochyta blight, fusarium wilt complex, rusts (lentil) and insect pests (African ball worm)]. There are also emerging challenges such as Orobanche and gall diseases in faba bean where resistance varieties are not yet available.

NARS should develop varieties with these specific traits employing both conventional or modern genomic tools to meet the demand of different seed value chain actors to boost legume production and create demand for inputs while confronting the emerging challenges of climate change. Moreover, legumes are inherently low yielders and breaking the yield barrier is of paramount importance through use of modern breeding tools.

Bridging yield gaps

Legume yields vary greatly across farmer' fields and regions due to biophysical, agronomic and other factors as shown elsewhere in this chapter. Legume productivity has shown an increase from 1.0 t ha^{-1} in 2001 to 1.68 t ha^{-1} in 2016, an average increase of 4.5% per year (Table 1). For selected legume crops, the average potential yield is about 4.94 t ha^{-1} compared to the achieved yield of 2.84 t ha^{-1} and national yield of 1.64 t ha^{-1} (Figure 1). Average legume productivity reached about 33% of the potential yield though it varies from crop to crop, ranging from the highest of 44% for lentil to the lowest of 23% for field pea. Average yield increases for legumes have not kept pace with cereal crops in Ethiopia or elsewhere. Low productivity due to lack of niche varieties and use of appropriate agronomic practices led farmers switching to mono-cropping or abandoning legume production in certain regions of the country. An integrated crop management is the best option to overcome the current level of low productivity, but farmers often adopt technologies partially which expose the crop to low yields. A concerted effort should be made to take advantage of the opportunities that exist and develop and promote simple but effective and specific integrated crop management technologies to realize the attainable yield within the context of the farming systems and production environments.

Development of hybrid varieties

Ethiopian farmers have demonstrated their strong demand for seed and their strong willingness to pay for hybrid technology. Adoption of hybrid maize varieties and seed is a clear testimony for the emergence and development of the private sector. In India, a pioneering work in hybrid technology development for pigeon pea has attracted the interest of the public and private seed companies and the

government. Similar opportunities should be explored for other legumes to attract the seed industry although the potential for greater yield improvement is unclear (Sivasankar *et al.*, 2016).

Research on value addition

Legumes are potential crops for value additions. NARS can play an important role in value addition technologies for the diversification of legume products and to increase farmers' income and better livelihoods. Sivasankar *et al.* (2016) suggested the food industries can offer new niche markets for pulse crops, especially where commercially viable uses can be found for all pulse fractions. Experiences elsewhere show that agricultural transformation and rural industrialization can be achieved through agricultural clusters linking production with the agro-industry. Can the legume exporters and the agro-processing industries play a role in the promotion of legumes in Ethiopia? Such changes are yet to be seen as the transformation of agro-industries may take off in the coming years.

Strengthening the Food Legume Seed Sector

To date, both formal (public and private) and informal sectors including alternative and innovative approaches (intermediate) are used in legume seed delivery. Despite progresses made in the past few years, the review of their performance clearly demonstrated that the legume seed delivery is yet not at the desired level in ensuring the availability, access and use of seed of desired varieties and serving most of the farming communities.

Institutionalization of EGS production

EGS remain a major bottleneck in commercialization of improved legume varieties leading to long time lag between variety development and use by farmers. Four principal issues are important for streamlining EGS production by the federal and the regional NARS: institutional framework and capacity for EGS production, adequate planning for EGS production, decentralization of EGS production, and adequate quality assurance (Bishaw and Atilaw, 2016; Atilaw *et al.*, 2017). There is no clear institutional arrangement for organizing EGS production for public-bred varieties which is very much an adhoc arrangement and inconsistent in terms of varieties, seed classes and amount of seed produced. NARS should take the lead in commercializing their varieties investing sufficient resources in promotion and production of EGS. Such arrangements may require the establishment of seed units to undertake this responsibility which will work as a commercial wing of NARS. Production planning for seed is a four-year cycle starting from breeder seed to certified seed where adequate consultation is required at the national level among the seed value chain actors as the varieties are moved from research centres to farmers' fields. NARS may also need to formally decentralize EGS production to regional agricultural research institutes

or centres for varieties with regional interest to ease the pressure on their capacity to produce EGS due to shortage of sufficient land. Variety maintenance and seed quality assurance are some of the areas that need to be strengthened to overcome the current problem of varietal purity and seed quality to build the confidence of both the seed suppliers and the seed users.

Apart from the strategy document on seed sector developed by ATA, an independent study on EGS was commissioned by ATA and financed by Scaling Seeds and Technologies Partnerships-Alliance for a Green Revolution in Africa (SSTP-AGRA). The study identified priority crops and EGS production archetypes, among which chickpea and haricot bean were included. Although both crops fall within the category of low demand for improved seed and low profit margin for producer, thus public-sector dependent for EGS production, the feasibility analysis of haricot bean showed that EGS production can be outsourced to the private sector while the public sector can produce certified seed. However, for a meaningful change of the current impasse, an action–oriented program should be developed and implemented instead of on the shelf-studies with no practical value, no further follow-up and execution of the recommendations.

A new approach and a drastic departure from the current stalemate on EGS production could be to create a mechanism to provide incentives for NARS where they have the authority to give exclusive rights for public or private seed companies for commercialization of their varieties within the context of revised breeders' rights proclamation in the country. In Turkey, for example, public varieties are equally protected as private varieties, and the royalty payment is shared between NARS and the breeders incentivizing the public breeding program.

Commercialization of public seed sector

The Ethiopian seed sector changed little over the last four and half decades in terms of diversity of seed suppliers and certified seed of crops and varieties available to farmers. Currently, the public seed sector, represented by one federal (Ethiopian Agricultural Business Corporation ex ESE) and three regional PSEs (Amhara, Oromia and South) and wheat and maize seed delivery continue to dominate the formal sector. EABC is reorganized with the new business model where, the corporation is intended to provide agricultural inputs (seeds, fertilizers) and services (mechanization) which may improve logistical and operational efficiency.

From the outset, PSEs are inherently lack commercial orientation and operation and focus on social services to meet government targets. Low productivity, high production costs, uncertain seed markets and farmers' willingness to pay are some of the factors affecting the legume seed delivery. A study by DGDA (2012)

showed that expansion in production of legumes such as chickpea, lentil and haricot bean would lend ESE profitable and financially sustainable while contributing to the national agricultural and rural development program of the country which is a positive outcome. PSEs should grapple with the paradox of financial sustainability and social services to the farming communities where they need to make strategic decisions in their seed operations.

Among legumes handled by the formal sector, haricot bean is the only crop with sizeable and regular seed supply though the amount remains low compared to national seed requirement and other cereal crops. The analysis of legume seed sales showed that PSEs are producing seed of few and also yet very old legume varieties. Focusing on promotion and seed production of newly released varieties with better yield and productivity would help them to offset high production costs and increase profitability by introducing legumes in their production plan. Small seed packs may also be used as marketing strategy since the landholdings are very small compared to cereals.

Participation of private seed sector

The Ethiopian national seed policy encourages that the private sector to play greater role in seed delivery. Despite policy pronouncements, the private sector remains weak in a primarily public sector dominated seed industry where there is lack of clear and practical incentives targeted to the seed sector. Moreover, given the technical constraints and lack of incentives the absence of private sector involvement in legume seed delivery is not surprising. As stated elsewhere only few members of ESA include legumes in their product portfolio dealing with legumes. How such modest beginning could be encouraged, motivated and supported to diversify and expand their operation in legume seed delivery is yet to be seen. Gareau *et al.* (2000) reported how public-private partnership drives legume production and seed delivery in countries like Australia and Canada and European Union.

Support to seed producer cooperatives

Empirical evidence from Ethiopia and elsewhere in Africa and Asia indicates that legume seed delivery will remain in the hands of smallholder farmers at least in the coming decade or so (Neate and Guei, 2011; Bishaw and Pandey, 2016). The diversity of farmer-based seed production approaches and lack of common framework (different contexts) however, bring into forefront the criteria to measure their performance in terms of technical feasibility, economic profitability and long-term sustainability, particularly in the absence of some external support. It is critical to distinguish between SPCs, where seed is a core business where the full responsibility of seed production and marketing lies within their remit and those which are organized for different purposes such as out-growers

for PSEs or for conservation of genetic resources or others for the social wellbeing of the member farmers.

Bishaw and van Gastel (2008) outlined the framework and critical steps for establishing and operating business-oriented VBSEs (village-based seed enterprises) and demonstrated their performance in terms of their technical feasibility and economic profitability (Srinivas *et al.,* 2010) which ensures long-term sustainability. The VBSEs can eventually be transformed into small-medium enterprises (SMEs) as they grow, diversify and expand their operations (Samadi and Aziz, 2015), if from the outset these enterprises are provided with appropriate facilities, technical support, access to finance and markets, linked to formal sector institution, have established enterprise governance, and mentored for sufficient number of years. Moreover, diversification of product portfolio and operations beyond their immediate vicinity would enhance their performance and thus their sustainability. In Ethiopia, market orientation (customer and supplier orientation and inter-functional coordination) along with marketing activities are expected to contribute to better performance of SPCs (Sisay, 2017). Under Ethiopian context, SPCs emerged as *force de majeure* and most effective seed delivery partners where they need to be promoted and supported for gradual evolution into the SMEs. The introduction of QDS provided greater opportunity for meaningful contribution of SPCs to seed delivery particularly of legume crops in terms of choice of seed quality and access to seed certification.

Undertaking seed market research

In Ethiopia, seed marketing is one of the critical challenges of the national seed sector, be it formal, intermediate or informal sector, leaving aside local seed exchange and trade among farmers. The centralized production planning, seed demand assessment, seed marketing, and seed pricing are lots to be desired (Bishaw and Atilaw, 2016; DGDA, 2012). It stifles competition and innovation among seed producers and suppliers. There is a general lack of reliable data on seed market– be it in terms of potential market demand (crop area and its agro-ecological characteristics like drought incidence), effective market demand (varietal use and seed renewal rates) and supply (seed volumes produced/traded).

Legume seed production should be informed and guided by the seed market and seed pricing by farmers' willingness to pay for seed of improved varieties. Legumes are inherently low yielders with high seed rates and low average yields of less than 2 tonnes ha^{-1}which impacted heavily on seed delivery due to high seed to grain price ratio. The DGDA (2012) study showed that while expansion of chickpea, lentil and haricot bean production will be profitable for ESE, the production of faba bean, field pea and soya bean appear problematic and incurring losses as the seed is priced below their

production costs. The study suggested for ESE to undertake market research to accurately understand and forecast demand estimates and market size and farmers' willingness to pay for seeds of all crops (including legumes) and decide on production mix where profits from some crops finance the production of other crops.

Under Ethiopian context, commercial seed production is at least a four-year cycle from breeder to certified seed where accurate production planning is critical to achieve annual targets. Creating a national forum of seed value chain actors including NARS, seed suppliers and policy makers would be more effective and practical to overcome the key constraints of seed sector including marketing rather an ambitious plan of GTP targets which remain un-fulfilled as seen from previous experiences. The federal and regional state institutions such as MoANR, BoANR, NARC and ESA have a major role to play in this endeavour.

Enabling Policy Environment

The policy environment can be a major driver for legume production and seed delivery and should take diversity into account by avoiding a uniform approach to all crops, given legume-specific challenges.

Creating functional legume value chains

A functional food legume sector is critical to attract farmers and private sector investments in seed delivery. According to National Agricultural Research Council (NARC), among legumes chickpea and haricot bean are identified as priority crops of commercial interest whereas faba bean and lentil as food security crops. In Ethiopia, the Agricultural Commercialization Clusters (ACC) project within the national agricultural transformation agenda aimed at providing a strategic platform to drive greater integration across priority value chains. Such farmer-ago-industry linkage through ACC may pave the way for contract farming and will be an opportunity for future expansion and uptake of agricultural inputs including seeds by the farming communities that can improve the production and productivity of legume crops. These plans are yet to put into practice to bring about desired changes.

Product segmentation

Currently, there is no grain legume grading system, hence no market signals are transmitted from end-users to producers and hence a dysfunctional legume value chains. Farmers lack the incentives for quality products since they receive no premium prices in primary markets. Abate (2012) reported the presence of grades and standards for common bean where a similar effort is underway for other legumes in Ethiopia. It is stated that introducing standards can reduce price risks and encourage adoption of improved varieties. Moreover, lower

quality and high domestic prices emanating from low productivity and high production costs render legume production less competitive in domestic and export markets.

Seed policy and regulatory framework

The Ethiopian Government has identified improving the efficiency of the seed system as the most effective means of meeting the Sustainable Development Goals. In GTP II, it is expected to strengthen the enabling policy environment to attract investment and develop a vibrant and competitive seed sector and reform or strengthen seed regulatory frameworks to meet international standards (Bishaw and Atilaw, 2016). Concrete steps are required to translate the policy direction into practical action if we need to support the entry of the private sector and diversify the seed industry.

Conclusion

There is a tremendous yield gap on research stations and on-farmersfields despite the avaiability of improved legume technologies with high yield potential. Lack of information, knowledge and skills and poor acess to technologies are some of the limiting factors. For legume seed delivery some of the crtical limiting factors are but not limited to the following:

i. Insuffcient investment in agricultural research and development of the grain legumes despite their importance in the farming systesms and multiple uses compared to food security cereal crops
ii. Lack of awareness of legume varieties and integrated crop management practicies due to insufficient demonstration or popularization by NARS and agricultural extension services
iii. Limited availability and access to EGS (breeder, pre-basic and basic seed) from NARS where priroity is given to major crops due to limited resources
iv. Limited interest from both the public and the private sector in certified seed production and marketing, contrary to empirical evidence, excusing themeselves with lack of reliable seed demand, small seed market and low profit margins
v. Lack of enabling policy environment for the input and output markets where grain legumes receive little attention compared to food security cereal crops

Hence detailed value chain analysis to identify the gaps and propose solutions based on an integrated seed system development to create functional linkages between demand for grain and demand for seed of improved varieties is critical.

In Ethiopia, given the diversity of the legume crops, farming systems and agro-ecologies, there will be no one solution for legume seed delivery where a mix of formal, intermediate or informal sector need to operate side by side at least for the decades to come.

However, the performance of the legume sector clearly demonstrated where SPCs emerge as *force de majeure* in seed delivery. Apart from commercialization of the public sector and incentivizing the private sector to engage in legume seed delivery, SPCs deserve a well targeted support and promotion. Strengthening the technical and financial capacity, business-orientation and management, improving enterprise governance, improving business skills and knowledge of its members and leaders is one of the best options for legume seed delivery in the years ahead. SPCs need to be nurtured and mentored leading to the development of the nascent legume seed sector.

The recent strategy developed by ATA is believed to provide the road map in transforming the Ethiopian seed industry. Translating the strategy into actions by allocating sufficient resources is critical whose success is dependent on adequate ownership, coordination, and accountability of partners and stakeholders at all levels which is equally relevant to the development of the legume seed sector.

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