

SEED SYSTEM AND QUALITY ANALYSIS OF FIELD PEA (*Pisum sativum* L.) IN ENARJ ENAWUGA AND YILMANA DENSA DISTRICTS, WEST AMHARA REGION, ETHIOPIA

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**Seed System and Quality Analysis of Field Pea (*Pisum Sativum* L.), in
Enarj Enawuga and Yilmana Densa Districts, West Amhara Region,
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MASTER OF SCIENCE IN AGRICULTURE
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BIOGRAPHICAL SKETCH

The author was born on 20 July 1980 in Lummame town, East Gojjam Zone, Ethiopia. He attended Elementary and Junior Secondary Schools at Lummame Elementary and Junior Secondary School. He completed his high school education at Debre Markos Senior Secondary School. Yenus joined Mekelle University in October 2001 and completed his undergraduate studies with B.Sc. degree in Dry Land Crop Science in July 2004. Upon graduation, he was recruited as an expert of crop protection and Agronomist in Achefer District Office of Agriculture and Rural Development from January 2005 and then became a seed multiplication expert in West Gojjam Zone Agricultural Department. From 2010 up to now he is working as a seed quality control expert in Amhara Seed Enterprise. He joined Haramaya University in October 2016 to pursue his postgraduate studies leading to M.Sc. degree in the field of Seed Science and Technology.

DEDICATION

I dedicated this thesis to my mother Fatuma Yibre, my wife Miraj Adem and my late father Ali Esleman.

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ACRONYMS AND ABBREVIATIONS

AARC	Adet Agricultural Research Center
ASE	Amhara Seed Enterprise
ATA	Agricultural Transformation Agency
BoA	Bureau of Agriculture
EEDOA	Enarj Enawuga District Office of Agriculture
EIAR	Ethiopian Institute of Agricultural Research
EQSA	Ethiopian Quality Standard Authority
ESE	Ethiopian Seed Enterprise
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
HARC	Holeta Agricultural Research Centre
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ISSD	Integrated Seed Sector Development
ISTA	International Seed Testing Association
KAs	Kebele Administrations
MoANR	Ministry of Agriculture and Natural Resources
NARS	National Agricultural Research Systems
NVRC	National Variety Release Committee
OSE	Oromya Seed Enterprise
PVRPQC	Directorate of Plant Variety Release, Protection and Quality Control
QDS	Quality Declared Seed
RARIs	Regional Agricultural Research Institutes
RSE	Regional Seed Enterprises
SAS	Statistical Analysis System
SoSE	Somali Seed Enterprise
SPSS	Statistical Package for Social Sciences
SSE	Southern Seed Enterprise
YDDOA	Yilmana Densa District Office of Agriculture

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Seed System and Quality Analysis of Field Pea (*Pisum Sativum* L.) in Enarj Enawuga and Yilmana Densa Districts, West Amhara Region, Ethiopia

ABSTRACT

*The productivity of field pea is low in Ethiopia though the crop has high demand for both local and export markets. The low productivity mainly due to the unavailability of quality seed supply system for limited number of improved varieties. Therefore, this study was conducted to understand the functioning of field pea seed system and assess the seed quality in Enarj Enawuga and Yilmana Densa districts during 2016/17 cropping season. Multi stage purposive and random samplings were employed to select a total of 200 farmers from six kebeles and interviewed using pretested structured questionnaire. Seed samples of two varieties of field pea were also collected from both formal and informal sector and tested for quality in complete randomized design (CRD) with four replications. The study revealed that 96.7% of field pea area was planted with local varieties showing low adoption of improved varieties. The quality of seed samples had significant difference for physical purity, germination and vigour indices among treatments. Farmers seed management practices enable to maintain and improve their field pea seed quality in both districts. Too low weeding and storage protection practice were observed at Yilmana Densa than Enarj Enawuga district due to a relative poor extension service provided in the area. The speed of germination was better to predict field emergence of the seed lot than the standard germination. Seed-borne fungi such as *Ascochyta pisi*, *Fusarium* sp, *Phoma* sp, *Septoria pisi*, *Colletotrichum* sp were found associated with the field pea seed. Among those fungi *Ascochyta pisi* was the dominant. Currently, the field pea seed system is dominated by the informal sector and a very wide gap exists between the demand and supply of quality seed of improved field pea varieties. This suggested the need to strengthening extension service to promote the adoption of improved field pea varieties and an integrated field pea seed system is needed to be in place to address the seed delivery system in the future.*

Key words: Adoption; Formal sector; Germination; Physical purity and Vigour.

1. INTRODUCTION

Field pea is a cool season legume that is grown on 7,881,943 ha with production of 12.5 million tons worldwide. Ethiopia ranked first in Africa and sixth in the world in field pea production with an area of 0.23 million ha and 0.34 million tons (FAOSTAT, 2015). Field pea is an important source of food and feed in developing and developed countries, respectively. Field pea is the major food legume with a valuable and cheap source of protein having essential amino acids (23-25%) that have high nutritional values for resource poor households (Nawab *et al.*, 2009). The crop has important ecological and economic advantage in the highlands of Ethiopia, as it plays a significant role in soil fertility restoration being used as a break crop to minimize the negative impacts of cereal based mono-cropping (Angaw and Asnakew, 1994). It is also used as a source of income for the farmers and foreign currency for the country (Girma, 2003). In Ethiopia, the pulse crops showed a slow growth in productivity for the last ten years. The average yield of field pea was 1.461 t ha⁻¹ in 2015/16 cropping season (CSA, 2016) and it was one of the crop where more work is expected to enhance its productivity (CSA, 2015a).

According to CSA (2016), the Amhara Regional State produced 1,150,035.6 tons (35.57% of the country) on 86,792.1 ha and it was the second major producing region of field pea in Ethiopia next to Oromia Regional state. However, the average yield of the crop was 1.325 t ha⁻¹ which was less than the national average yield of field pea. Enarj Enawuga and Yilmana Densa are potential districts for field pea production in Amhara Regional state but the productivity of field pea is declining. The total area and production of field pea were decreased by 40% and 25.9% respectively from 2008/09 to 2016/17 (EEDOA and YDDOA, 2016). The limited used of new technologies of field pea production as one of the low productivity in the region and districts mentioned.

Seed is a crucial input for agricultural production and the most affordable external input for farmers (Kumar *et al.*, 2014). Seed availability and accessibility by farmers are determined by many factors including the crop breeding systems, institutional/organizational arrangements and socio-economic conditions of farmers (Zewdie *et al.*, 2008). It is noteworthy that an effective seed system is relevant to increased productivity and overall agricultural production (Oyekale, 2014).

The formal and the informal systems are in place in Ethiopia. There is also a system that combine the two referred to as an integrated seed system (Abebe and Lijalem, 2011). Seed systems can even vary considerably between crops on a single farm. The seed system may vary as the source of seed for pollinating and vegetatively propagated crops like rice and potato than that of maize which is predominately cross pollinated. The seed system may even vary between varieties grown by a single household, when improved and local maize varieties are planted (Almekinders, 2000).

According Bureau of Agriculture (BoA) report (2016), between 2003/04-2006/07 cropping season, the total amount of field pea varieties seed demand in Amhara Region was 21.21 tons per year while the supply was only 1.99 tons. This was only 9.38% of the total improved certified field pea seed requested. From 2007/08 to 2016/17 cropping season, only 0.36 tons of basic seed of improved varieties was supplied by the regional seed enterprise for contractual seed production. In 2016, during survey year of this study, there was no certified seed allocated for field pea to the BoA due to too low supply from the formal seed sector (BoA, 2016).

A number of improved varieties of field pea are released by the federal and regional agricultural research institutes but still the seed supply is negligible and unable to satisfy the seed demand of end users. Moreover, there is little information on field pea seed system, seed sources and local knowledge in seed selection, maintenance and management practices. Therefore, a baseline information on the current field pea seed system and quality of seed used for production is important to identify the field pea seed supply problem and suggest the establishment/strengthening of field pea seed system. The objectives of this study were to asses:

1. The relative importance of formal and informal field pea seed system, and
2. The quality of seeds from informal and formal seed systems in Enarj Enawuga and Yilmana Densa Districts

2. LITERATURE REVIEW

2.1. Field Pea Importance and Distribution

Field pea (*Pisum sativum* L.) is one of the world's oldest domesticated crops cultivated before 10th and 9th millennia BC (Zohary and Hopf, 2000). It includes both wild species (*Pisum fulvum* and *Pisum eratius*) and cultivated species (*Pisum abyssinicum*) originated from the Mediterranean region, primarily in the Middle East (Ellis *et al.*, 2011). Field pea has a unique sub species called *Pisum sativum subsp. Abyssinicum* which is originated in Ethiopia. The existing germplasm in the country has a phenotypic diversity and tolerance/resistance to diseases (MoANR, 2016). However, the exact center of field pea diversity is not known yet due to significant change in the areas of origin and loss of passport data of the early accessions (Petr *et al.*, 2012).

Field pea is of indeterminate (climbing) type or determinate (bush or dwarf) type. Flowers are borne on racemes arising in the axils of the leaves and are highly self-pollinated. In most varieties, the flowers are reddish-purple or white. Pods are about three inch long and contain four to nine seeds (Grubben and Denton, 2008).

The major field pea producing countries include Canada, Australia, the U.S and Europe (French, Germany and United Kingdom) (Endres *et al.*, 2016). The main field pea exporting countries are Canada, Australia, France and China. Canada focuses on the European feed market and in recent years on the food market in India. Australia focuses on the food markets and the domestic feed market. The top importers for pea feed or food are Spain, Bangladesh, Belgium, India, China, United States, Colombia, United Arab Emirates and Malaysia (Grubben and Denton, 2008).

In Ethiopia field pea is mainly grown in the North, South, West and Central parts of the country. It is also grown in pockets in the highlands and mid highlands with altitude ranging from 1800-3000 masl (MoANR, 2016). Almost all the production in Ethiopia is consumed locally (Grubben and Denton, 2008).

Field pea is the cheapest source of protein or cash source to many people (Bhujel *et al.*, 2015). It has high levels of amino acids, lysine and tryptophan, which are relatively low in cereal grains. Field pea contains approximately 21-25% protein. Peas contain high levels of carbohydrates, are low in fiber and contain 86-87% total digestible nutrients, which makes it an excellent livestock feed. Field pea contains 5 to 20% less of the trypsin inhibitors than soybean and can be directly fed to livestock without having to go through the extrusion heating process. Field pea is often cracked or ground and added to cereal grain rations (Endres *et al.*, 2016).

As a nitrogen-fixing crop, field pea can improve soil fertility and reduce fertilizer input. Pea can also be used as a green manure crop to improve soil quality. When grown alone and incorporated or killed in the spring, field pea residues decompose rapidly and can contribute nitrogen to the following crop (Munakamwe, 2008).

A study in Ethiopia by Sentayehu (2009) showed that pea seed exhibited considerable variations in protein, fat and mineral contents, respectively with a range from 20 to 25.9%, 0.7 to 1.5 %, and 2.0 to 4.5%. In Ethiopia, the annual per capital consumption of field is estimated at 6-7 kg. Main dishes include '*shiro wot*' (split pea seeds ground and made in to stew) and '*kik wot*' (split pea seeds boiled and made in to stew). Snacks include '*eshet*' (fresh green pea seeds either eaten raw or roasted), '*nifro*' (boiled dry or fresh green pea seeds) and '*endushdush*' (seeds soaked first and then roasted). In local markets white and cream colored seeds are preferred for '*kik*', and grey colored seeds for '*shiro*' (MoANR, 2016).

2.2. Importance of Improved Seed

The genetic and physical characteristics of seed determine the productivity of other agricultural inputs and agronomic practices within the farming system (Maredia *et al.*, 1999). Seed can be an important entry point for promoting productivity, nutrition and resilience among smallholder farmers (McGuire and Sperling, 2016). The broad rationale for focusing on seed sector interventions is that seed is a vehicle for delivering a range of advances in agricultural technologies, all of which can benefit smallholder farmers. Seed can be the

conduit for moving new varieties, giving farmers access to more productive, yield-enhancing traits and return per unit area (Bouis and Welch 2010).

Unlike other agricultural inputs such as fertilizer and pesticides, the unique characteristics of seed make its delivery to farmers' complex. Seed is a living organism and requires appropriate handling during production, processing and storage operations in order to ensure that its viability is maintained until it is sown in the fields. High quality seed should have high germination and vigour, high levels of genetic and physical purity and be free from pests and diseases when provided to farmers. Multiple cycles of multiplication are necessary to produce quality seed and in order to obtain the quantities required to meet market demand. Thus, the seed supply chain generally differs greatly from that of other inputs (Swaminathan, 2009).

2.3. National Seed System

Van Amestel *et al.* (1996) defines the seed system as the sum total of physical, organizational and institutional components, their action and interactions that determine seed supply and use, in quantitative and qualitative terms. It recognizes the formal and informal sectors which are interacting and playing complimentary roles. This and other definitions emphasize the quantity and quality of improved seed supplied and the proper timing and proper place of delivery at a reasonable cost (Vankatesan, 1994). The formal seed system is an organized operation which includes official variety development, evaluation and release; seed production, processing, marketing and quality control are supported with policy and regulatory framework. On the other hand the informal seed systems can be defined as the ways in which farmers produce, select, save and acquire seeds with no regulatory control (Sthapit *et al.*, 2008). In Ethiopia two distinctive but interacting seed systems are now recognized– the formal and the informal sectors (Abebe and Lijalem, 2011). The formal sector involves the production, processing, and packaging, labeling and marketing of certified seed by registered producers. This normally involves private and public seed companies with outlets in many parts of the country (CTA, 2014).

Two distinctive but interacting seed multiplication and delivery systems are now recognized for legumes especially for chickpea and lentil – the formal and the informal sectors. The Ethiopian Seed Enterprise (ESE) produces, processes, distributes and markets improved seeds of legumes including chickpea, lentil and field peas based on the official demand projection of regional bureaus of agriculture (Million *et al.*, 2011).

2.3.1. Formal Seed Systems

The major actors of the formal system in Ethiopia are the Federal and Regional National Agricultural Research Systems (NARS), Ministry of Agriculture and Natural Resources (MoANR), Federal (Ethiopian Seed Enterprise (ESE)), and Regional Seed Enterprises (Oromia-OSE, Amhara-ASE, Southern-SSE, Somali-SoSE) and private seed companies (Abebe and Lijalem, 2011; Amsalu *et al.*, 2014). However, ESE, OSE, ASE and SSE are all largely involved in major cereals, few pulses and oilseeds seed production while SoSE largely deals with forage crops seeds (Amsalu *et al.*, 2014).

Variety development, evaluation and release: Variety development for major crops began in 1966 with establishment of the Ethiopian Institute of Agricultural Research (ex, Institute of Agricultural Research), a semi-autonomous public organization (Dawit, 2011). Currently, almost all improved varieties of major field crops are developed by the public agricultural research system, which consists of the federal agricultural research institute (EIAR), the Regional Agricultural Research Institutes (RARIs in Regional States) and higher learning institutions (HLIs). The National Agricultural Research Systems (NARS) also works closely with the international agricultural research centers - mainly the Consultative Group on International Agricultural Research (CGIAR) to access germplasm, capacity building and addressing broader challenges in agricultural research. In addition, a handful of international seed companies such as Pioneer Hi-bred and Seed Co. have been introducing, adaptation testing, and registering varieties (MoANR and ATA, 2013).

All varieties, whether private or public, intended to be released in the country are evaluated by the National Agricultural Research System (NARS), more often by EIAR. Following different stages of variety evaluation trials candidate varieties are submitted for variety verification

trials. After Variety Verification Trials (VVT), crop varieties are released by the National Variety Release Committee (NVRC) under the patronage of the Directorate of Plant Variety Release, Protection and Quality Control (PVRPQC) of the Ministry of Agriculture and Natural Resources (MoANR, 2016). The NVRC is a standing committee under the MoANR and entrusted with exercising its responsibility of variety release since 1982 (Getinet *et al.*, 2001). The NVRC is assisted by a technical committee that evaluates trial data and makes recommendations to the NVRC, which is responsible for the final decision on release of a variety. There are three critical bottlenecks: (a) current varietal release system is not independent from varietal development, (b) varietal release and registration process has severe capacity constraints and (c) post-release duties and rights of the variety owners are not enforced due to capacity constraints (MoANR and ATA, 2013).

Varietal development and release has been dominated by the public research system which has released more than 1200 varieties over the last four decades, of which cereals comprise a third. The last decade has been significant growth in the number of crop varieties developed and released by Ethiopian NARS when compared with previous decades. Despite the development and release of large number of varieties by NARS, most of these varieties have not yet been commercialized with very few old varieties dominating overall seed and crop production. Moreover, some varieties released by NARS do not adequately meet the diverse needs of farmers, particularly in less favorable agro-ecologies. And only 8% of the varieties have been released for low rain fall areas. For cereals, 90% of all varieties released by NARS are targeted for high rain fall areas (MoANR and ATA, 2013).

Seed production, marketing and distribution: The formal seed system aims to supply adequate amounts of seed of high quality, at the right time and place, and at reasonable prices. Currently the share of the formal seed system is estimated to be about 10-20% while the rest (80-90%) is covered by the informal system in Ethiopia (Zewdie *et al.*, 2008). There are now more than 30 private seed companies, public seed enterprises and cooperative seed producers in Ethiopia. Most private seed producers focus exclusively on hybrid maize seed, although some also produce *teff*, wheat, haricot bean, sunflower, and vegetable seed. There is an

organized body for the formal seed producers, the Ethiopian Seed Association, which primarily serves to represent the interests of seed producers (Benson *et al.*, 2014).

In Ethiopia, seed marketing and distribution has long been under public control (Shimelis, 2015). The process of seed production starts with an assessment of seed demand, which is carried out by the Development Agents (DAs) at kebele (village) level. Information on seed demand is then passed upwards the government administration ladder and collected by the Bureaus of Agriculture (BoA) and the Ministry of Agriculture and Natural Resources (MoANR). The MoANR, based on this information, orders the amount of seed production of various crops by the ESE whereas the BoAs determine production of the regional public seed enterprises and the private seed companies in the area (Husmann, 2015).

Seed distribution is usually managed by farmer cooperative unions (FCU). The FCUs bring the seed to the warehouses of zones and the primary (multipurpose) cooperatives and finally bring it to the woredas (districts) and kebeles. The unions charge for transport, handling costs (uploading and unloading) and make only small profits (Husmann, 2015). Increased interest from private seed companies and other stakeholders led to the first trials, in which the seed companies could directly sell their seed to farmers. It started in Amhara Region in 2011 and followed by Oromia and Southern Region in 2012. Ethiopian seed companies were allowed for the first time to directly market their seed to farmers without going through intermediary agencies like Agricultural Input and Supply Corporation in the early formative years and FCUs since 1990s. It was first started with hybrid maize then followed by wheat where seed is directly marketed to farmers in these regions (Husmann, 2015). However, most cereal and pulse seed producers of public varieties cannot market seed directly to farmers as the district BoA controls the seed allocation and distribution (MoANR and ATA, 2013).

Seed quality control and certification: Guiding principles in the formal system ensure that the varietal identity and purity are maintained throughout various generations of seed multiplication, with optimal physical, physiological and sanitary quality. Conscious efforts are made to ensure that the appropriate documented multiplication process and procedures are

followed and that quality control measures are taken at various stages of the operation (FAO, 2011).

In Ethiopia, the total volume of improved seeds used in 2014/15 cropping season was about 514,223 tons covering an estimated crop area of estimated 1.23 million hectares. The larger volumes of improved seeds used were that of maize and wheat which amounted to 23,381.1 tons and 23,068.5 tons, respectively. The largest area on which improved seeds used were under maize and wheat estimated at 978,760 hectares and 122,364 hectares, respectively. Only 0.5% of the area cultivated with legumes was covered by improved seed whereas the cereal crops were 11.7%. Among legumes 1.62, 1.46, 0.73 and 0.14% area coverage was with haricot beans, soya beans, chickpeas and faba beans, respectively (CSA, 2015b).

2.3.2. Intermediate (Semi-formal) Seed Systems

Within Ethiopian seed system the nascent intermediate seed system centered on community-based seed production has been recognized (MoANR and ATA, 2013). The system receives high technical support from agricultural research, NGOs and seed projects and some supervisory oversight from BoA. Under this system farmers access seed of improved varieties through technology transfer and dissemination mechanisms of the research centers. This is usually followed by community-based seed production and distribution initiatives by individuals and farmers' cooperatives. The seed distribution channel of this system includes community based seed production by organized farmers in the form of cooperatives, model farmers, and/or individual entrepreneurs (Amsalu *et al.*, 2014).

The existence of the formal seed sector at the national level cannot guarantee small-farmer seed security at the community and household levels. The integrated approach that takes into account the formal and informal seed sector in breeding, seed production and distribution has shown potential for improving seed supply to smallholder farmers (Mula *et al.*, 2013). ISSD (Integrated Seed Sector Development) in collaboration with government offers technical support to develop seed policies for the simultaneous and parallel development of various seeds systems that together cater for the diversity of demands related to different crops,

farming systems and farmers (Louwaars *et al.*, 2013). It has very significantly increased seed availability to farmers especially for new varieties, and reduced the lag period between variety release and use through community based approach (Rubyogo *et al.*, 2010).

Community seed production is necessary to improve formal and informal seed system links (FAO and ICRISAT, 2015). Community based seed production and dissemination is being promoted as a means of accelerating the diffusion of new varieties for the self-pollinated crops like common beans (Rubyogo *et al.*, 2007; Rubyogo *et al.*, 2010). Odeyemi *et al.* (2010) found that limited knowledge of the community seed producers on production and handling of high quality maize seeds. However, this will require capacity enhancement of the community seed producers and managers in areas like management and harvesting of seed crop, management of postharvest operations, and detailed record-keeping.

The seed quality management procedures through introduction of quality declared seed programs with a view to accommodate the plurality of seed systems in place and to even recognize diversity of use within crops is likely to lead to an increase of the quality of seeds available to farmers and spur local seed businesses, which supports sustainable and robust seed systems (Peter and Bram, 2015).

In Tigray region, Integrated seed system approach had increased 60% overall adoption rate and the number of farmers participating in the new barley varieties have reached from 5,000 to 60,000 but it needs institutional and policy support and recognition (CTA, 2014). For Cooperative Community-based Seed Enterprises (CCBEs) to be successful they need to collaborate with and develop strong working relationships with critical agricultural stakeholders at the local level (Bureau of Agricultural and Rural Development, Agricultural Cooperative Commission) as well as among formal seed system actors (NARS, Ethiopian seed enterprises, and universities), and farmers in the informal seed system (FAO and ICRISAT, 2015).

The intermediate seed system becomes more complex and even more challenging with the presence of several uncoordinated activities by different actors (agricultural development

programs, NGOs, CBOs dealing with improved varieties and landraces). There is also a general challenge how the seed demand and supply can be realized, as common discrepancies prevail and no effective model exists to be adapted. This situation becomes more unpredictable as the diversity both within and among crops increases (Asnake *et al.*, 2011).

2.3.3. Informal Seed Systems

Informal seed systems are about the knowledge, skills and practices of seed selection, production, and exchange by farmers. Farmers obtain seed and varieties through informal networks based on exchange (bartering) or gifts from relatives, neighbors, and other farmers or cash purchases from other farmers or local markets. Key issues in determining the use of seed by farmers are availability, quantity and quality, and price. Seed has to be available, which means that there has to be physical access to the quantity of seed of the right variety at the right time, and it needs to be affordable to buy and use. Informal seed systems are also referred to as farmer-managed seed systems (Bal and Douglas, 1992), traditional seed systems (Cromwell *et al.*, 1992), and local seed systems (Almekinders *et al.*, 1994). We refer to the informal seed system as to distinguish it from the formal seed system (Almekinders *et al.*, 1994; Zewdie *et al.*, 2008; Dalton *et al.*, 2010).

In Ethiopia in light of the diversified cropping pattern, poor multiple crop seed delivery scheme, and weak private sector involvement, decentralizing seed production and supply should be taken as an option. Wereda-level farmer-based seed multiplication would be a strategic approach, up until a better system is developed to provide the services (Asnake *et al.*, 2011). The approach has different forms but have the same final goal – farmer-based seed production (Yonas *et al.*, 2008), farmers research group (FRG) for technology and seed promotion (Endashaw *et al.*, 2009), farmers practice in seed production and processing (Louwaars and Almekinders, 2008), village-based seed enterprises (Zewdie and van Gastel, 2008), farmer seed enterprises (Soniia, 2008), PVS-based chickpea demonstration for seed and technology source (Asnake and Kebebew, 2008-2010), community-based seed production (Krishna *et al.*, 2008), multiple crop technology pre-scaling up (Kebebew *et al.*, 2011).

Girma and Tesema (2008) reported the market for local varieties is generally restricted to the village level, and mostly to the level of farmer-to-farmer exchange. Specific local varieties as such usually exist only at the farm gate. The authors found that even at the rural assemblers' level, different local varieties and improved varieties of the same crops are found mixed and undifferentiated for further market channel analysis.

The Ethiopian Seed Enterprise (ESE) and newly established regional seed enterprises have never able to supply enough improved seed of faba bean and, as a result, the majority of farmers depend on the informal sector. A very significant proportion (99.6%) of the total faba bean area cultivated is dependent on the informal seed source (Tamene *et al.*, 2011).

2.4. Seed Quality Control

Seed quality is a concept made of different attributes. Hampton (1979) outlined 10 seed quality components with varying degrees of practical importance to agriculture, viz; cultivar purity, species purity, analytical purity, freedom from weeds, germination capacity, vigour, size, uniformity, health and moisture content. These attributes are of interest to different segments of the industry to the producer, the processor, the certification authority and the government agency responsible for seed control. Seed quality control measures were developed to minimize the risks of crop failure by assessing the quality of seed before it is sown. Seed quality measures include field inspection and laboratory seed testing.

In Ethiopia, the formal seed system was started five decades ago with crop improvement by the agricultural research and higher learning institutes on ad hoc basis and did not serve the farming communities well. Later on, seed production showed better organization under the Chillalo Agricultural Development Unit (CADU). CADU was a pioneer in the introduction of partial seed quality control in the country. Seed quality testing was started as early as 1972 by the CADU at its laboratory in Kulumsa and later expanded to other agricultural research centers like DebreZeit, Holeta, Bako, Alemaya, and Hawassa. With the establishment of the Ethiopian Seed Enterprise in 1979, a central seed testing laboratory was established as part of an internal seed quality control mechanism at its headquarters in Addis Ababa. Later on with the financial support of the World Bank, one central and several satellite seed testing

laboratories were established at different locations of the country to serve the seed regulation (Abebe and Lijalem, 2011).

Seed quality control was also officially legalized with an enactment of Seed Proclamation No 2000 and the revised Seed Proclamation No 783 issued in 2013. The Ethiopian Field and laboratory Standards were officially issued for 74 crops under the coordination of the Ethiopian Quality and Standards Authority (now ESA) and was enforced following the Seed Proclamation No 206/2000. Recently 27 key seed quality standards revised and published by the Ethiopian Standard Agency in November 2012 in alignment with new proclamation (MoANR and ATA, 2013).

The national seed regulatory system consists of: quality standards and legal frameworks at the federal level, with the implementation at regional level. The federal system is expected to ensure consistency across regions and facilitates application of similar standards by regional regulatory agencies, which are well positioned to support and partner with local stakeholders. This Federal-Regional role sharing is compatible with Ethiopia's broader federal structure in which the federal body focuses on coordination, export-import issues, certifying federally registered companies, and laboratory accreditation (MoANR and ATA, 2013). According to the revised seed law varieties for production of certified and quality declared seed are expected to be listed in national crop variety register and also be in conformity with the Ethiopian seed standard. The emergency seed is also expected to fulfill the national standard.

The bottlenecks and interventions around regulatory structures include three critical areas: 1) Regulatory structures need to be autonomous (finance, managerial and technical) from the seed business so that they can enforce standards impartially among all producers and distributors for the benefit of farmers. 2) Regulatory structures need to have capacity - vehicle, equipment, etc, so that they can enforce standards thoroughly across the country. 3) Regulatory system robust enough to share and adopt technologies and harmonize standards and protocols with other countries. They also need to make farmers aware of their rights to

good quality seed and actions they can take to protect themselves against fraud (MoANR and ATA, 2013).

2.5. Seed Quality Attributes

2.5.1. Physical Purity

Farmers require seed that is uncontaminated with seed of different crop or weed species, or inert matter that may reduce the quality of their product (ISTA, 2008). Some farmers do not follow proper methods to maintain the purity of the seeds (Dhedhi *et al.*, 2011). Physical or analytical purity indicates the proportion of pure seed of the species concerned in a seed lot. According to ISTA (2008), the analysis identifies and quantifies pure seed and impurities such as other crop seeds (including weed seeds) and inert matter that may occur in the seed lot. These components are always expressed as a percentage by weight of the seed sample analyzed. It is the first seed quality attribute recognized in seed trade to protect farmers against the use of impure seed which is contaminated with seeds of other crops, or inert matter.

Pure seed refers to the seed of species stated, whereas other crop seeds include seeds and seed-like structures of any other species and inert matter includes non-biological matters like soil, sand, stones, chaff, leaves or biological such as nematode galls, fungal bodies such as ergot, sclerotia or bunt balls (ISTA, 2008). During analysis, the sample is separated into three components: pure seed, other crop seeds and inert matter and the percentage is determined on weight basis (FAO, 2010).

2.5.2. Physiological Seed Quality

The importance of physiological quality of seed cannot be over emphasized because the seed can only fulfill its biological role if it is viable. The physiological quality of the seed includes viability, germination and vigor. Viability refers to the state of seed being alive whether it germinates or not. Germination capacity refers to the ability of the seed to emerge and develop into a normal plant under favorable conditions (Dekker, 2004). Seed vigour refers to those properties of seed which influence the speed and uniformity of germination, and the ability to germinate and emerge under a wide range of field conditions (Scott, 1980). The

germination percentage is an indicator of the seed's ability to emerge from the soil to produce a plant in the field under normal conditions. Therefore, physically uniform seed of an adapted variety will be useless if it is low in germination or if it fails to germinate when planted (FAO, 2011).

The term vigour cannot be identified as a single defined physiological process such as germination or deterioration. In fact, seed vigour is an interaction of characteristics that also could be considered as independent attributes of physiological potential such as speed of germination, seedling growth, ability to germinate above or below optimal temperatures, and other aspects of tolerance to stresses (Marcos-Filho, 2015). Seed vigor tests do not replace the germination test, but they can supplement it. Each factor that causes loss of germination formally reduces seed vigor, because vigor is more sensitive in comparison with germination (Sheidaei *et al.*, 2014).

Field pea cultivars and the environment in which the seed has grown can affect germination and thus the quality of a seed lot for the sprout industry (Fowler *et al.*, 2006). Delaying pea harvest could also cause the seed to become too dry and therefore be more easily damaged (Padrit *et al.*, 1996). Field pea seed will germinate at a soil temperature of 40⁰ F. Emergence normally takes 10 to 14 days. Field pea has hypogeal emergence in which the cotyledons remain below the soil surface. When seeding pea, always adjust for germination and allow for a certain percent of the seed that germinates not to become an established plant (Endres *et al.*, 2016).

Factors influencing seed physiological potential include germination and vigor, which govern the theoretical capacity of seeds to express their vital functions under both favorable and unfavorable environmental conditions. The concept of suboptimal conditions varies according to species, cultivar and plant development stage, but usually includes temperature, water availability, soil characteristics, plant protection and management practices. Unfortunately, today there is no universally accepted single test for assessing seed vigor of a given species or group of species. For this reason, research on seed testing and the identification of factors that

affect seed performance have been considered priorities among seed scientists in comparison to other quality attributes (Marcos-Filho, 2015).

2.5.3. Seed Health

Seed health refers to the presence or absence of disease-causing organisms, such as fungi, bacteria and viruses, as well as animal pests, including nematodes and insects. Seed health testing can be carried out in order to assess seed sanitary quality. Ensuring seed health is important because the diseases initially present in the seed may give rise to progressive disease development in the field and reduce the commercial value of the crop and imported seed lots may introduce diseases or pests into regions where they were not present (FAO, 2011).

Yield losses caused by seed-borne diseases may reach total loss in some crops in Ethiopia (Dereje and Yaynu, 2001). It is estimated that 25.1% of the yield losses of crops due to diseases were caused by seed-borne diseases without considering quality losses such as shriveling, discoloration, biochemical change, toxin contamination. Seed health studies are very important as they enable to establish threshold levels for seed treatment and take sound decision in the planting value of a particular seed lot (Dereje and Sangchote, 2003). Infected seeds may fail to germinate, produce abnormal seedlings and have low germination or low seedling vigor affecting grain yield and quality (Zewdie *et al.*, 2013).

Seed-borne fungi are one of the most important biotic constraints in seed production worldwide. They are responsible for both pre and post-emergence death of grains, affect seedling vigor, and thus cause reduced germination and also variation in plant morphology (Niaz and Dawar, 2009). In Ethiopia diseases, particularly, Ascochyta blight (*Ascochyta pisi*), powdery and downy mildew (*Erysiphe polygoni*) are the major constraints, causing substantial yield loss and instability in yield (ICARDA, 2000).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The field pea seed system study was carried out in Enarj Enawuga district in East Gojjam Zone and Yimana Densa district in West Gojjam Zone of Amhara Regional States (Figure 1).

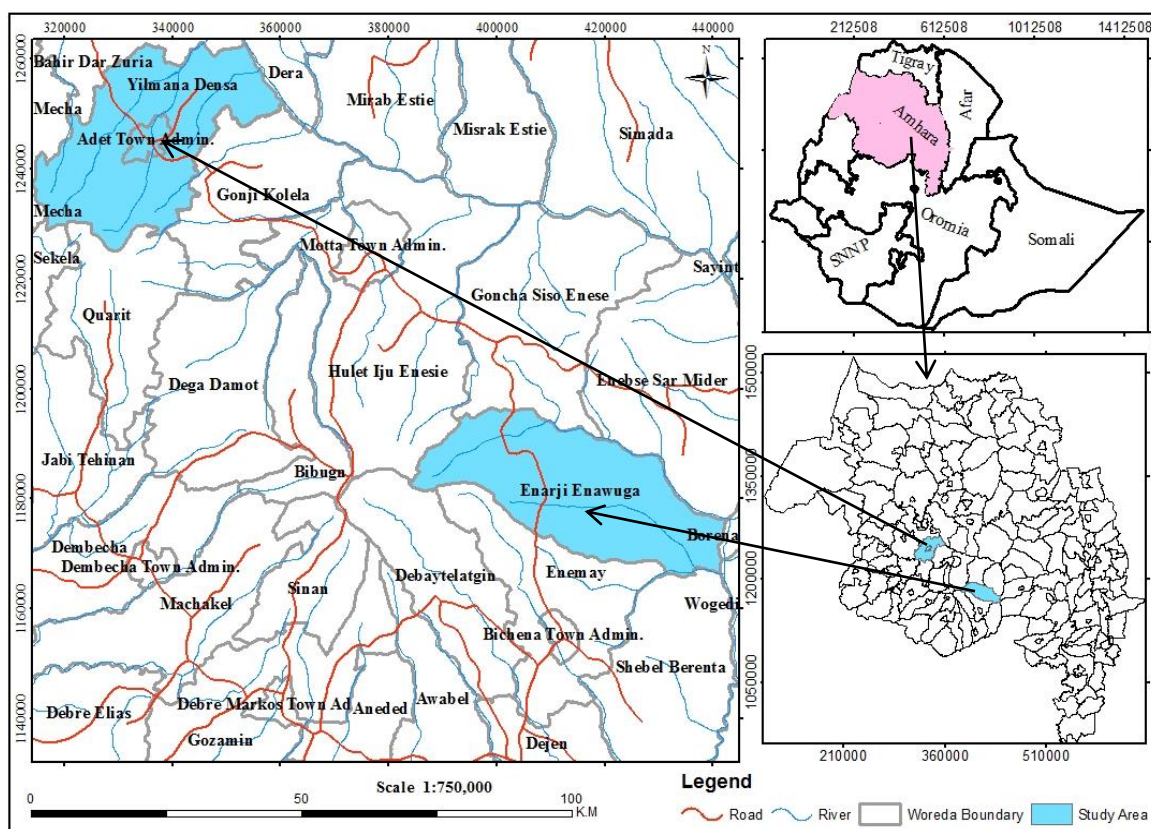


Figure 1. Location map of Enarj Enawuga and Yimana Densa Districts in Amhara Regional State Ethiopia.

Enarj Enawuga has an altitude ranges from 1100 to 3200 masl where 30%, 50% and 20% of the total land area lies in *Dega*, *Weynadega* and *Kolla*, respectively. The area receives a mean annual rainfall of 1228 mm with a mean maximum temperature of 25 °C and a mean minimum temperature of 22 °C. From the total area of 96,095 hectares about 45,053 hectares (46%) is cultivated land and the major crops grown in the district are *teff*, wheat, barely, maize, faba bean, grass pea, field pea and potato. The Enarj Enawuga district consists of 25 rural and three

urban (towns) kebele administrations with 165,415 farm households and a total population of 185,124; and over 98% of the population is involved in agriculture (EEDOA, 2016).

Yilmana Densa district has an altitude in the range between 1552 to 3535 masl, and average annual rainfall of 1270 mm with the main rainy season from May to October. The district is classified into three traditional agro climatic zones of which 24%, 57% and 19% of the total area lies in *Dega*, *Weynadega* and *Kolla*, respectively. The Yilmana Densa district consists of 33 rural kebele administrations with a total human population of 217,356. The total area is 99,180 hectares, and about 54,508 hectares (55%) is covered with annual crops. The mixed crop and livestock farming is predominant, since the area is suitable for both rearing of livestock and cultivating crop. The majority of the farmers depend on growing *teff*, maize, wheat, barley, faba bean, field pea, haricot bean, and chickpea as major source of cash income and household consumption (YDDOA, 2016).

3.2. Data Collection

3.2.1. Formal Field Survey

The study involved both multi stage purposive and random sampling techniques to select sample farmers. The two study zones, two districts and six Kebele Administrations (KAs) were selected purposively for being a major field pea growing areas. First, two major field pea growing districts (Enarj Enawuga and Yilmana Densa) were selected where some interventions have been made in the dissemination of improved field pea production technologies. Second, three KAs with highest field pea growing areas from each district were selected in consultation with the experts from the Agricultural Offices of the respective districts. Third, a total of 200 sample farmers, of which 120 from Enarj Enawuga and the remaining 80 from Yilmana Densa district were randomly selected for the survey.

The questionnaire was designed and pre-tested in randomly selected farm households before the beginning of the survey and a checklist was prepared for the survey. During the survey, data was collected with the help of trained enumerators. Enumerators were trained on farmers' demographic characteristics, knowledge and source of information on new agricultural technologies, seed supply systems, perceptions on seed quality, timeliness of seed

availability, conditions under which the seed is available, appropriateness of variety, seed management practices, capacity to innovate performed by a seed system to avail high quality seed of varieties preferred by farmers. Group discussions with key informants were also employed in order to acquire supplementary information. Two group discussions one per district was conducted which composed farmers, extension agents and kebele leaders having experience in field pea production. Ten participants from each district were purposively selected. Personal observations were also made as part of the qualitative information appraisal procedure.

3.2.2. Secondary Data Collection

Secondary data was obtained from various sources such as reports, agricultural research centers, Central Statistical Agency (CSA), Amhara Seed Enterprise (ASE), Amhara Bureau of Agriculture (BoA), district agricultural offices, previous findings, internet and other published and unpublished materials.

3.3. Seed Quality Analysis

Seed samples of two improved field pea varieties, Tegegech and Hassabe, which are grown by most farmers were selected and seed samples were collected for laboratory seed quality test. In each KA, two seed samples from each field pea variety were collected from farmers i.e. 4 seed samples per KA. In total 12 seed samples each of two varieties (total 24 seed samples) were collected during the survey. In addition, one sample of Tegegech from ASE and one of Hassabe from Adet Agricultural Research Center representing the formal seed source was included making a total of 26 seed samples to carry out laboratory seed quality and seedling emergence tests.

A sample of 1 kg seed was drawn from the farmers' seed harvested in 2016/17 cropping season for laboratory seed quality analysis including physical purity, thousand seed weight germination, vigor and seed-health tests. All tests were conducted according to ISTA rules (ISTA, 2008) at Bahir Dar Seed Testing Laboratory and Bahir Dar Plant Health Clinic (for seed health). Field emergence tests were conducted at the green house of Amhara Regional Agricultural Research Institute, Bahir Dar.

3.3.1. Moisture Content

For moisture test about 5g seed sample were taken and distributed on the surface of the container incubating in an oven at a constant high temperature of 130 °C ±1 and dried for about 1 hour with coarse grinding (ISTA, 2008). After drying, the sample were covered and allowed to cool for 30 minutes in desiccators and weighed again. The moisture content was calculated using the formula given below.

$$M = \frac{M2 - M3}{M2 - M1} \times 100$$

Where:

M1=the weight in grams of empty container and its cover

M2=the weight in grams of the container its cover and its content before drying and

M3= the weight in grams of the container and contents after drying

3.3.2. Physical Purity

According to ISTA (2008), the weight of submitted and working sample of field pea is 1000 g and 900 g, respectively. For each seed sample about 900 g seed sample was used for purity analysis. Each seed sample was divided into four replicates and separated in to three components: (i) pure seed, (ii) other crop seed and (iii) inert matter (ISTA, 2008). The components were weighed on precision balance to the nearest two decimal places and the percentages of each component were calculated as follows:

$$\text{Physical purity (\%)} = \frac{\text{Weight of pure seed(g)}}{\text{Total weight of working sample(g)}} \times 100$$

Thousand Seed Weight (TSW): Thousand seed weight was determined by counting from pure seed fraction and weighing eight replicates of 100 seeds and there mean weight has taken and multiplied by 10 (ISTA, 2008).

3.3.3. Standard Germination (StG) Test

Standard seed germination test was carried for all seed samples in a completely randomized design (CRD). Four hundred seeds from the pure seeds component were taken and divided into four replicates of 100 seeds each and planted in sand media at a temperature of 20 °C. The first count were done 5 days after planting, and the final count 8 days after planting as specified by ISTA (2008). The result of the germination test was calculated as the average of four replicates. It was expressed as the percentage of normal seedlings. The percentages of abnormal seedlings, hard, fresh and dead seed were calculated in the same way.

$$\text{Germination (\%)} = \frac{\text{Total number of normal seedlings}}{\text{Total number of seeds planted}} \times 100$$

3.3.4. Seed Vigor Test

Speed of germination:

Hundred seeds were counted and taken from each source. The seeds were divided into four replicates of 25 seed each then after seeds were planted in between germination paper at 20 °C for 10 days in a dark room. The speed of germination (SG) was calculated according to Maguire (1962).

The number of germinated seeds was counted every day from the first day of seed germination and the cumulative index was made by the formula:

$$N = \frac{n_1}{1} + \frac{n_2}{2} + \dots + \frac{n_x}{x}$$

Where:

n_1, \dots, n_x is the number of speed seed germinated on day 1 to day x

$1, \dots, x$ is the number of days

Seedling dry weight: The seedling dry weights were measured after the final count of the standard germination (StG) test. Ten randomly selected seedlings excluding cotyledon from each replicate were taken, and placed in envelopes and dried in an oven at 80 °c for 24 hours

then the dried seedlings were weighed to the nearest milligram (three decimal) using sensitive balance and the average seedling dry weight was calculated (Wood Stock, 1976).

Seedling shoot and root length: Assessment of the seedling shoot and root were taken after the final count in the standard germination test. After 8th day of sowing, ten normal seedlings were randomly taken from each replicate. The shoot lengths were measured from the point of attachment to the cotyledon to the tip of the seedling. Similarly, the root lengths were measured from the point of attachment of the cotyledon to the tip of the root. The average shoot and root lengths were computed by dividing the total shoot or root lengths by the total number of normal seedlings measured (Abdul-Baki and Anderson, 1973).

Vigour index-I and Vigor index-II: For each sample, vigour indices were calculated. Seedling vigour index-I was calculated by multiplying the standard germination with the average sum of shoot and root length after the final days of germination:

Vigour index I = Germination % × [Root length + Shoot length (cm)] (Abdul-Baki and Anderson, 1973).

Vigour Index II= (Seedling dry weight X Germination (%))/ 100 (Kharb *et al.*, 1994).

3.3.5. Field Emergence Index

Pot experiments were conducted for field emergence index using well mixed soil. Twenty five seeds of four replications were planted from each seed source using complete randomized design (CRD). The number of seedlings emerged out of sown seed were counted till no more seedlings were emerged. The field emergence index was determined by following formula (Maguire, 1962).

$$EI = \frac{\text{Number of seedlings emerged}}{\text{Days of first count}} + \dots + \frac{\text{Number of seedlings emerged at final count}}{\text{Days of final count}}$$

Field emergence (%): the total seedling emerged from the soil was summed up at the end of field emergence index experiment and it was calculated as field emergence in percent.

$$\text{Field emergence (\%)} = \frac{\text{Total number of emerged seedlings}}{\text{Total number of seeds planted}} \times 100$$

3.3.6. Seed Health Testing

Agar plate was used which is the most common method used for identification of seed borne fungi (Rao and Bramel, 2000). One hundred (100) undamaged seeds per sample were surface sterilized quickly by rinsing in 70% ethanol alcohol followed by soaking in 1% NaOCl for two minutes and then washing by distilled water. The seeds then plated on general purpose agar medium (five seeds per plate) and were incubated for two weeks. Petri dishes were incubated at $28 \pm 1^\circ\text{C}$ with 12 hours alternating cycles of day and darkness and fruiting bodies of pathogens were examined under compound microscope (Agrios, 2005). During the period the fungi were identified and recorded and the percentage seed infection were calculated. Identification of fungi and appropriate reference materials were used and finally the occurrence of each fungal pathogen was recorded. According to Zewdie *et al.* (2013), the frequency and percent of infection were determined by the following formulae given below.

$$\text{Frequency of infection} = \frac{\text{Number of samples with infection}}{\text{Number of samples collected}} \times 100$$

$$\text{Percent of infection} = \frac{\text{No. of infected seeds}}{\text{Total number of seeds examined}} \times 100$$

3.4. Data Analysis

Information collected from the field survey was coded, tabulated and analyzed by using Statistical Package of Social Science (SPSS) version 23. Simple descriptive statistics was used to separate the mean, percentage and standard deviation to describe the socio-economic characteristics of the respondents.

Data collected data from laboratory and pot experiments were subjected to analysis of variance for completely randomized (CRD) using SAS (9.0). Treatment means were separated using Least Significance Difference (LSD) test. Pearson's correlation coefficient was used for correlating the data from seed quality and the field emergence index.

4. RESULTS AND DISCUSSION

4.1. Household Characteristics

4.1.1. Demographic Characteristics and Farming Experience

Data collected from 200 respondents from the two districts showed that 179 (89.5%) of the respondents were male headed households and only 21(10.5%) were female headed households (Table 1).

Education is expected to increase the probability of the farmers to adopt new technologies. As shown in Table 1, 45% of the total respondents had no formal education while 24.5, 14, 11 and 5.5% were read and write, some primary, completed primary and some secondary respectively. However in Enarj Enawuga district 34% of the respondents were adult education where as in Yilmana Densa 42% of them were read and write. In Yilmana Densa district, about 38% of the respondents were illiterate as compared to 11% in Enarj Enawuga. Ideally, educated farmers are expected to display better adoption of a technology because they can process information more rapidly than others. The result is in agreement with earlier literatures conducted in the country (Zewdie *et al.*, 2010; Solomon *et al.*, 2012; Wuletaw and Daniel, 2015).

Age was one of the demographic characteristics that influenced the decision to adopt new technologies. The mean age of the respondents in Enarj Enawuga and Yilmana Densa districts, respectively were 38.68 (SD=8.52) and 43.09 (SD=8.98) with minimum and maximum range from 22-51 and 33-65 in the same order (Table 1). In Enarj Enawuga younger farmers could be main avenue for introducing new varieties as well as non-varietal technologies in the communities. The result is in agreement with recent adoption studies of Amare (2015) and Odhiambo *et al.* (2016) but in Yilmana Densa could be because age of a farmer was used as a measure of his experience and experienced farmers were often expected to use modern technologies and it is in agreement with recent adoption studies in Amhara region (Solomon *et al.*, 2012; Afework and Lemma, 2015).

The mean field pea producing experience of the respondents in Enarj Enawuga and Yilmana Densa were 13.77 years (SD=6.13) and 12.91 years (SD=5.72) respectively (Table 1). In contrast to age, Enarj Enawuga district has relatively higher experience of field pea production than Yilmana Densa district. Farming experience can help the farmers to evaluate the advantage of incorporating seeds of improved field pea varieties in to their field pea production system.

Table 1. Sex, education, age and farming Experience of sample farmers in Enarj Enawuga and Yilmana Densa districts (n=200)

Indicators	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Sex of respondents						
Male	105	87.5	74	92.5	179	89.5
Female	15	12.5	6	7.5	21	10.5
Total	120	100	80	100	200	100
Educational level						
Illiterate	14	11.6	31	38.8	45	22.5
Read and Write	15	12.5	34	42.5	49	24.5
Adult Education	41	34.2	4	5	45	22.5
Some Primary (1-4)	24	20	4	5	28	14
Completed Primary (5-8)	15	12.5	7	8.7	22	11
Some Secondary(9-12)	11	9.2	0	0	11	5.5
Age						
Mean	38.68		43.09		40.45	
SD	8.52		8.98		8.951	
Minimum	22		33		22	
Maximum	51		65		65	
Farming experience						
Mean	13.77		12.91		13.43	
SD	6.13		5.72		5.97	

Source: own survey data, 2016/17 cropping season

4.2. Information on Field Pea Technologies and Use

4.2.1. Source of Information for Agronomic Packages

Among farmers the awareness of field pea production packages were high for fertilizers (97%), agronomy (93.5%), storage (86%) but low for improved varieties (39.5%), respectively. The formal BoA extension service was the main source of information for agronomic practices (100%), storage (77.8%) and fertilizers (67.1%) for field pea production but low in improved field pea varieties (34.1%). In contrast, the research centre was main source of information improved varieties (57%). In addition to research centre, farmers had information about improved field pea varieties from different sources such as relatives (5.1%) and neighbors (3.8%) (Table 2).

Generally, Farmers used multiple sources of information as much as possible but the research centre was the main source of information for most of improved field pea packages due to the dissemination system practiced in both districts. Informal source of information such as relatives and neighbors are also important particularly for improved varieties, fertilizer and grain storage. There is general lack of effective extension information related to seeds. Tesfaye *et al.* (2008) also found that the majority of the farmers (62%) in the central area of Ethiopia obtained information on improved potato technologies from Holleta Research Centre, whereas 33% obtained it from fellow farmers and only 4% from the office of agriculture.

Table 2. Farmers' source of information on agronomic packages for field pea production (n=200)

Source of information		Improved variety		Agronomy		Fertilizers		Storage	
		n	%	n	%	n	%	n	%
Have information	Yes	79	39.5	187	93.5	194	97	172	86
Sources of information									
	BoA	27	34.1	87	100	63	67.1	56	77.8
	Research Centre	45	57	0	0	5	5.3	0	0
	Relatives	4	5.1	0	0	19	20.2	10	13.9
	Neighbors	3	3.8	0	0	7	7.4	6	8.3

Source: own survey data, 2016/17 cropping season. Note: BoA= Bureau of Agriculture

4.2.2. Agronomic Practices Used for Field Pea Production

The majority of the respondents (55%) plough their field pea land twice and the rest (45%) of the farmers plowed one time to facilitate crop establishment (Table 3). However, 80% of the respondents in Yilama Densa district plow once where as 78% of Enarj Enawuga plow their field pea land twice. Field pea is large seeded crop that does not require fine tith as compared to cereals for establishment. The primary objectives of soil tillage are to provide suitable seedbed and adequate weed control (Rao, 2000). The result is in agreement with Fisseha and Tewodros (2014) finding that ploughing twice is economical and profitable for field pea producing farmers.

About 15.5% of the farmers in the study area sowed in mid-May and 31.5% in early June and 53% in late June (Table 3) which is as per recommendation (mid-May to early July) of field pea production packages of BoA depending on the onset of rain and soil type. In both locations the late June was preferred by most farmers. Farmers in the highlands sow earlier (mid-May) than mid altitude particularly where water-logging during vegetative stage and drought during flowering time were a major problem. Appropriate planting time has an impact in improving the productivity of legumes (Berhane *et al.*, 2016). Grubben and Denton (2008) suggested early sowing for optimum yields to overcome low moisture availability and heavy aphid infestation at medium altitudes and frost damage at high altitudes.

About 56.5% of the respondents used as per recommendation of BoA with seed rate of 80-120 kg ha⁻¹ while 43.5% used a seed rate of less than 80 kg ha⁻¹ which will result to low plant population and productivity per hectare. The quantity of seed sown per hectare determines the density of the plant population and ultimately the productivity of the crop. Similar trend was observed in both location. It was found that high yields are realized with optimum plant population and planting method (Yayeh *et al.*, 2014).

It also provides ease for crop management that increases overall production of the crop. The majority of farmers (60.5%) row planted while 39.5% broadcasted field pea (Table 3). In both districts, broadcasting could be due to mixed cropping practice of field pea with faba bean to

prevent lodging of field pea. Row planting has more advantages over broadcasting as it reduces labour and costs of production. Yayeh *et al.* (2014) however found that sowing field pea with 25 cm row spacing and 15 cm intra row spacing (or 20 cm row spacing and 5 cm intra row spacing) gave the highest mean seed yield. It was a similar trend between in both districts

The majority of farmers (58%) carry out one time weeding as per the recommendation while 42% did not practice weeding their field pea plot (Table 3) due to the overlapping of agricultural activities with other crops like *teff* and wheat. Weeding practice was too low in Yilmana Densa district (83%) than in Enarj Enawuga (14%) due to poor extension service provided in Yilmana Densa district. The extent to which yield is depressed as a result of competition from weeds depend on the resources available and competitive ability of crops (Roberts, 1982). Fisseha and Tewodros (2014) and Getachew and Hailu (2009) found that weeding once is the best option and economical to grow field pea.

Table 3. Agronomic practices used for field pea production by sample farmers in Enarj Enarj Enawuga and Yilmana Densa districts (n=200)

Agronomic practice	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Plowing time						
One	26	21.7	64	80	90	45
Two	94	78.3	16	20	110	55
Panting date						
Mid May	24	20	7	8.8	31	15.5
Early June	45	37.5	18	22.4	63	31.5
Late June	51	42.5	55	68.8	106	53
Weeding frequency						
No weeding	17	14.2	67	83.8	84	42
One weeding	103	85.8	13	16.2	116	58
Seed rate kg/ha						
<80	56	46.7	31	38.8	87	43.5
80-120	64	53.3	49	61.2	113	56.5
Planting method						
Row planting	74	61.7	47	58.8	121	60.5
Broad casting	46	38.3	33	41.2	79	39.5

Source: own survey data, 2016/17 cropping season

4.2.3. Farmers' Perception of Soil Fertility and Fertilizer Use

It was found that, the majority (54%) of the respondents assumes that their land having intermediate fertility while 31 and 15% considered their field pea land having poor and good soil fertility respectively (Table 4). It was also constant in both locations.

The growth and grain yield of field pea is influenced by the application of fertilizers. The majority of the respondents (71%) apply DAP fertilizer and none of the sample farmers use natural fertilizers such as compost in both districts. From those that apply fertilizer, 68.3% use between 60-80 kg ha⁻¹ which was lower N and higher P₂O₅ and the remaining 31.7% uses less than 60 kg ha⁻¹ which was less in both N and P when compared with the findings of Getachew *et al.* (2003) and Getachew and Hailu (2009) which found the application of 18 kg nitrogen and 20 kg phosphorus per hectare for growing field pea. Lower application was observed could be due to high cost of fertilizer and more attention given to cereals having large area coverage.

Table 4. Farmers' perception of soil fertility and fertilizer use on field pea in Enarj Enawuga and Yilmana Densa districts (n=200)

Interviewed items	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Soil fertility status						
Good	23	19.2	7	8.8	30	15
Medium	60	50	48	60	108	54
Poor	37	30.8	25	31.2	62	31
Apply fertilizer						
Yes	103	86	39	48.8	142	71
No	17	14	41	51.2	58	29
Fertilizer type						
DAP	103	86	39	48.8	142	71
No Fertilizer	17	14	41	51.2	58	29
DAP Kg ha ⁻¹						
<60	34	33	11	28.2	45	31.7
60-80	69	67	28	71.8	97	68.3

Source: own survey data, 2016/17 cropping season

4.3. Adoption of Field Pea varieties and Farmer's Perception

Adet Agricultural Research Centre together with Bahir Dar University has carried out participatory research for pre-scaling up of field pea varieties three years ago within the watershed project in East and West Gojjam Zones of Amhara region. Seed distribution was officially through BoA. Dissemination of field pea improved varieties therefore seems concentrated around project areas. There is low average rate of adoption of improved field pea varieties in the region.

Currently, only 3.29% of the area is under field pea production in both districts is covered by improved varieties whereas 96.7% is covered by local varieties (EEDOA and YDDOA, 2016). The ASE and Ethiopian Seed Enterprise (ESE) of Bahir Dar branch have never supplied enough improved certified seed of field pea varieties in both districts and as a result, the majority of farmers depend on the local varieties. Lower adoption rate together with absence of functional agency for field pea seed production makes the formal sector not sustainable.

The local field pea varieties are less resistance to major diseases like blight and less tolerant to pests like pea aphid, bean bruchid, African bollworm and birds; and this caused disappointment among farming communities of both districts. The two adopted improved field pea varieties grown in the districts are Tegegnech (12%) followed by Hassabe (6.5%) by the respondents in the study area. The most desirable characteristics of good quality field pea variety suggested by the respondent farmers were seed size, seed yield, early maturity, disease/insect pest tolerance and seed color and ranked them as 1st, 2nd, 3rd, 4th and 5th, respectively (Table 5).

Two local varieties of field pea but with different maturity period and seed size were identified. The early maturing variety is medium in seed size and sown early in May on vertisols and is less resistant to water logging while the late maturing variety is large in seed size and sown in red soil. Farmers prefer the early maturing variety for double cropping with grass pea. Among improved varieties Tegegnech with cream seed color, large seed size, round

shape and higher yield is preferred by farmers than Hassabe with light brown color, medium seed size, wrinkled shape and relatively lower yield. Some farmers however prefer Hassabe variety because it matures earlier than Tegegnech. In beans the farmer preferred traits are yield, seed size, early maturity or disease tolerance (Asrat *et al.*, 2013).

Table 5. Farmers' criteria of good seed in Enarj Enawuga and Yilmana Densa districts (n=200)

Characteristics	Enarj Enawuga		Yilmana Densa		Total		Rank
	n	%	n	%	n	%	
Seed yield	30	25	9	11.2	39	20	2
Seed size	55	45.8	33	41.3	88	44	1
Seed color	7	5.8	9	11.2	16	8	5
Disease/ insect pest tolerance	11	9.2	10	12.5	21	10	4
Early maturity	17	14.2	19	23.8	36	18	3

Source: own survey data, 2016/17 cropping season

4.4. Field Pea Seed Sources and Perceptions

4.4.1. Farmer's Seed Sources

Farmers' seed source and acquisition for both local and improved field pea varieties grown is presented in Table 6. Here we can distinguish two aspects: (a) Seed source from where farmers sourced their seed for planting field pea varieties they are growing during 2016/17 cropping season and (b) original source from where farmers sourced or accessed the seed for the first time all field pea varieties currently grown.

In 2016/17 cropping season, the majority of respondent farmers (64.5%) used their own stock followed by (19.5%) used seed purchased from market, 6% purchase from farmers and the rest 5.5% and 4.5% of the respondent farmers exchange with other crop seeds and purchase from traders, respectively (Table 6). The majorities of farmers used seed from the informal seed systems and own stock was the dominant one. Farmers considered seeds obtained from their own farm have better quality than purchased but have no any justification for changing the seed unless to acquire a new variety on the market.

Many factors were found to influence farmers' seed sources: economic (as related to wealth), social (ethnic, cultural, and traditional), biological (varietal characteristics, multiple uses, etc.), and ecological (adaptive characteristics, weather factors, etc.) (Friew, 2007). Farmers might use various seed sources for different crops or even for a single crop or variety they grow on the farm for various reasons (Zewdie, 2010). Regassa *et al.* (1998) also found that lack of seeds (42%), followed by seed price (35%), to be the most important seed-supply constraint in southeastern Ethiopia. Similarly, Zewdie (2010) found that 79% of respondents used retained seed of wheat crop. Firew (2007) also found own stock was the dominant seed source in normal years for sorghum.

The original source of the field pea varieties they are growing currently were obtained from own stock (57.5%), gift from research/NGO (18.5%), purchase from market (12%), purchase from farmers (6.5%), exchange with other crops (4%) and the rest 1.5% was purchase from traders. Original source of filed pea varieties were mostly own stock. Many findings indicated that own stock was the dominant seed source in most developing countries. The second important original seed source was from NGO through AARC by disseminating improved varieties in the water shade project areas of two districts. The result in agreement with Zewdie (2010) found that informal sector was an initial source of modern wheat varieties for 58% of the farmers.

Generally farmers use different seed sources for growing field pea on their farm. The four major seed source channels from informal sector were own stocks and exchange with or purchase from other farmers, local markets or traders. Since there was no new improved variety on the market own saved seed was the main seed source of field pea in both districts. Further, they are familiar with the seed they grow and know that it is adapted to local conditions and preferences. Those who prefer purchasing from market was because local market offers local varieties grown in neighboring areas and the seed price was lower than other sources. They also get chance for exchange with other crops (*teff*) which have same cost as field pea in local markets. Some farmers prefer purchasing seed from other farmers because

they know and certain about seed quality. Few grain traders also potential seed source for field pea due to affordable price higher than grain.

Table 6. Farmers' field pea seed sources in Enarj Enawuga and Yilmana Densa districts (n=200)

Seed Source	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Survey Year						
Purchase from farmers	8	6.7	4	5	12	6
Purchase from traders	7	5.8	2	2.5	9	4.5
Purchase from Market	25	20.8	14	17.5	39	19.5
Own stock	75	62.5	54	67.5	129	64.5
Exchange with other crop seeds	5	4.2	6	7.5	11	5.5
Original Source						
Purchase from farmers	9	7.5	4	5	13	6.5
Purchase from traders	0	0	3	3.75	3	1.5
Gift from NGO/research Centre	22	18.3	15	18.75	37	18.5
Purchase from Market	16	13.4	8	10	24	12
Own stock	70	58.3	45	56.25	115	57.5
Exchange with other crop seeds	3	2.5	5	6.25	8	4

Source: own survey data, 2016/17 cropping season

4.4.2. Seed Replacement and Reason for Seed Replacement

Here a regular practice a farmer is following to replace field pea seed and the reasons for seed replacement were assessed.

From the respondents of both districts, it was estimated that the mean number of years farmers used field pea seed without replacement was three to four years. From the total households only 49 (24.5%) replace field pea variety. Seed replacement among field pea variety users was low due to limited availability of seed of new varieties on the market. Reddy *et al.* (2007) found that farmers save seed of local varieties and use this continuously for about 3-4 years with low seed replacement ratio of 2-3% because the proportion of quality seed available each year is only 10-12%.

Most of the respondents (44.9%) replace the variety due to susceptibility to diseases, the rest 32.6, 18.4, 4.1% replace their variety due to low yielding capacity, low pest tolerance and late maturing variety, respectively (Table 7). As discussed above the local varieties are low yielders, less tolerant to disease and pest, and due to those reasons majority of the farmers want to replace their field pea seed stock with new seed of improved varieties and there was no possibility due to availability of limited in the market.

Formal seed source appeared to be one of the strategies for acquiring a new variety or renew old seed of improved variety (Zewdie, 2004). The decision made by farmers to change varieties is termed variety ‘replacement’, whereas the distinction to obtain fresh seed stocks of the same variety is termed seed ‘renewal’ (Zewdie and Kugbei, 1997). Similarly, GTZ (2000) reported that reasons for farmers to use off-farm seed are: loss of seed due to crop failure, the incapability to save seed because of low-yields, need to replace seed because of degeneration or disease contamination, and to obtain new varieties.

Table 7. Farm households reasons for varietal and seed replacement of field pea varieties in Enarj Enawuga and Yilmana Densa districts (n=49)

Reasons for seed replacement	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Susceptible to diseases	15	45.5	7	43.75	22	44.9
Low pest tolerance	5	15.1	4	25	9	18.4
Low yielding capacity	11	33.3	5	31.25	16	32.6
Late maturing	2	6.1	0	0	2	4.1
Total	33	100	16	100	49	100

Source: own survey data, 2016/17 cropping season

4.5. Farmers Seed Management

4.5.1. Seed Selection

Farmers used different selecting criteria and method to select their seed at different stages. Response from most informants revealed that farmers’ selection criteria and practice were focused on observable attributes such as seed size and yield performance during harvesting, threshing and after threshing. Most of the selection practices were selected grain and very few

based their selection on plants or pod. This indicates that farmers are interested in different traits of a variety.

Farmers select seed during harvesting and threshing (51.5%), just after threshing (37%) or just before planting (11.5%). Men (56.5%), women (21.5%), both men and women (7.5%) or all household members (14.5%) were responsible for selection as shown in Table 8. However female farmers are important in Enarj Enawuga (28%) as male in Yilmana Densa (58%). Some farmers selected; collected; threshed and stored seed separately for sowing and evaluated the crop the next season.

Most farmers select seed before and/or after harvesting the crop. Some farmers designate part of the field and use the harvest as a seed. Field and plant selections are based on a set of criteria, which vary from place to place, crop to crop and farmer to farmer (Baniya *et al.*, 2003). Similarly, Asrat *et al.* (2013) also found that among farmers practicing selection, 53% selected plants before harvest in the field, 15% at harvest just before threshing, and 7% just after threshing while 18% just before sowing of common bean in southern Ethiopia. Bajracharya (1994) reported that women played a significant and key role in on-farm seed management in Nepal.

Table 8. Farmers seed selection and time of field pea seeds in Enarj Enawuga and Yilmana Densa districts (n=200)

Seed selection	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Time of selection						
During harvesting and threshing	62	51.7	41	51.25	103	51.5
Just after threshing	49	40.8	25	31.25	74	37
Just before Planting	9	7.5	14	17.5	23	11.5
Responsibility of seed selection						
Female farmer only	34	28.4	9	11.25	43	21.5
Male farmer only	66	55	47	58.75	113	56.5
Both male and female farmers	7	5.8	8	10	15	7.5
All household members	13	10.8	16	20	29	14.5

Source: own survey data, 2016/17 cropping season

4.5.2. Seed Cleaning

The majority (62.5%) of the respondents clean by winnowing just before planting using homemade equipment known as *Sefed*, and this activity separates seeds by using differences in size and weight between seed and impurities. 37.5% of them by hand picking of large particles such as large soil clods or other inert matters to improve seed quality/ remove inert matter, remove small/broken damaged seeds and to remove weeds and other crops. Main cleaning time is just before planting. Men do the winnowing after threshing and women clean the seed at planting time.

About 57.5 % of the respondent farmers clean their seed to remove small or broken/damaged seeds, 30% of them were to remove weeds and other crops, and 12.5% to increase quality by removing inert matter (Table 9).

For most crops, cleaning of seed follows similar principles as for food grains using local practices and may include winnowing to remove light particles like straw and dust; sieving to select the seed by shape and size and hand-picking to remove damaged, diseased or discoloured seeds (Zewdie, 2004). Zewdie (2004) also reported that about 52% and 17% of the farmers cleaned their seed by hand-winnowing or hand-sieving, respectively, at planting time using handmade tools to increase purity, reduce weed contamination or even remove insect damaged seed grains. According to FAO (2014) all seed infested by insects must be destroyed to effectively remove sources of future infestation or contamination.

Table 9. Farmers' seed cleaning practice and purpose in Enarj Enawuga and Yilmana Densa Districts (n=200)

Seed Cleaning	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Method of cleaning						
Winnowing	73	60.8	52	65	125	62.5
Hand picking	47	39.2	28	35	75	37.5
Purpose of Cleaning						
Improve quality/ remove inert matter	17	14.17	8	10	25	12.5
Remove small/broken damaged seeds	66	55	49	61.2	115	57.5
Remove weeds and other crops	37	30.83	23	28.8	60	30

Source: own survey data, 2016/17 cropping season

4.5.3. Seed Storage and Protection

Majority of the farmers (81%) used sacks and stored the seed in the house and 19% stored in local structures such as *gota/gotera* especially in the highland areas (Table 10). The average quantity of seed stored was 30 kg with range from the 15kg to 50 kg for field pea. They re-used fertilizer sacks without plastic linings to protect the seed from moisture. A study in Kenya shows that farmers stored beans in their houses (98%) or used some raised platforms near their houses (2%) (Odhiambo *et al.*, 2016).

During storage, the majority of the respondents (64%) used chemicals (phostoxin or actellic 2%) for storage pest control and the remaining 36% did not take any control measures. Farmers who take no control measure specially in Yilmana Densa distric believe that as bruchides are inside the seed treating the seed does not control the storage pest. None of the respondents use cultural methods to protect the seed from storage pest assuming that cultural measures do not have immediate result.

Advantages for farmers in storing their own seed include cash outlays are reduced, seed is available on time and nearby, and knowledge of varieties and management requirements (Walsh *et al.*, 2014). The location, storage structures and the material used to construct the structures play an important role in enhancing the shelf-life and viability of the stored grain/seed (Odhiambo *et al.*, 2016). Esayas *et al.* (2016) found that the majority (63%) of farmers surveyed relied on chemical insecticides (actellic dust or phostoxin) and lack knowledge of cultural practices to control pea weevil in North and North West Ethiopia.

Table 10. Farmers' seed storage and protection measures in Enarj Enawuga and Yilmana Densa districts (n=200)

Seed Storage	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Storage structure						
Sacks in the house	96	80	66	82.5	162	81
Gota/Gotera	24	20	14	17.5	38	19
Protection measures						
Chemicals	71	59.2	57	71.25	128	64
No measures taken	49	40.8	23	28.75	72	36

Source: own survey data, 2016/17 cropping season

4.6. Household Seed Security

It was found that the majority of the farmers (83%) were seed insecure. The main underlying reasons for seed insecurity were seed unavailability (43.1%), pests (25.7%), diseases (19.8%), drought (6.6%) and hailstorm (4.8%) as shown in Table 11. The seed unavailability followed by production related problems (insect, disease and bird) and natural calamities (drought and hailstorm) were the major reasons affecting seed security in the study area.

Farm families are seed secure when they have access to seed and (other planting material) of adequate quantity, acceptable quality, and in time for planting. Seed security is best framed within the broader context of food and livelihood security. Helping farmers to obtain the planting materials they need enables them to produce for their own consumption and sale (FAO, 2014). Similar findings reported by Friew (2007) that in a bad cropping season, farmers were forced to use seed sources other than their own (depleted) stock.

Farmers indicated different ways to cope and reduce seed insecurity include: increasing availability of seed (43.1%), proper pest and agronomic management (31.8%) and changing the variety (25.1%) of the crop (Table 13). FAO (2014) recommended that communities can be capacitated to produce/multiply, store and market seed of desired crops and varieties.

Table 11. Farmers' perception of seed security in Enarj Enawuga and Yilmana Densa districts (n=200)

Seed security	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Seed insecure farmers	105	87.5	62	77.5	167	83.5
Reasons for seed insecurity						
Drought	9	8.6	2	3.2	11	6.6
Hailstorm	8	7.6	0	0	8	4.8
Seed unavailability	31	29.5	41	66.2	72	43.1
Diseases	21	20	12	19.3	33	17.8
Pests	36	34.3	7	11.3	43	25.7
Suggestion to reduce seed insecurity						
Proper agronomic and pest management	37	35.2	16	25.8	53	31.8
Change varieties	28	26.7	14	22.6	42	25.1
Avail seed through seed production	40	38.1	32	51.6	72	43.1

Source: own survey data, 2016/17 cropping season

4.7. Crop Mixtures

From the total surveyed farmers, 64% grows field pea in mixture with faba bean, and 36% of them grow pure field pea crop. The main reason for the majority of farmers (85.2%) for crop mixture was to avoid lodging of field pea, while 14.8% were to use yield advantage of mixtures of both crops (Table 12). Field pea is a prostrate crop with all or part of the biomass lying on the ground when mono cropped but supported more or less in an erect position when mixed-cropped with faba bean.

Tollera and Daba (2009) found that a maximum land use efficiency of 0.53 or relative yield advantage of 53% from intercropping of faba bean and field pea on 3:1 ratio; and recommended growing faba bean both as a sole crop and intercropping with field pea is a viable option for sustainable productivity in total grain yield and profit to farmers in southern Ethiopia. Similarly, Grubben and Denton (2008) reported the advantage of growing field pea and faba bean mixture in Ethiopia. He indicated that faba bean provides physical support and good aeration to field pea, whereas field pea suppresses weed growth and significantly slow down the rate of *Ascochyta* blight development resulting in higher yields than pure stands.

Table 12. Faba bean-field pea crop mixture in Enarj Enawuga and Yilmana Densa districts (n=200)

Interview items	Enarj Enawuga		Yilmana Densa		Total	
	n	%	n	%	n	%
Grow crops mixture						
Yes	72	60	56	70	128	64
No	48	40	24	30	72	36
Reasons for growing crop mixture						
Avoid lodging of field pea	63	87.5	46	82.1	109	85.2
Yield	9	12.5	10	17.9	19	14.8
Total	72	100	56	100	128	100

Source: own survey data, 2016/17 cropping season

4.8. Seed Quality of Field Pea

Field pea seed samples of two improved varieties, Tegegnech and Hassabe, were collected from informal (farmers) and formal (ASE and AARC) sources were analyzed for the main quality parameters moisture content, physical seed purity, thousand seed weight, physiological quality (germination and vigor) and seed health presented below.

4.8.1. Physical Purity

There were highly significance difference in all physical purity parametes among seed samples collected from formal and informal seed souce (Table 13). The physical purity ranged from 98.47% to 98.87% with a mean value of 98.66%. The highest physical purity was observed from sample F17 (98.87%) of Hassabe variety in Yilmana Densa followed by F12 of Hassabe variety from Enarj Enawuga district where as the lowest was from samples F19 (98.47%) and F15 (98.47%) of Tegegnech variety all from Yilmana Densa district informal seed source (Table 13). The highest contamination by other crop seeds was observed in seeds obtained from sample F23 (0.36%) of Tegegnech variety where as the lowest was from sample F18 (0.31%) of Hassabe variety both from Yilmana Densa district informal seed source. On the other hand, contamination of field pea seed by inert mater was highest in seeds obtained from F19 (1.20%) and the lowest from F17 (0.77%) both of Hassabe variety from Yilmana Densa district informal seed source.

The mean separation showed no observed differences (except other crop seed) in physical purity and inert matter between formal and informal seed sources, varieties and districts (Table 13). Crop seed admixtures could occur at the time of sowing, harvesting (poor threshing floors) and post-harvest activities (threshing, seed cleaning or storage) that would result in increased percentage of other crop seed in the informal seed source of the study area. Crop seed admixtures could occur at the time of sowing, harvesting (poor threshing floors) and post-harvest activities (threshing, seed cleaning or storage) that would result in increased percentage of other crop seed in the informal seed source of the study area. The result is in agreement with the reports of Melkamu (2015) and Girma *et al.* (2015) who found no

significant differences in physical purity and inert matter between seed sources except for other crop seed in *teff* and barley crops, respectively.

According to the national field pea certified seed standard (EQSA, 2012), the percentage of pure seed, inert matter and other crop seeds should be 97%, 0.2% and 1%, respectively. Except for other crop seeds, all the seed samples maintained the physical purity above the certification standards. Similarly, Zewdie *et al.* (2012) reported that most of the samples collected from farmers satisfied the physical purity standards set for wheat seed production in Ethiopia.

4.8.2. Thousand Seed Weight

Highly significant difference in thousand seed weight were observed among treatments. The average thousand seed weight of the entire seed sample collected was 170.81g ranging from the lowest of F14 (143.72 g) and F16 (145.03 g) of Hassabe variety from Yilmana Densa district to the highest from ASE (197.966 g) from formal seed sector and F1 (197.04 g) of Tegegneh variety from Enarj Enawuga of informal seed source. Tegegneh variety showed higher higher thousand seed weight than Hassabe variety could be due to differences in seed size (Table 13).

Thousand grain weights is one of important traits of seed quality. It depends to embryo size and seed storage for germination and emergence (Cordazzo, 2002). Girma *et al.* (2015) and Zewdie *et al.* (2012) found significant difference in thousand seed weight in barley and wheat varieties, respectively.

Table 13. Mean values of Physical Quality, Moisture Content, and Thousand Seed Weight of field pea seeds from formal and informal seed sources

Seed Samples	Pure seed	Other crop	Inert mater	Moisture	Thousand seed weight
F1	98.7475 ^{abcde}	0.33000 ^{def}	0.9000 ^{bcde}	13.7000 ^{abcde}	197.045 ^a
F2	98.7875 ^{abcd}	0.3575 ^{abc}	0.8550 ^{cde}	13.7250 ^{abcd}	164.53 ^e
F3	98.6575 ^{abcde}	0.36250 ^{abc}	0.9800 ^{abcde}	13.7000 ^{abcde}	194.985 ^{ab}
F4	98.8425 ^{ab}	0.3200 ^{def}	0.8375 ^{cde}	13.6500 ^{bcdef}	148.015 ^{fgh}

Table 13 (continued)

Seed Samples	Pure seed	Other crop	Inert mater	Moisture	Thousand seed weight
F5	98.6675 ^{abcde}	0.3500 ^{abcd}	0.9825 ^{abcde}	13.6500 ^{bcdef}	195.665 ^{ab}
F6	98.585 ^{abcde}	0.3500 ^{abcd}	1.0650 ^{abcde}	13.5250 ^{cdef}	152.335 ^f
F7	98.4825 ^{de}	0.34500 ^{abcdef}	1.1725 ^{ab}	13.8500 ^{ab}	194.735 ^{ab}
F8	98.6481 ^{abcde}	0.34438 ^{abcdef}	1.0075 ^{abcde}	13.8250 ^{abc}	144.453 ^h
F9	98.7106 ^{abcde}	0.34188 ^{abcdef}	0.9475 ^{abcde}	13.6250 ^{bcdef}	175.743 ^d
F10	98.6725 ^{abcde}	0.34250 ^{abcdef}	0.9850 ^{abcde}	13.6500 ^{bcdef}	144.393 ^h
F11	98.5750 ^{abcde}	0.33250 ^{bcdef}	1.0925 ^{abcd}	13.625 ^{bcdef}	188.145 ^c
F12	98.8575 ^{ab}	0.32750 ^{cdef}	0.8150 ^{de}	13.7500 ^{abcd}	147.510 ^{fgh}
F13	98.5150 ^{cde}	0.3525 ^{abcd}	1.1325 ^{abc}	13.6500 ^{bcdef}	193.073 ^{abc}
F14	98.655 ^{abcde}	0.3575 ^{abc}	0.9875 ^{abcde}	13.4000 ^{ef}	143.720 ^h
F15	98.4775 ^e	0.34750 ^{abcde}	1.1750 ^{ab}	13.6250 ^{bcdef}	189.578 ^{bc}
F16	98.8006 ^{abc}	0.35938 ^{abc}	0.8400 ^{cde}	13.3750 ^f	145.033 ^h
F17	98.875 ^a	0.34750 ^{abcde}	0.7775 ^e	13.6000 ^{bcdef}	194.748 ^{ab}
F18	98.5525 ^{bcde}	0.31250 ^f	1.1325 ^{abc}	13.5500 ^{bcdef}	145.52 ^{gh}
F19	98.4775 ^e	0.31500 ^{ef}	1.2075 ^a	13.5250 ^{cdef}	193.073 ^{abc}
F20	98.6781 ^{abcde}	0.34438 ^{abcdef}	0.9775 ^{abcde}	14.00 ^a	148.45 ^{fgh}
F21	98.5575 ^{bcde}	0.33750 ^{abcdef}	1.0725 ^{abcde}	13.575 ^{bcdef}	193.163 ^{abc}
F22	98.6925 ^{abcde}	0.3575 ^{abc}	0.9500 ^{abcde}	13.4500 ^{def}	152.793 ^f
F23	98.5525 ^{bcde}	0.3675 ^a	1.0750 ^{abcde}	13.6250 ^{bcdef}	192.345 ^{abc}
F24	98.8075 ^{abc}	0.3425 ^{abcdef}	0.8500 ^{cde}	13.7000 ^{abcde}	144.045 ^h
ASE	98.7031 ^{abcde}	0.32188 ^{def}	0.9750 ^{abcde}	13.7250 ^{abcd}	197.966 ^a
AARC	98.65 ^{abcde}	0.33250 ^{bcdef}	1.0175 ^{abcde}	13.7250 ^{abcd}	151.565 ^{fg}
Mean	98.66	0.34	0.99	13.64	170.81
LSD (5%)	0.08	0.009	0.084	0.09	6.1
CV%	0.22	7.55	22.5	1.8	13.5
Formal	98.67	0.32	0.996	13.72	174.76
Informal	98.66	0.34	0.992	13.63	170.16
Tegegnech	98.62	0.34	1.03	13.66	192.78
Hassabe	98.70	0.34	0.95	13.64	148.85
Enarj E.	98.68	0.33	0.97	13.66	171.79
Yilmana D.	98.64	0.34	1.00	13.62	169.84

LSD (5%) values with the same letter in a column are not significantly different at $p \geq 0.05$. F1-F12=seed sample from farmer Enarj Enawuga, All odd numbers =Tegegnech, All even numbers= Hassabe, ASE=seed sample Tegegnech variety from Amhara Seed Enterprise, AARC=seed sample Hassabe variety from Adet Agricultural Research Center. F13-F24=seed sample from Yilmana Densa district.

4.8.3. Physiological Seed Quality

Standard germination

The overall average mean germination percentage was 84.27% with the range from 72.75% to 95.5%. The highest value was recorded for Tegegnech variety from seed sample F23 (95.5%) in Yilmana Densa district informal seed source and Amhara Seed Enterprise (94.5%) formal seed source. Seed samples of Tegegnech variety obtained from F19 (94.5%), F17 (92.75%), F13 (92.25%) from Yilmana Densa and F7 (92%) from Enarj Enawuga districts informal seed source showed better normal seedling percentage. Seed samples of Hassabe variety obtained from F12 (72.75%) in Enarj Enawuga district of the informal seed source showed lowest normal seedling percentage. The lowest abnormal seedlings were observed from seed samples F21 (0.00%) in Yilmana Densa and F11 (0.00%) Enarj Enawuga districts followed by F23 (1.00%) all of Tegegnech variety from Yilmana Densa district informal seed source and Amhara Seed Enterprise (1.00%) of formal seed source. The highest abnormal seedlings were observed from F12 (12.00%) followed by F2 (8.00%), F4 (8.25%) from Enarj Enawuga and F18 (7.75%), F22 (8.25%) from Yilmana Densa districts. All of which were from Hassabe variety of informal seed source. The dead seedlings showed lower from seed samples F13 (3.00%), F19 (2.5%) and F23 (3.5%) of Tegegnech variety from Yilmana Densa district informal seed source while the highest were from F18 (18.75%) of Hassabe variety from Yilmana Densa district informal seed source (Table 14).

Most of the seed samples except four (samples 2 and 12 of Hassabe variety in Enarj Enawuga while 18 and 22 of Hassabe variety from Yilmana Densa districts) from the informal seed sources had registered germination capacity above certified seed of EQSA (75%) (Table 14).

The mean separation showed observed difference in normal and abnormal seedlings between the seed sources and varieties but no observed difference in normal and abnormal seedlings and dead seeds between the districts. The dead seeds only showed difference between varieties (Table 14). The difference in production management, timely harvest and post-harvest activities are all important factors that would affect germination. Tegegnech variety has larger seed size with higher germination and vigour than Hassabe with lower seed size.

Large seed size having more food storages and utilized it at a faster rate to have greater rate of stem elongation and accumulation of root and shoot dry weight than small seed sizes. The result is in agreement with the studies of Peksen *et al.* (2004) in pea. Zewdie *et al.* (2012) and Melkamu (2015) also found that there were highly significant ($p \leq 0.001$) differences in germination between different seed sources of wheat and *teff* respectively.

Table 14. Mean value of Standard germination of samples collected from formal and informal seed source

Seed Samples	Standard Germination	Abnormal Seedlings	Dead Seedlings
F1	90.5 ^{abc}	2.00 ^{gh}	7.50 ^{hijk}
F2	74.25 ^{ij}	8.00 ^b	17.75 ^{ab}
F3	88.25 ^{bcde}	2.00 ^{gh}	9.75 ^{efghi}
F4	80.75 ^{fgh}	8.25 ^b	11.00 ^{defgh}
F5	88.5 ^{bcd}	2.5 ^{fgh}	9.00 ^{fghij}
F6	76.75 ^{hij}	7.00 ^{bc}	16.25 ^{abcd}
F7	92 ^{ab}	3.75 ^{ef}	4.25 ^{jk}
F8	79.25 ^{ghi}	6.75 ^{bc}	14.00 ^{abcdef}
F9	84.75 ^{def}	6.00 ^{cd}	9.25 ^{efghij}
F10	77.75 ^{hij}	6.75 ^{bc}	15.5 ^{abcd}
F11	85.5 ^{cdef}	0.00 ⁱ	14.50 ^{abcde}
F12	72.75 ^j	12.00 ^a	15.25 ^{abcd}
F13	92.25 ^{ab}	4.75 ^{de}	3.00 ^k
F14	76.75 ^{hij}	7.50 ^{bc}	15.75 ^{abcd}
F15	83.75 ^{defg}	3.25 ^{efg}	13.00 ^{bcdefg}
F16	76.5 ^{hij}	6.00 ^{cd}	17.5 ^{ab}
F17	92.75 ^{ab}	2.00 ^{gh}	5.25 ^{ijk}
F18	73.5 ^j	7.75 ^b	18.75 ^a
F19	94.25 ^a	3.25 ^{efg}	2.5 ^k
F20	80.5 ^{fgh}	6.75 ^{bc}	12.75 ^{bcdefgh}
F21	92.25 ^{ab}	0.00 ⁱ	7.75 ^{ghijk}
F22	74.75 ^{ij}	8.25 ^b	17.00 ^{abc}
F23	95.5 ^a	1.00 ^{hi}	3.5 ^k
F24	80.5 ^{fgh}	6.00 ^{cd}	13.5 ^{abcdef}

Table 14 (continued)

Seed Samples	Standard Germination	Abnormal Seedlings	Dead Seedlings
ASE	94.5 ^a	1.00 ^{hi}	4.5 ^{ijk}
AARC	83.25 ^{efg}	4.75 ^{de}	12.00 ^{cdefgh}
Mean	84.27	4.75	0.99
LSD (5%)	3.03	1.19	2.29
CV%	9.6	67	22.5
Formal	88.8	2.8	8.2
Informal	83.5	5.0	11.4
Tegegnech	90.6	2.3	7.0
Hassabe	77.8	7.1	14.9
Enarj E.	83.5	5.0	11.4
Yilmana D.	85.0	4.4	10.5

LSD (5%) values with the same letter in a column are not significantly different at $p \geq 0.05$. F1-F12 = seed sample from farmer Enarj Enawuga, All odd numbers = Tegegnech, All even numbers = Hassabe, ASE = seed sample Tegegnech variety from Amhara Seed Enterprise, AARC=seed sample Hassabe variety from Adet Agricultural Research Center. F13-F24 = seed sample from Yilmana Densa district.

Vigour tests

Highly significant differences of vigor indices were observed among treatments (Table 15). The difference genetic, environmental condition during seed development, seed size and density, mechanical damage, seed aging and deterioration observed between seed source, variety and location could affect vigour differences among treatments.

Speed of Germination

The average speed of germination was 25.34 (Table 15). The highest speed of germination F5 (28.41) of Tegegnech variety from while the lowest were from F4 (22.58) of Hassabe variety both from Enarj Enawuga informal seed source. The mean separation test has showed speed of germination was the same for formal and informal seed sources for both locations. There exist difference in speed of germination related to variety. The result is in agreement with Khaliliaqdam *et al.* (2013) and Girma *et al.* (2015) for soybean and barely, respectively. Both found difference speed of germination only for variety.

Root and Shoot Length

The highest and lowest shoot length was F6 (13.85) of Hassabe variety and F9 (11.62) cm Tegegneh variety both from Enarj Enawuga informal seed source, respectively and the root length was range from Ase (15.8) of Tgegneh variety representing the formal seed source to F22 (9.77) cm of Hassabe variety from Yilmana Densa district informal seed source (Table 15). It is assumed that seedlings with well-developed shoot and root systems would withstand any adverse conditions and provide better seedling emergence (Zewdie, 2004).

The mean separation showed observed difference among vigor indices (except for shoot length) between formal and informal seed sources and varieties but not between districts (Table 15). This could be due to the difference in pre and post-harvest management between seed sources and seed size between two varieties examined. Girma *et al.* (2015) found significant difference between varieties and seed sources for vigour one and speed of germination whereas Zewdie *et al.* (2012) and Melkamu (2015) found the difference only for root length and vigour index one between different seed sources. Previous research indicated that under less suitable weather conditions during seed development, seed vigour was affected to a larger extent by the cultivar than by the location (Chloupek *et al.*, 2003).

Table 15. Mean values of Vigour parameters of field pea collected samples from formal and informal seed source

Sample	SG	RL	SL	DW	VI	VII	EI	EP
F1	27.02 ^{abcd}	12.47 ^{efg}	12.09 ^{bcd}	1.08 ^{hij}	2219.9 ^{def}	0.977 ^{ghijklm}	3.06 ^{abcd}	84.00 ^{bcd}
F2	22.88 ^{gh}	13.10 ^{cdef}	12.93 ^{abcd}	1.18 ^{ghi}	1936.2 ^{ghijkl}	0.88 ^{ijklmn}	2.81 ^{gh}	80.5 ^{cdef}
F3	27.77 ^{abc}	14.17 ^{abcde}	13.57 ^{ab}	1.27 ^{defghi}	2445.4 ^{bc}	1.12 ^{fghij}	2.91 ^{defg}	79.50 ^{ef}
F4	22.58 ^h	14.00 ^{bcde}	12.22 ^{abcd}	1.33 ^{cdefgh}	2117.7 ^{efg}	1.08 ^{fghijk}	3.03 ^{bcd}	84.75 ^{ab}
F5	28.41 ^a	14.20 ^{abcde}	12.62 ^{abcd}	1.34 ^{cdefgh}	2372.0 ^{bcd}	1.18 ^{defgh}	3.17 ^{abc}	86.25 ^{ab}
F6	25.86 ^{abcdefg}	10.52 ^{hi}	13.85 ^a	1.04 ^{ij}	1867.6 ^{ijklm}	0.80 ^{lmn}	3.00 ^{cdef}	85.00 ^{ab}
F7	24.24 ^{defgh}	14.00 ^{bcde}	12.75 ^{abcd}	1.875 ^b	2461.3 ^b	1.72 ^b	2.80 ^{gh}	77.00 ^{fg}
F8	22.94 ^{fgh}	11.00 ^{ghi}	13.03 ^{abcd}	1.08 ^{hij}	1871.9 ^{ijklm}	0.859 ^{klmn}	3.03 ^{bcde}	83.50 ^{bcde}
F9	26.17 ^{abcdefg}	13.05 ^{def}	11.62 ^d	1.13 ^{hij}	2090.2 ^{efghi}	0.959 ^{hijklm}	2.88 ^{defg}	80.00 ^{edf}
F10	23.75 ^{defgh}	13.66 ^{bcde}	13.02 ^{abcd}	1.28 ^{defghi}	2074.2 ^{efghij}	1.00 ^{ghijklm}	2.61 ⁱ	71.75 ^h
F11	26.87 ^{abcd}	14.23 ^{abcd}	11.75 ^{cd}	1.61 ^{bc}	2224.1 ^{cde}	1.37 ^{cde}	3.04 ^{abcd}	84.5 ^{abc}
F12	22.46 ^h	13.10 ^{cdef}	12.87 ^{abcd}	1.30 ^{defghi}	1890.2 ^{hijklm}	0.94 ^{hijklm}	2.81 ^{gh}	77.25 ^{fg}
F13	26.36 ^{abcdef}	11.52 ^{fgh}	12.60 ^{abcd}	1.17 ^{ghij}	2227.1 ^{cde}	1.08 ^{ghijk}	2.91 ^{defg}	80.00 ^{def}

Table 15
(continued)

Sample	SG	RL	SL	DW	VI	VII	EI	EP
F14	23.10 ^{efgh}	13.57 ^{bcde}	11.67 ^d	1.20 ^{fghi}	1926.9 ^{ghijkl}	0.92 ^{ijklmn}	2.67 ^{hi}	74.25 ^{gh}
F15	24.60 ^{cdefgh}	13.03 ^{def}	12.10 ^{abcd}	1.24 ^{efghi}	2105.0 ^{efgh}	1.04 ^{ghijkl}	2.85 ^{efgh}	78.25 ^{fg}
F16	23.89 ^{defgh}	10.52 ^{hi}	11.92 ^{bcd}	1.07 ^{hij}	1715.0 ^{lm}	0.82 ^{lmn}	2.88 ^{defg}	80.00 ^{def}
F17	24.21 ^{defgh}	13.67 ^{bcde}	13.02 ^{abcd}	1.42 ^{cdefg}	2473.7 ^b	1.31 ^{cdef}	2.88 ^{defg}	80.00 ^{def}
F18	26.48 ^{abcde}	11.19 ^{ghi}	13.35 ^{abcd}	1.04 ^{ij}	1802.4 ^{klm}	0.767 ^{mnn}	3.17 ^{abc}	85.00 ^{ab}
F19	26.55 ^{abcde}	14.92 ^{ab}	12.09 ^{bcd}	1.53 ^{cd}	2544.2 ^b	1.44 ^c	2.83 ^{fgh}	77.75 ^{fg}
F20	24.67 ^{cdefgh}	11.37 ^{fghi}	11.72 ^d	1.05 ^{ij}	1866.0 ^{ijklm}	0.949 ^{klmn}	2.89 ^{defg}	79.50 ^{ef}
F21	25.10 ^{abcde fgh}	13.10 ^{cdef}	12.27 ^{abcd}	1.27 ^{defghi}	2360.2 ^{bcd}	1.16 ^{efghi}	2.89 ^{defg}	80.5 ^{cdef}
F22	27.02 ^{abcd}	9.77 ⁱ	12.60 ^{abcd}	0.90 ^j	1669.9 ^m	0.67 ⁿ	2.89 ^{defg}	79.50 ^{ef}
F23	26.73 ^{abcd}	14.82 ^{abc}	11.97 ^{bcd}	1.48 ^{cde}	2561.7 ^{ab}	1.426 ^{dc}	3.20 ^{ab}	86.75 ^{ab}
F24	24.94 ^{bcdefgh}	13.02 ^{def}	11.90 ^{bcd}	1.25 ^{efghi}	2002.0 ^{fghijk}	1.00 ^{ghijklm}	2.89 ^{defg}	79.50 ^{ef}
ASE	28.18 ^{ab}	15.8 ^a	13.48 ^{abc}	2.22 ^a	2768.3 ^a	2.099 ^a	3.22 ^a	88.75 ^a
AARC	24.32 ^{cdefgh}	13.73 ^{bcde}	12.68 ^{abcd}	1.46 ^{cdef}	2201.1 ^{efd}	1.215 ^{cdefg}	3.04 ^{abcd}	84.12 ^{bcd}
Mean	25.34	13.11	12.56	1.34	2170.12	114.5	81.45	2.95
LSD (5%)	1.07	0.71	0.47	0.13	125.22	14.69	1.85	0.07
CV%	11.3	14.5	10.12	27.16	15.4	34.2	6	6.65
Formal	26.25	14.76	13.08	1.84	2484.69	1.667	86.43	3.13
Informal	25.19	12.84	12.47	1.25	2117.69	1.059	80.62	2.92
Tegegnech	26.45	13.93	12.59	1.49	2401.52	1.358	82.28	2.99
Hassabe	24.23	12.30	12.52	1.19	1938.7	0.93	80.62	2.91
Enarj E.	25.39	13.04	12.72	1.38	2185.74	1.17	82.107	2.97
Yilmana D	25.29	12.83	12.4	1.29	2154.5	1.11	80.8	2.93

LSD (5%) values with the same letter in a column are not significantly different at $p \geq 0.05$.

SPG=Speed of germination; SL=Shoot length; RL=Root length; V1=Vigour index 1; VII =Vigour index 2; DW=Seedling dry weight; EI=Emergence Index; EP= Emergence Percentag. LSD values with the same letter in a column are not significantly different at $p \geq 0.05$. F1-F12=seed sample from farmer Enarj Enawuga, All odd numbers =Tegegnech, All even numbers= Hassabe, ASE=seed sample Tegegnech variety from Amhara Seed Enterprise, AARC=seed sample Hassabe variety from Adet Agricultural Research Center. F13-F24=seed sample from Yilmana Densa district.

Field Emergence

The mean field emergence percentage of collected sample was 81.45% and it ranges from the highest ASE (88.75%) of Tegegnech variety to the lowest F10 (71.75%) of Hassabe variety from Enarj Enawuga district informal seed source. The seed samples F4 (84.75%), F6 (85.00%) from Enarj Enawuga and F18 (85.00%) from Yilmana Densa district of Hassabe variety as well as F5 (86.25%) from Enarj Enawuga and F23 (86.75%) from Yilama Densa district of Tegegnech variety informal seed source also showed higher field emergence percentage.

The time and rate of seedling emergence are affected by an array of interacting factors including genetic constitution, seed dormancy, seed vigor, depth of planting, soil impedance and aeration, temperature and water supply (Forcella *et al.*, 2000; Samarah and Al-Kofahi, 2008). Although many seeds germinate satisfactorily under ideal laboratory conditions, they may fail to emerge successfully in the field (Kulik and Yaklich, 1982; Wang *et al.*, 2004)

Simple correlation between germination and vigour tests with field emergence were done (Table 16). Standard germination showed an intermediate and non-significant correlation ($r=0.25$) with field emergence. The result showed that the standard germination test was not a good indicator for field emergence. Aliloo and Shokati (2011) had also found no significant correlation between the standard seed germination and the field emergence. Melkamu (2015) however found that a positive and highly significant correlation between germination and seedling emergence of *teff* seed.

Speed of germination is the only vigour test that showed intermediate significant correlation ($r=0.47$) with field emergence. The speed of germination was better to predict field emergence of the seed lot than the standard germination. Speed of germination measures the rate at which the seeds germinate and where those seedlings with the higher index were expected to show rapid germination and seedling emergence and escape adverse field conditions. Speed of germination is an important measure of vigor. It depends on the time taken to reach 50% germination at constant temperature. Seeds with low vigor take longer time to germinate.

Many researchers have examined speed of germination (Maguire, 1962; Kulik and Yaklich, 1982; Wang *et al.*, 2004) and had found a significant correlation with field seed emergence.

Table 16. Simple Pearson correlation coefficients between physiological quality and seedling emergence of field pea sample from formal and informal seed source

	SPG	RL	SL	DW	VI	VII	EP
Standard Germination	0.51 ^{**}	0.51 ^{**}	-0.09 ^{ns}	0.59 ^{**}	0.91 ^{**}	0.76 ^{**}	0.25 ^{ns}
Speed of Germination	1	0.16 ^{ns}	0.11 ^{ns}	0.20 ^{ns}	0.45 [*]	0.32 ^{ns}	0.47 [*]
Root length		1	-0.06 ^{ns}	0.79 ^{**}	0.82 ^{**}	0.78 ^{**}	0.08 ^{ns}
Shoot length			1	0.13 ^{ns}	0.09 ^{ns}	0.08 ^{ns}	0.20 ^{ns}
Seedling dry weight				1	0.79 ^{**}	0.96 ^{**}	0.22 ^{ns}
Vigour Index I					1	0.88 ^{**}	0.25 ^{ns}
Vigour Index II						1	0.26 ^{ns}
Emergence percentage							1

*, ** significant at $p \leq 0.05$ and $p \leq 0.01$, respectively; SPG= Speed of germination; RL= Seedling root length; SL= Seedling shoot length; DW= Seedling dry weight; VI= Vigor index 1; VII= Vigor index 2; EP= Emergence percentage.

4.8.4. Seed Health Test

The seed health quality of field pea seed samples obtained from different sources was checked for the presence of seed-borne fungal pathogen. The fungi found associated with field pea seed were *Ascochyta pinodes*, *Phoma sp*, *Fusarium sp*, *Septoria pisi*, *Ascochyta pisi* and *Colletotrichum sp*. From the total field pea seed samples collected from informal and formal sources, 57.6% of the samples were infected with *Ascochyta pinodes*, 50% by *Phoma sp*, and 26.9% by *Fusarium sp*, 15.3% by *Septoria pisi*, 7.7% by *Aschochyta pisi* and 7.6% by *Colletotrichum sp*. (Table 17). The result is in agreement with Dereje and Sangchote (2008) who found that out of 94 field pea samples tested for seed health, 57.4% were infected with *Ascochyta* with infection levels as high as 23%.

Since the percentage of seed infection is higher than 0.2%, all the seed samples did not meet the national seed standard of maximum infection level for certified seed in Ethiopia. Dereje *et al.* (2011) found that pre-basic seed of Adi and Tegegnech varieties produced at HARC had

infection levels of 4.0% and 3.0%, respectively which are higher than the seed health standards in Ethiopia.

Table 17. The percent and frequency of infection by fungal species on field pea seed in Enarj Enawuga and Yilmana Densa districts

Pathogens	Source		Variety		Location		No. of samples Infected (%)
	Informal	Formal	Tegegnech	Hassabe	Enarj Enawuga	Yilmana Densa	
<i>Ascochyta pinodes</i>	2.3	0.8	3.4	0.9	1	3.24	57.6
<i>Phoma sp.</i>	0.67	1	0.7	0.69	0.97	0.42	50
<i>Fusarium sp.</i>	0.82	0	0.77	0.74	0.38	1.12	26.9
<i>Septoria pisi</i>	0.29	0	0.32	0.22	0.43	0.11	15.3
<i>Ascochyta pisi</i>	0.35	0	0	0.64	0.38	0.6	7.7
<i>Colletotrichum sp.</i>	0.49	0	0.91	0	0.24	0.66	7.6

5. SUMMARY AND CONCLUSIONS

Field pea can play an important role for household food security and sustainable farming systems. Availability of quality seed of improved field pea varieties at sufficient quantity is one of the major constraints to increase productivity. This study was conducted to quantify the relative importance of formal and informal seed system and to assess the seed quality of field pea seed grown in Enarj Enawuga and Yilmana Densa districts during the 2016/2017 cropping season.

Multi stage purposive and random samplings were employed to select a total of 200 farmers from six kebeles and interviewed using pretested structured questionnaire. Two varieties of field pea were collected from both formal and informal seed sources and were laid out in complete randomized design (CRD) with four replication in laboratory and seedling emergence tests in green house.

In Yimala Densa district, majority of the respondents were read and write, aged, plow their field pea land one time, no weeding practice, low seed storage protection measure and males were responsible for seed selection while in Enarje Enawuga district, most of them were adult education, young, plow their field pea land two times, one time weeding practice, better seed storage protection and females were more responsible for seed selection.

About 3.45 % of field pea area is covered by improved field pea varieties in both Enarj Enawuga and Yilmana Densa districts during 2016/17 cropping season. The study revealed that the adoption of improved field pea variety was very low. Low adoption of improved varieties could be related to ineffective seed extension and popularization. Inadequate sowing methods, low seed rates and poor weeding practices were contributed to lower field pea productivity in both districts.

The two improved field pea varieties namely, Tegegnech, and Hassabe were grown in the study districts. Farmers had originally obtained seed of these varieties from AARC and Bahir Dar University through pre scaling up program under watershed project in two districts.

Farmers in both districts were preferred in new field pea varieties for having such as large seed size, high grain yield, early maturity, disease and insect tolerant and creamy seed color. The majority of the respondents grew field pea in mixture with faba bean to avoid lodging. Addressing the problems of smallholder farmers has greater impact on field pea varieties uptake and increase productivity of the crop in the study area.

To date, there are 35 improved field pea varieties released by the regional and federal agricultural research institutes but many improved field pea varieties were not known by the farmers and the regional seed production was limited to only one variety (Tegegnech). In both study areas few farmers still use the two improved field pea varieties that are more than 20 years old after release by National Variety Release Committee. This indicates that there was a limited linkage among seed value chain actors in the Amhara Region.

The existing seed system of field pea in both districts is dominated by the informal seed system and a very limited supply of seeds of field pea was available from limited activity of the formal seed system. The continuous use seeds of farmers cultivars from the informal seed system may be one of the reasons for low production and productivity of field pea in both districts. Low efficiency of the current field pea formal system and due to poor support to strengthening the in formal seed system was one of the major reasons that most of the farmers in both districts to produce the crop from farm saved seeds of farmers cultivars.

The seed quality and seed emergence test indicated the presence of observed difference among seed samples of two varieties (Tegegnech and Hassabe) obtained from formal and informal seed system in the two districts (Enarj Enawuga and Yilmana Densa). The seed samples collected farmers also exhibited in seed quality test results as equal to the seed samples from formal seed system for same parameters and even better than seed sample from formal for some quality parameters. This may be due to farmers seed management practices (seed selection, cleaning and separate storage) enabled them to keep varieties seed quality comparable with the national standard. Most farmers who save seed, however select seed at harvesting, threshing, and/or planting time. Farmers stored seed separately from grain either

in sacks or in *gotta/gottera*, and the majority of farmers cleaned seed before planting to improve seed quality. However none of the seed samples from different sources met the seed health standards of EQSA. It could be concluded that high quality field pea seed could be produced under farmers' condition by adopting better management practices.

Generally, there is a potential for expanding field pea production in the two districts due to the favourable agro ecology and interest of farmers to produce the crop. If this potential can be linked with the existing increased demand for export and domestic consumption of field pea in a fertile ground to increase the yield and productivity of the crop. The main challenge was the lack of an effective seed system capable of producing and supply certified seed of field pea to improve varieties of the required amount.

The farmers in the study districts experienced some good practices to keep the field pea seed quality to the national standard for the crop. This could be strengthened through good agricultural extension service to become as a source of quality seed supply. Therefore, based on results of the current research it could be possible to forward the following recommendation:

- 1) The improved field pea varieties need to be demonstrated and promoted by the respective responsible government and non government organization to improve the adoption of varieties in both districts.
- 2) Extension should play a crucial role in training farmers in on-farm quality seeds of the field pea crop production and is therefore a prerequisite for the improvement of the informal seed system in both districts and a special focus also needed for Yilmana Densa district.
- 3) National and regional policy should promote integrated field pea seed system through participation of effective community seed production and marketing in both districts.
- 4) Strengthen coordination between stakeholders in the seed value chain specially the regional research centers with regional public (ASE) and private seed producers.

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7. APPENDIX

Appendix Table 1. Area and production of field pea in Enarj Enawuga from 2008/09-2016/17

Area (ha)									
Crop	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Teff	10136	14036	12328	11662	12458	12911	11284	9546	13187
Wheat	11903	13510	11379	8877	8416	10961	10519	10227	11021
Barely	4053	5188	4071	5687	5623	5423	5514	5409	6380
Sorghum	2135	286	4628	4567	3001	1995	2136	1060	3887
Faba bean	3198	2027	2846	3774	4713	5336	6081	5669	4115
Field pea	2522	1002	2188	1938	2194	2162	1450	899	1073
Chick pea	1120	1530	782	683	1112	489	322	1784	184
Grass pea	700	1943	938	1019	1206	325	299	1049	19

Production (tons)

Crop	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Teff	181532	270293	220565	204223	265443	263471	289867	126207	370939
Wheat	333284	565445	356244	203435	243191	343585	358102	396256	414894
Barely	72954	119818	83987	107879	90811	130540	151480	129952	216740
Sorghum	79184	9152	157069	131141	77516	45760	49649	8040	77740
Faba bean	52447	49776	40049	56974	93027	137391	153590	24788	88090
Field pea	38173	19134	36061	26222	33568	35399	25858	11820	12756
chick pea	22400	35190	18457	13660	22240	9959	5635	18252	4600
Grass pea	15400	48625	23263	23437	26521	6592	6578	13536	475

Source: EEDOA(2016)

Appendix Table 2. Area and production of field pea in Yilmana Densa district from 2005/06-2016/17

Area (ha)

Crop	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2013/14	2014/15	2015/16	2016/17
Teff	18136	14411	16339	15910	15313	15471	15500	12911	15500	9546	13187
Wheat	1596	3690	3287	3890	3909	3178	3603	10961	3600	10227	11021
Barely	5420	5977	6295	4053	6600	5935	6470	5423	5328	5409	6380
Maize	11256	12189	13273	11942	12755	13259	13548	612	13701	1930	2294
Faba bean	2803	1923	1601	2020	2054	2060	2600	5336	1791	5669	4115
Field pea	300	620	610	821	927	577	703	2162	188	899	284
chick pea	818	509	326	352	2731	810	2145	489	2587	1784	184
Haricot bean	415	300	394	688	424	1256	1223	1096	3285	631	2237
Potato	985	4070	5299	1607	4663	4745	4329	3200	4590	3776	3537

Production (tons)

Crop	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2013/14	2014/15	2015/16	2016/17
Teff	5307.34	3076.21	2965.02	3782.89	4208.04	4813.55	4294.36	2634.71	3930.91	1262.07	392445
Wheat	707.52	1051.27	783.39	1050.94	1090.92	1201.5	1270.95	3435.85	941.66	3962.56	324458
Barely	1522.8	1426.24	1373.75	729.54	1902.41	216389	2185.4	1305.4	1669.35	1299.52	196440
Maize	6613.32	5368.08	5797.83	6022.1	5393.62	10368.9	9865.24	225.59	9174.85	752.55	153331
Faba bean	623.55	346.14	320.18	444.4	534.04	489.53	716	1373.91	303.48	247.88	61725
Field pea	36	99.2	61	114.94	88.23	96.84	119.04	353.99	28.2	118.2	4260
Chick pea	155.46	81.44	147.65	66.82	546.34	162	402.4	99.59	517.44	182.52	2208
Haricot bean	66.4	39.24	34.9	94.48	81.64	188.51	289.12	244.8	384.72	1570	75856.7
Potato	1975.5	81.4	10599	2011.5	8827.85	13789.8	13972.7	3065.41	15671.4	487335	12076.4

Source: YDDOA (2016)

Appendix Table 3. List of field pea varieties released by the national and regional research centres

Name of Variety	Year of Release	Breeder/Maintainer
FP DZ	1979	HARC/EIAR
Mohanderfer	1979	HARC/EIAR
G22763-2c	1981	HARC/EIAR
NC-95 Haik	1981	HARC/EIAR
Tegegnech	1993/94	HARC/ EIAR
Tulu (PGRC/E32 21-181)	1994/95	SARC/OARI
Dadimos	1994/95	SARC/OARI
Markos	1994/95	HARC/EIAR
Milky	1995/96	HARC/EIAR
Hassabe	1995	HARC/EIAR
Adi	1995/96	HARC/EIAR
Holetta	1995/96	HARC/EIAR
Sefinesh	1997	ADARC/ARARI
Adet 1	1997	ADARC/ARARI
Hursa (KFP-103/B/)	1997	SARC/OARI
Wolmera	1999/00	HARC/EIAR
Tullu-dimtu	1999/00	SARC/OARI
Weyitu (EH 90-006-2)	1999/00	SARC/OARI
Arjo-1(EH 90025-1)	2005	BARC/OARI
Bariso (EH 90011-1-2)	2005	BARC/OARI
Bamo (Flagman)	2005	BARC/OARI
Gume (EH96026-1-4)	2006	HARC/EIAR
Megeri (Helina)	2006	HARC/EIAR
UrjiI (Acc. 32615-1)	2007	SARC/OARI
Ambericho (IG-51664)	2008	SRARI/ArARC
Meti (NI-21)	2008	HU
Agrit (IFP 308-4)	2009	SRARC/ARARI
Senk (GFP 233)	2009	SRARC/ARARI
Burkitu(EH99004-2)	2009	HARC/EIAR
Latu (EH02-036-2)	2010	KARC/EIAR
Gedo-1(EH99002-1)	2010	BARC/OARI
Teshale (EH99005-7)	2012	AARC/EIAR
Haranna (Cool 38/00-4)	2012	SARC/OARIC
Bilalo (EH 02-002-3)	2012	KARC/EIAR
Bursa (EH05027-2)	2015	KARC/EIAR

Source: MoANR (2016)

Appendix Table 4. Minimum requirements for field pea seed certification

Characteristics	Breeder/ pre basic seed A	Basic Seed	Certified Seed C1	Certified Seed C2	Certified Seed C3	Certified Seed C4	Commercial /Emergency class	Method of test
Field standard								
Rotation (min, year)	2	2	1	1	1	1	-	-
Isolation (min, meters)	10	5	3	3	3	3	-	-
Off types & other cultivar (max %)	0.2	0.2	0.5	0.5	0.5	0.8		
Laboratory standard								
Pure seed (min %)	99	98	97	96	95	93		ES 472
Other crop seed (max %)	N.s	0.1	0.2	0.2	0.4	0.4		ES 473
Weed seed (max %)	N.s	0.1	0.2	0.2	0.4	0.4		ES 472
Infected /infested/ seeds (max %)	N.S	0.05	0.2	0.2	0.2	0.2	0.4	ES 476
Inert matter (max %)	N.S	1	1	2	2	2		ES 472
Germination (min %)	85	80	75	75	75	75	75	ES 474
Moisture content (max %)	12	12	12	12	12	12	12	ES 478

N.S = Not specified

Source; ESA (Quality and Standards Authority of Ethiopia), Second edition, 2012

Appendix Table 5. Mean square of result of physical purity, thousand seed weight and moisture content on the field pea seed sample

Source of variation	DF	Mean square				
		Pure seed	Other crop seed	Inert mater	TSW	MC
Treatment	25	1.02**	0.245**	0.441**	2293.36**	4.553**
Error	75	0.15	0.07	0.08	19.72	0.14

*= Significant at ($P \leq 0.05$), **= highly significant ($P \leq 0.01$).

Appendix Table 6. Mean square of Physiological seed quality test and Seedling Emergence Evaluation

Source of variation	DF	Mean square										
		NS	ABS	DS	SL	RL	SDW	GR	VI	VII	EP	EI
Treatment	25	238.78**	39.44**	111.34**	3.13**	10.57**	0.44**	14.2**	489718.6**	5530.41**	73.73**	0.10**
Error	75	13.3	1.46	15.15	0.024	1.59	0.00002	0.0094	27741.5	0.131		0.01

*= Significant at ($P \leq 0.05$), **= highly significant ($P \leq 0.01$), ns =Non-significant ($P \geq 0.05$). Treatments means field pea seed samples. VI= Vigour index I, VII=Vigour index II, EP= Emergence percentage, EI= Emergence Index

FIELD PEA SEED SYSTEMS STUDY
 FORMAL SURVEY OF FARM HOUSEHOLDS
 IN ENARJ ENAWUGA AND YILMANA DENSA DISTRICTS, WEST AMHARA
 REGION, ETHIOPIA

Information and Objectives

The objectives of this questionnaire is to collect information on seed system and seed source and farmers' perception on seed quality and seed management practices of field pea in Enarj Enawuga and Yilmana Densa Districts, West Amhara Region, Ethiopia. The information you provide in this questionnaire will be kept confidential and will solely be used for scientific purposes

PART ONE: IDENTIFICATION

- 1.1. Zone: _____
 1.2. Woreda: _____
 1.3. Kebele: _____
 1.4. Date: _____
 1.5. Farmer name: _____
 1.6. Serial number: _____

PART TWO: FARMER CHARACTERISTICS

- 2.1. Sex of respondent: -
 Male-----1
 Female-----2
- 2.2. Household type:
 Male headed household -----1
 Female headed absent husband ---2
 Female headed no husband-----3
 Single male with children-----4
 Single male not married-----5
 Male headed divorced-----6
 Other (specify) -----7
- 2.3. Education of respondent:-
 Illiterate ----- 1
 Read and write ----- 2
 Adult education -----3
 Some primary (1-4) -----4
 Completed primary (5-8).....5

- Some secondary (9-12) ----- 6
 Completed secondary ----- 7
 Post - Secondary ----- 8

2.4. How many years have you been producing field pea on your own?

- < 10 years.....1
 10-20 years.....2
 21-30 years.....3
 >30 years.....4

2.5. Age of respondent: _____years old

PART THREE: VARIETEIS GROWN

3.1. Do you usually grow field pea?

Yes-----1

No-----2

3.3. Have you used certified improved varieties? Yes (1) ----- No ---- (2)

3.4. If yes, what criteria have you used for adopting the certified improved varieties?

Criteria for selection/Famers' Varieties adopted and grown in the area
 perception (✓)

seed yield

seed size

seed color

Marketability

Early maturity

Uniform maturity

Pest tolerance

Disease tolerance

Drought tolerance

Low soil fertility tolerance

Others (specify)

PART FOUR: SEED SOURCES

4.1. What was your initial source of seed of field pea initial source?

BoA1

Research Centre.....2

Trader.....3

Gift from parents.....4

Purchase from farmer.....5

Purchase from traders.....6

Loan from farmer.....	7
Gift from parents.....	8
Others (specify).....	9

4.2. What was your source of seed for field pea in 2016? (Use counter method to indicate proportion and farmers must use 50 seeds.)

BoA	1
Research center/NGOs.....	2
Trader.....	3
Own stock.....	4
Purchase from farmer.....	5
Loan from farmer.....	6
Gift from farmers.....	7
Gift from parents.....	8
Others (specify).....	9

4.3. What was your original source of field pea growing currently?

BoA.....	1
Research centre/NGOs.....	2
Trader.....	3
Own stock.....	4
Purchase from farmer.....	5
Own stock and farmers.....	6
Own stock and BoA.....	7
Loan from farmer.....	8
Gift from farmers.....	9
Gift from parents.....	10
Others (specify).....	11

4.4. Do you use improved certified seed? Yes---- (1) No---- (2)

4.5. If yes, how often do you use certified seed?

Every year-----	1
Every other year-----	2
Rarely (every three or more years) -	3
Never -----	4
Other (specify) -----	5

4.6. If you use certified field pea seed, reasons for using improved certified field pea seed?

Replace old variety.....	1
Replace old seed.....	2
Better seed quality.....	3
No own seed.....	4
Others.....	5

PART FIVE: AGRONOMIC PACKAGES

5.1. Are you provided appropriate agronomic packages for certified improved variety? 1. Yes
2. No

5.2. If yes, where do you get/who gave you the information?

Source of information	Improved variety (✓)	Agronomy (✓)	Fertilizers (✓)	Herbicides (✓)	Pesticides (✓)	seed storage (✓)
BoA						
Research center						
Media(TV Radio)						
NGO						
Relatives/friends						
Neighbors						
Other farmers						
Traders						

5.3. Land preparation, seed rate and sowing

5.3.1. How many times do you plough for field pea seed production? One times (1), two times (2), three times (3), Four times (4)

5.3.2. Time of sowing (planting) -----

5.3.3. Method of planting (1) Row (2) Broadcast

5.3.4 Seed rate Kg/ha= -----

5.4. Farmers' perception on soil fertility of their land of field pea?

Good (1) Medium (2) Poor (3). I do not know (4).

5.4.1. If soil fertility is low, do you apply fertilizer Yes (1). No (2)

5.4.2.. If yes, what type of fertilizer do you use for field pea production?

(1) Animal manure (2) Compost (3) Urea(4)DAP (5) DAP and Urea

5.4.3.. If you use Urea and/or DAP, what is the rate kg/ha for Urea= -----
for DAP= -----

5.5. Weed control

5.5.1. When is the first Weeding done?

5.5.2. How many times do you weed? = ----- at what growth stage?

5.5.3. Do you apply herbicides? Yes (1) ----- No----- (2)

5.5.3.1. If yes, what type? _____ at what rate liter/ha?

5.5.3.2. When do you apply herbicides on field pea fields?

PART SIX: SEED MANAGEMENT AND PROTECTION

6.1. In your household who sorts grain from seed?

Female farmer only-----1

Male farmer only-----2

Both male and female farmer---3

All household members-----4

Does not sort-----5

Casual laborers-----6

If any other (specify) -----7

6.2. When do you sort the field pea seed you intend to plant?

At physiological maturity before harvesting....1

During harvesting and threshing2

Just after threshing-----3

Just before planting-----4

Does not sort-----5

If any other (specify) -----6

6.3. Do you replace seeds of the same/different field pea variety (ies)?

Yes-----1

No-----2

If yes,

6.4. Which field pea variety have you replaced?

1. _____ by _____

2. _____ by _____

3. _____ by _____

6.5. Why you replaced the field pea (intra and inter-varietal replacement)?

Susceptibility to disease.....1

Lodging.....2

Moisture stress.....3

Low yielding capacity.....4

Others (Specify).....5

6.6. According to your view, what are the five most important characteristics of a good crop seed (for field pea)?

1. _____

2. _____

3. _____

4. _____

5. _____

6.7. After harvesting in each season before and in 2014 and 2016, how much field pea did you put into storage for seed purpose?

Years						
	Type of variety	Amount stored in kg/q	Type of variety	Amount stored in kg/q	Type of variety	Amount stored in kg/q
2014						
2015						

6.8. Where do you store seed of field pea? Where do you store grain of field pea?

Storage methods	Seed	Grain	Remark
With sacks in the house			
With Sacks own separate store			
Cooperative store			
Trader's store (rent)			
Relatives and friends store			
Others (specify)			

6.9. What measures do you take to protect seed of field pea from storage pests? What measures do you take to protect grain of field pea from storage pests?

Protection measures	Seed	Grain
No measures taken		
Chemicals		
Cultural methods		
Cultural and chemical		
Sunning		
Others (specify)		

6.10. Seed Cleaning

6.10.1. How do you clean your field pea seed?

- Hand shaking-----1
- Winnowing2
- hand3
- Sieving.....4
- Small seed cleaner.....5
- Pay to get the service.....6
- Do not clean.....7

6.10.2. Reasons for cleaning field pea seed

Improve quality/remove inert matter-----	1
Remove weeds/other crops -----	2
Remove small/broken damaged seed-----	3
Reduce seed rates-----	4
Remove insect damaged/diseased seeds---	5

PART SEVEN: VARIETAL MIXTURE (CROP/ VARIETAL MIXTURES)

7.1. Do farmers plant crop/variatal mixtures intentionally? Separate

Yes.....1

NO.....2

If Yes,

7.2. What are the reasons for using crop/ variatal mixtures?

1. Avoid lodging of field pea
2. Best food quality
3. Shattering
4. Yield
6. Disease

7.3. What are the major components of the crop variatal mixtures?

Component type	Crop mixture	Variety Mixture

PART EIGHT. FARMERS BREEDING (SEED SELECTION AND MAINTENANCE)

8.1. Do farmers practice varietal/ seed selection? Yes---- (1) ----- No (2)

8.2. If yes, what are farmer's variety selection criteria?

Please mark (✓) the selection criteria indicated below if cited by the farmers

Please mark (X) the selection criteria indicated below if not cited by the farmers

Criteria used for selection	Please mark (✓) or Please mark (X)
Early maturity	
Uniform maturity	
Seed yield	
Low soil fertility tolerance	
Disease tolerance	
Seed size	
Seed color	
Marketability	
Drought tolerance	
Resistance to shattering	
Others	

8.3. Do farmers exercise specific selection methods? Yes --- (1)No ----- (2)

8.4. If yes, breeding methods are:

Pure line selection.....1

Mass selection.....2

Bulk selection -----3

If any others (specify) -----4

8.5. Selection for /at what?

Select field or section of field.....1

Select plants.....2

Select pods with in a plant.....3

If any others (specify) -----4

8.6. Stage of selection

- Pre harvesting.....1
- At harvesting.....2
- At threshing.....3
- Storage.....4

PART NINE: SEED SECURITY

9.1. Are you seed secured yes ---- (1) No ---- (2)

9.2. If No, how often are you unsecured?(Frequency of seed insecurity)

- Every year (always) (1)
- Every other year..... (2)
- Rarely (>3 year)..... (3)

9.3. Reasons for seed insecurity?

- Human consumption.....1
- proper credit service for buying seed.....2
- Disease.....3
- Drought.....4
- Hailstorm.....5
- Un availability of seed6
- Total.....7

9.4. What do you suggest to reduce seed insecurity?

- Proper agronomic and pest management1
- Seed aid2
- Credit services for buying seed.....3
- Change varieties.....4
- Seed availability5
- Separation of seed from grain6

Interviewers'**comment:**

CHECKLISTS FOR COLLECTING DATA FROM EXTENSION AGENTS AND KEY INFORMANTS

Do you provide extension service on field pea production in in Enarj Enawuga /Yilmana Densa woredas? 1. Yes 2. No

1.1. If yes, what are the services?

1.2. If no, what are the reasons?

Where do the farmers in the Woredas get improved field pea seeds?

Which improved varieties farmers are provided with?

What the reasons for selecting the improved varieties?

What do you think are farmers' reasons for adopting improved field pea varieties?

Are there any dis adoptions of improved field pea varieties? 1. Yes 2. No

Which seed source do you think the farmers prefer most? Why?

Do you think farmers have access to QUALITY SEED? 1. Yes 2. NO

If no, what are the reasons for lack of access to quality seed?

Since the distribution of improved field pea varieties, are farmers Seed Secured? 1. Yes 2. No

If No, what are the reasons for seed insecurity?

Do you provide improved seed management trainings to field pea growers? 1. Yes 2.

No _____

If yes, what are the contents of the training?

If No, what are the reasons?

Do you supply information to field pea growers on time? 1. Yes 2. No

Do you know what contractual seed production is? 1. Yes 2. No

What are the challenges and opportunities of contractual seed production (farmer based seed production or community based seed production)?

Challenges: _____

Opportunities: _____

What are the services that you provide to field pea seed growers in particular and field pea producers in general?

Are there any problems that you feel important in production and distribution of improved field pea varieties?

20. What are the major challenges of field pea production in the Wereda?

20. Would you please give your general comments on field seed production and distribution?

CHECKLISTS FOR COLLECTING DATA FROM FORMAL SEED SYSTEM

1. Do you involve in field pea varietal improvement and seed production? 1. Yes 2. No. If yes, on what type of varieties?

2. Is there any demand of field pea seed for production to your organization? 1. Yes 2. No

3.1 If yes, who & how is seed demand forecasted and collected?

4. Who is buying your field pea seeds? _____

5. Do you directly sell your field pea seeds to farmers ONLY? 1. Yes 2. No

5.1 If No, who else is taking/buying the seeds?

6. What do you think are the factors for adoption of improved field pea varieties?

7. What are the challenges & opportunities of small scale seed multiplication of field pea varieties by farmers?

Challenges _____

Opportunities _____

8. Are there any problems that you feel important in improvement, production and distribution improved field pea seed?

9. What are the major challenges of field pea production in the region?

10. Would you please give your general comments on field pea seed production and distribution?

CHECKLISTS ASKED TO THE GROUP DISCUSSION

1. What are the field pea varieties grown in your Wereda?
2. What parameters are considered during selection of seed from grain at field level?
3. What are the characteristics of good quality seed?
4. What is contractual seed production?
5. Do you participate in the contractual seed production (Participant & non-participant)? 1. Yes 2. No
6. If yes, what are the challenges & opportunities?
 - a. For participating farmers in CSP, what are the benefits from CSP? What are the benefit and risks?
from CSP?
 - b. What additional measures you have taken for CSP as compared with normal grain production?
 - c. If no, do you like to participate in the CSP? 1. Yes 2. No
 - d. If yes, why you would like to participate now?
6. What are the expectations, for CSP participating farmers, from Das/Extension agent?

Do they meet your expectations? 1. Yes 2. No. If no, why?

What do you suggest to solve these challenges?
7. What are the major challenges of field pea production in the Wereda?