EVALUATION OF FARMERS' SEED HANDLING PRACTICES AND EFFECTS OF SEED SOURCE AND STORAGE CONDITION ON QUALITY PARAMETERS OF SOYBEAN (*Glycine Max* (L) SEED IN EAST WOLLEGA, ETHIOPIA

MSc Thesis

Solomon Dafa Jigsa

August 2023

HARAMAYA UNIVERSITY

Evaluation of Farmers' Seed Handling Practices and Effects of Seed Source and Storage Condition on Quality Parameters Of Soybean (*Glycine max* (L) Seed in East Wollega, Ethiopia

A Thesis Submitted to the Department of Plant Sciences,

Postgraduate Programs Directorate, Haramaya University

In Partial Fulfillment for the Degree of

MASTER OF SCIENCE IN AGRICULTURE (SEED SCIENCE AND TECHNOLOGY)

Solomon Dafa

August 2023

Haramaya University

POSTGRADUATE PROGRAMS DIRECTORATE

HARAMAYA UNIVERSITY

As thesis research advisors, we hereby certify that we have read and evaluated the thesis under our guidance, which is entitled "Evaluation of Farmers' Handling Practices and Effects of Seed Source and Storage Condition on Quality Parameters of Soybean (*Glycine max* (L) Varieties in east Wollega, Ethiopia" prepared by Solomon Dafa. We recommend that the thesis be submitted as it fulfills the requirements.

Bulti Tesso (PhD) _________________ _______________

Major Advisor Signature Date

Chaluma Tujuba (MSc) __________________ ________________

Co-Advisor Signature Date

As members of the Board of Examiners of the open MSc thesis defense examination of Solomon Dafa, we certify that we have read and evaluated the thesis and examined the candidate. We recommend that the thesis be accepted as it fulfills the requirement for the degree of Master of Science in Agriculture (Seed Science and Technology).

______________________ ________________ _______________

Chairperson Signature Date

______________________ ________________ ________________

Internal examiner Signature Date

______________________ ________________ ________________

External examiner Signature Date

Final approval and acceptance of the thesis is contingent upon the submission of the final copy to the Council of Graduate Studies (CGS) through the candidate's School Graduate Committee (SGC).

DEDICATION

I dedicate this Thesis to my father Dafa Jigsa and my mother Biritu Ilike who encouraged me to attend my education from the very beginning in such inaccessible area even if they gone to their beloved God without attaining my success that they dream for me.

STATEMENT OF THE OUTHER

I declare and affirm that the thesis titled ''Evaluation of Farmers' Handling Practices, Seed source, and Storage Condition on the Quality parameters of Soybean (Glycine Max (L) Varieties in East Wollega Zone, Ethiopia'' is my own work. I have followed all ethical principles of scholarship in the preparation, data collection, data analysis and completion of this thesis. All scholarly matter that is included in the thesis has been given recognition through citation. I affirm that I have cited and referenced all sources used in this document. Every serious effort has been made to avoid any plagiarism in the preparation of this thesis.

This thesis is submitted in partial fulfillment of the requirement for degree from the Postgraduate Directorate at Haramaya University. The thesis is deposited in the University Library and is made available to borrowers under the rules of the library. I solemnly declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Brief quotations from this thesis may be used without special permission provided that accurate and complete acknowledgement of the source is made. Requests for permission for extended quotations from, or reproduction of, this thesis in whole or in chapter may be granted by the Head of the School or Department or the Dean of the Postgraduate Directorate when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author of the thesis.

Name: Solomon Dafa

Signature: ______________________

Date: _________________________________

School/Department:

BIOGRAPHICAL SCETCH

The author, Solomon Dafa, was born on January 23, 1975 in Tulu guracha kebele of Boji Cokorsa district West Wollega zone of Oromia Region from his father Mr Dafa Jigsa and his mother Mis. Biritu Ilike. He attended his Elementary education at Abo Manajarte School and Secondary School at Nekemte Comprehensive high School. After he completed the high school education he joined the Bako agricultural training center and attended the course given for development agents in 1994. After his graduation he worked at East Wollega Zone Guduru district and West Wollega Zone Boji dirmeji district as development agent and supervisor starting from 1994 to 2001. In 2001 he joined Alage Technical Vocational Education and Training College (ATVET) graduated with Diploma in 2005 and after one year on work he joined Hramaya University to attend his BSc study program in plant science under the summer program and graduated in 2010.After his graduation he worked at different agricultural office levels as expert of crop Agronomist, district agricultural office coordinator, agricultural extension expert, coffee quality expert, team leader of crop production and now working as at Oromia agricultural input regulatory authority Nekemte branch seed quality inspector. He joined the school of Graduate Studies at Haramaya University in November, 2021 to pursue a study leading to the Degree of Master of Science in agriculture (Seed Science and Technology).

ACKKNOWDLEGEMENTS

First of all, I would like to thank the Almighty God who gives me life, health, opportunity and strength to accomplish the work. Without his help this work was unthinkable.

Next I want to express my sincere thanks to my Major Advisor Bulti Tesso (PhD) and my Co-Advisor Chaluma Tujuba (MSc) for their unreserved and genuine technical supervision, advice and corrections throughout the whole period of drafting the research proposal to the course of doing the experiment and the thesis write up, without their genuine caring and frequent follow up, this work would never have been come to this end.

My thanks also go to Ethiopia-Netherlands seed partnership (ENSP) and Oromia Agricultural Input Regulatory Authority who sponsor my research expense and gave me the opportunity to attend my study

I would like to extend my deepest appreciation and thanks to my colleagues, for their encouragement, considerable assistance, consistent visit, care and love during the study period. I am very proud by being their batch. At last but not the least I am also very much grateful to my wife Meseret Negera with our children, my beloved sisters with their spouses for their assistance and encouragement during my study time.

LIST OF ABBREVATIONS AND ACCRONYMS

ARC	Agricultural Resource Center
ACWIP	Agricultural Input Certification with International program
CADU	Chilalo Agricultural Development Unit
CSA	Central Statistical Agency
ENI	Ethiopian Nutritional Institute
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistical Authority
FGD	0cal Group Discussion
GTP	Growth and Transformation
IAR	Institute of Agricultural Research
IITA	International Institute of Tropical Agriculture
ISTA	International Seed Testing Authority
MOA	Ministry of Agriculture
MOANR	Ministry of Agriculture and Natural Resource
NaOH	Sodium Hydroxide
NGO	None Governmental Organization
USDA	United States Development Agency

TABLE OF CONTENTS

Content **Page**

LIST OF TABLES

Content **Page**

LIST OF FIGURES

Content **Page**

LIST OF TABLES IN APPENDEX

Content **Page**

Evaluation of Farmers' Seed Handling Practices and Effects of Seed Source and Storage Condition on Quality Parameters of Soybean (*Glycine max* (L) Seed in East Wollega, Ethiopia

ABSTRACT

Soybean [Glycine max (L) Merrill] is one of the important legume crops produced in northwestern Ethiopia. The production of seeds of improved varieties from accredited sources and stored for the shortest possible duration are among the requirements of quality seed production. Shortage of such quality seeds is one of the production constraints in soybean. This study was conducted to assess farmers' seed handling practices and investigate the effects of seed source and storage duration on seed quality parameters of two soybean varieties. Household survey, field experiments, and laboratory tests conducted in East Wollega zone of Oromia region in 2022/23 main cropping season. The household survey data was collected from 90 Hhs were conducted in the selected districts. The field experiment consisted of three factors involving two varieties (Didhesa and Korme), three seed sources (Ano farm, Haro sabu, and farmer saved), and three storage durations (two month, six month, and one year) arranged in factorial combinations using randomized complete block design with three. Completely randomized design with four replications was used for laboratory analysis. The results from pre-sowing test revealed that seed quality parameters were significantly influenced by one or more main factors (variety, growing condition and storage period). In addition, moisture content, abnormal seedling, shoot length, root length and vigor index II were significantly influenced by the interactions of variety x seed source x storage period. Hundred seed weight was significantly influenced by interaction of variety x seed source. Germination percentage of seeds was significantly influenced by interaction of seed source x storage period, and variety x seed source; whereas speed of germination was significantly influenced by interaction of variety x storage duration and seed source x storage period. At field condition, interaction of variety x seed source had significant effect on days to physiological maturity and number of pods per plant; whereas interaction of variety and storage period had significant influence on seed yield. The growing of Didhesa variety from seed source of Haro sabu stored for six month produced higher seed yield of 11.38Qt/ha, while growing of korme variety from farm saved seed stored for one year produced significantly lower seed yield (6.3Qt/ha).The results from the two experiments showed that variety, storage duration, seed source, and interaction of the two and/or three factors had significant effects on seed yield, yield related traits, and seed quality parameters of soybean. Thus it is suggested to consider varieties; seed source and seed storage duration to produce high yield and quality seeds to improve the productivity of soybean.

Keywords: Growing condition, Pre-sowing test, Seed quality parameters, Storage perio

1. INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a legume crop and taxonomically belongs to the family *leguminaceae*, sub family *papilionaceae,* tribe *phaseolae*, Genus Glycine and subgenus soja (Lackey *et al.,* 1977). The wild (*G. soja*) and cultivated (*G. max*) annual species are grouped under the subgenus soja. However, the chromosome number of the cultivated soybean species is a diploidized tetraploid (2n=2x=40). The cultivated species, *Glycine max* (L.) has never been found in the wild; therefore its probable ancestor is *G. soja* which is the major gene source (Hymowitz *et al.,* 1970). Soybean is considered either a short or a day neutral plant that requires 25-30^{o}c temperature for growth and proper nodulation. Soybean is a medium altitude crop well adapted to altitudes varying from 1300 to 1800 m.a.sl receiving annual rainfall of 900 to 1300 mm and it is also well adapted at 1900 m.a.s.l having 550 to 700 mm annual rainfall (Amare *et al.,* 1987). The crop has a wide range of soil adaptation, but performs well on light textured, loams and medium black clays with a pH range of 6.5 to 7 in Ethiopia (IAR, 1982).

In 2021, about 352.74 million metric tons of soybeans were produced in the world. The major producers are Brazil: 149,000,000, The United States of America: 122,606,000, and Argentina: 51,000,000 metric tons, respectively (USDA, 2021).

The economic viability of soybean is determined by commercial utilization of both sub products; oil, and meal, which accounts for one and two third of the crop's economic value, respectively. Soybean oil is dominant in the world market, accounts about 30% of the total vegetable oils. In global market, its oil share is estimated nearly 44%, and ranked first among the major oil crops such as rapeseed, groundnut, and sesame (Chung and Singh, 2008). Moreover, on the weight basis, soybean protein yield is about two, four, and twelve times more than that of the meat, eggs, and milk, respectively (Anon *et al*., 1984). The nutritional value of soybean primarily lies in its quality protein and oil content which is free of cholesterol (Antalina.*et al.,* 1999). The crop is a promising pulse proposed for alleviation of acute protein and oil shortage in the world. Soybean is also nutritious and healthy due to proportional composition of carbohydrate, fiber, vitamins and minerals (Carter and Wilson *et al.,* 1998).

In spite of the fact that soybean is a recent introduction in Ethiopia, the records obtained for the period 2008 through 2016 indicate that area, production and yield of soybean have shown an increasing rate per annum and reached 83,797 ha of land to produce 2,086,763.89 quintal of soybean with national average yield of 24.9 qt/ha CSA, 2020/21.

Since the crop is well adapted from the lowlands to the mid altitude agro-ecologies of the country where the vast majority of the potential arable land is found, including Western, South western, Southern, and North-western parts, there is a huge potential to increase the production of the crop in Ethiopia. The entire low to mid altitude maize belt areas of the country are also appropriate for soybean production. In addition, Ethiopia's strategic location closer to the world's largest consumers of soybean and soybean products is also a feature which makes it a great open door for the nation to target soybean as potential export commodity and import substitution (Birhanu *et al*., 2018).

However, although soybean breeding and production have been going on in Ethiopia since the 1950's, it was not widely disseminated and produced across the different potential areas of the country. The maize belt west Oromia areas such east Wollega zone is among the potential areas for expanding production of the crop. However, the use of low quality seeds due to poor farmers' handling practices, unreliable seed sources, and sub-optimal storage conditions of the seeds are the major constraints for increasing productivity of the crop in the area. The other limitations are limited knowledge of the farmers on the use of soybean in cropping systems, weak linkage between research, producers, processors, exporters and consumers.

Faster germination and emergence is an important factor for better and uniform crop stand establishment. The poor crop emergence and establishment might happen due to unpredictable and erratic rain fall, low or inadequate soil nutrients, low quality seeds, low moisture content of the soil, disease and pest infestation at storage and field. Under such conditions, seed germinations, seedling emergence and establishment can be inhibited and reduced.

Seed quality is described in terms of various aspects such as physical, physiological, genetical, and seed health related parameters. While the genetic purity of the seed may vary depending on the class of seed used as well as seed source, the other seed quality parameters are highly influenced by environmental factors and management practices along the value chain from field to storage. Especially, the type of storage and conditions of soybean seed are important factors that affect the physical and physiological seed quality aspects as well as seed health related parameters. Therefore evaluation of farmers seed handling practices and investigating the effects of seed source and storage duration on the quality parameters of soybean is required before seed sowing to overcome such adverse environmental effects for better, more and uniform seed germination, seedling emergence establishment. However, such assessments (studies) have not been conducted in East Wollega zone. Therefore, this study was designed with the following objectives.

1. Assess farmers' production practices and handling of soybean seeds:
2. Determine seed quality of soybean varieties as influenced by seed sources and storage duration; and
3. Determine the effects of seed sources and storage duration on yield and seed quality of soybean varieties.

2. LITERATURE REVIEW

2.1 Origin and Distribution of Soybean

The soybean [*Glycine max* (*L*.) Merrill, family *Leguminosae*, subfamily *Papilionoidae*] was originated in Eastern Asia, probably in north and central China. It is believed that cultivated varieties were introduced into Korea and later into Japan some 2000 years ago. Soybeans have been grown as a food crop for thousands of years in China and other countries of East and South East Asia and are an important component of the traditional popular diet in these regions (Berk, *et al*., 1992).

Soybean is a grain legume that is very nutritious and contains on average 40% protein. It is gaining ground internationally due to its multiple uses as human food, livestock feed, manufacturing purposes, and more recently, as a source of bio-energy (Myaka *et al*., 2005). Currently it also comes to be the world's most important source of vegetable oil. Unlike most other beans it contains 40% protein compared to 20% and 13% protein content in meat and egg, respectively (FAO, 2010)). Moreover it contains 20% non-cholesterol oil and its fortified foodstuffs are considerably low-priced than other sources of high quality protein. It very well may be utilized directly for nourishment in the family unit or handled for soy milk, cooking oil and a scope of different items including newborn child weaning sustenance. Also the poultry sector industry uses soybean for feed production. Soybean grain often has a good market demand. The crop residues are also wealthy in protein and are great feed for domesticated animals form a good basis for compost or manure. It is a source of edible oil (second most consumed oil in the world after palm oil) with the highest gross output of vegetable oil among the cultivated crops with total cultivated area of 117.7 million ha and total production of 308.4 million tons (FAOSTAT, 2015).

Soybean entered to Ethiopia 50 years ago by CADU (Chilalo Agricultural Development Unit) because of its nutritional value, multipurpose use and wider adaptability in different cropping systems (Amare *et al.,* 1987 and Daniel et al., 1996). However, this attempt was unsuccessful due primary due to unacceptability by farmers, which was due to lack of knowledge for domestic consumption and market constraints. The next introductions were made by CADU in collaboration with ENI (Ethiopian Nutrition Institute) in 1970's mainly to replace imports of soybeans used in preparation of children's meals and introduce soybean in to the local diet of the community (Singh *et al*., 1987; CCGIAR, 2004). With the establishment of the Institute of Agricultural Research (IAR) in 1966, the task of soybean research was transferred from CADU to Institute of Agricultural Research (IAR). IAR undertook a number of research activities on soybean in different locations throughout the country (Asrat *et al.,* 2006).

2.2 Botany and Morphological Description of Soybean

Soybean is an annual, erect hairy herbaceous plant, ranging in height between 30 and 183cm, depending on the genotype (Ngeze *et al*., 1993). The stems, leaves, and pods are covered with brown or grey hairs. The leaves are trifoliate, having three to four leaflets per leaf. The fruit is a hairy pod that grows in cluster of three to five, each of which is five to eight centimeters long and usually contains two to four seeds (Rienke and Joke *et al*., 2005). Soybean seeds occur in various sizes, and in many, the seed coat color ranges from cream, black, brown, yellow to mottle. The hull of the mature bean is hard, water resistant and protects the cotyledons and hypocotyls from damage (Borget *et al*., 1992).

Soybean [*Glycine max* (L.) is among the industrial legume crops grown growing in low to medium altitude that needs warm climate (Hagos and Bekele *et al*., 2018). Unlike other beans it contains 40% of protein compare to 20% and 13% protein content in meat and egg respectively (Greenberg and Hartung *et al*., 1998). Moreover it is the highest in gross output of vegetative oil and primary source of edible oil among the cultivated crops with total cultivated area of 117.7 million and total area of 308.4 million tons (FAOSTAT, 2015). Soybean has multipurpose that used for human food, animal feeds, soil nutrient improvement and raw material for agro-industries. Production of this crop is vital in Ethiopia to overcome food insecurity and malnutrition and can substitute the relative expensive of animal protein. Potentially, it grows in Beneshangule Gumuze, Oromia, Amhara, Tigray and south Nation and Nationalities people and become the main source of income for smallholder farmers (Bekabi *et al*., 2015).

2.3 Soybean production

2.3.1 Climate Requirement

Soybean is a legume species grows well in tropical, subtropical and temperate climates (IITA, 2007).Plant breeders have argued that within the soybean species, there are varieties which react differently to photoperiod, and classified them as long day, short day and day neutral plants (Borget *et al*., 1992). Rienke and Joke (2005) described soybean as being typically a short day plant, physiologically adapted to temperate climatic conditions. However, some have been adapted to the hot, humid and tropical climate. In the tropics, the growth duration of adapted genotypes is commonly 90-110 days, and up to 140 days for the late maturing ones (Osafo *et al*., 1997). The relatively short growth duration is primarily due to sensitivity to the day length. This affects the extent of vegetative growth, flower induction, production of viable pollen, and length of flowering, pod filling and maturity characteristics (Norman *et al*., 1995).

Soybean can grow from 300 to 2200 meter above sea level (m.a.s.l). However, it thrives best between 1300 and 1700 m.a.s.l. It grows in an area with 450 to 1500 mm annual rainfall. Its requirement per day per plant is about 7.6mm and its requirement increases at the germination and grain filling stages (ARC, 2004; MOA. 2005).

The temperature ranging from 23 to 25°C has been reported to the optimum for soybean production. However, it thrives best at warm temperature and medium relative humidity. Very high temperatures adversely affect its pod production and seed filling (ARC, 2004).

2.3.2 Soybean production, productivity and area of land

There are good climatic and soil conditions for soybean production in South and Western Ethiopia which is indispensable both for commercial purposes in addition for subsistence farming (CDI, 2012). The issues (problems) of producing soybean is not only limited to market access in addition low profitability and production, lack of processing facilities, lack of capital to increase production and no market information system (no market data framework) for effective agricultural marketing (successful farming promoting) (Emana *et al*., 2010).

The total area coverage under the production and whole volume of production of soybean has been increasing over years. According to Kaleb (2014), it is found, that the significant wellspring of increment in the total production of soy bean has been principally come about because of increment in area of land allocated for its production. The total hectare of land under soybean production between 2002/03 and 2011/12 has increased by 10 folds and the total increment between 2002/03 and 2016/17 is greater than 20 folds, this is double as compared to the former one; while the total volume of soybean production during (2001/02 - 2016/17) has increased by more than 50 folds, this is far greater from the study of (Kaleb *et al*., 2014) total increment between 2002/03 and 2011/12 equals to 21 fold. The increased hectare of land for the production of soybean as well as increased total production during the last 15 years has been resulted from increasing demand for soybean at local and international market (CSA 2002-2017).

Productivity level of many other major crops is very low. The current normal national productivity level of soybean is additionally low. The average productivity level of soy bean during the last 15 year was 1.4 ton/ha. This level is additionally low contrasted with the potential which could go up to 4 ton/ha if improved varieties are used. The last 15 years trend in the productivity level has grown from 0.92 ton/ha in 2002/03 to 2.22 ton/ha in 2016/17.

2.4 Use of Soybean

Soybean is a multipurpose crop. It is useful for the preparation of different kinds of foods, prevention of chronic human diseases, crop rotation, improving soil fertility, and raw material for oil and concentrates food- producing factories. It is one of the most nutritious food crops in order to solve the food insecurity and malnutrition are among the urgent difficulties that creating nations confront nowadays.

Producing and consuming more soybean would enhance the circumstance (Food Security) as soy gives a nutritious mix of both calorie and protein consumption: it is the most nutritionally rich crop product, as its dry seed contains the highest protein and oil content among grain legumes (topmost rich in protein) (40 to 42% protein) with a good sense of balance of the essential amino acids and has 18-20% oil on a dry seed weight basis (FAO, 2014). It is discounted and rich source of protein for poor farmers, who have less access to animal source protein, because of their low acquiring limit (low purchasing power). In this way, Soybean is an elective protein source to the rural families and can be utilized at home in different structures and the surplus can be sold to different buyers, producers and manufacturer for money (Urgessa *et al*., 2014).

2.5 Seed Sources of Soybean

Farmers in Ethiopia can obtain seed from formal and informal sources. The formal seed source is a system composed of institutional and organizational arrangements consists of all enterprises and organizations that are involved in the flow of modern varieties from the Agricultural Research Centers to farming communities, which include variety development, release and registration, seed multiplication and processing, seed marketing and distribution and seed quality control and certification. The informal seed sources under Ethiopian context are defined as a system of seed production and distribution along with the different actors where there is no legal certification in the process (Dawit *et al*., 2010). In Ethiopia, the informal (either self-saved seed or farmer-to –farmer seed exchange, cooperative based seed multiplication and distribution, NGO based seed multiplication and distribution) seed source is the dominant for seed supply which accounts for 90% of the seed used by smallholder farmers (ESSP, 2006)

2.6 Seed Quality

Seed quality describes the potential performance of a seed lot. Trueness to variety; the presence of inert matter, seeds of other crops, or weed seed; germination percentage ;vigor; appearance; and freedom from disease are important aspects of seed quality. High- quality seed lot should meet minimum standards for each of these characteristics. Trueness is usually determined by records of seed sources and by field inspection of the plants that produce the seed. It is also defined as a uniformed sum of seed features that after sowing lead to rapid and uniform germination, forming of strong and healthy seedlings which will give the necessary number of plants in favorable and unfavorable environmental conditions. The seed quality is also reflected in the final growth, maturity of plants, their uniformity and stability of yield. For seed to play a catalytic role, it should reach farmers in a good quality state, *i.e*. high genetic purity and identity, as well as high physical, physiological and health quality (Chloupek *et al*., 2003 and Moinar *et al*., 2005). If the seed lot possess high genetic purity, high germination percentage and a minimum of inert matter, weed and other crop seeds, free from disease and meets the certification standards, is said to have high quality (Banu *et al*., 2004).

2.6.1 Genetic purity

Genetic purity refers true to type, or the degree of contamination of seeds caused by undesirable genetic varieties or species (Crmwell, *et al*., 1990). This is the most important seed quality attribute. The genetic purity of the seed governs the yield potential of variety (Soltani *et al*, 2001). It is, therefore, very important that the genetic purity status of the seed lot should be high.

2.6.2 Seed Physical Purity

Purity analysis is to determine the percentage composition by weight of pure seeds, seeds of other species and inert matters that make up the sum total of the sample (GOA, 2009). According to Umarani (2006) purity test is the first test to be made in laboratory of seed physical purity test. Seed samples can contain impurities such as weed seeds, seeds of other crop species, detached seed structures, leaf particles and other materials. Pure seed is defined as seeds of the cultivar stated by the sender or found to predominate in the purity test (khare and Bhale *et al*., 2005).

2.6.3 Seed physiological quality parameter

2.6.3.1 Seed Germination

Germination capacity of quality seed lot should be high for obtaining the desired crop stand in the field. Poor quality seeds will reduce the field establishment and yield. Seed germination is affected by a variety of factors which are imposed to the seed during its formation, maturation and ripening; such as infection with pests and pathogen, sub-optimal conditions of nutrients and water supply, and untimely rain or frost at the maturity stage (ISTA 2018). In addition, post-harvest operations and handling of the seed lots during marketing or distribution are also responsible for affecting seed quality.

2.6.3.2 Seed Viability

Seed viability is a measure of the percentage of seeds that are alive after storage. The greater the viability of your seeds, the fewer seeds will be needed to establish a desired number of plants in the field or nursery. Khare and Bhale, (2005). Seed viability can be tested in many ways and seed germination test is among the most probably simple and common method;

seeds are given the needed resources (air, water, warmth and light) to germinate and grow in to a seedling.

2.6.3.3 Seed Vigor

Seed vigor is defined as the potential of seeds for rapid and uniform germination and fast seedling growth under general field conditions. Since many aspects of seed physiology contribute to successful emergence, there has been a considerable debate on the definition of seed vigor in past, however, Khare and Bhale (2005) defined seed vigor as the "sum total of those properties of seed that determine the potential attributes of the seed express during the process of germination and seedling establishment" implies the sum of all seed aspects that result in rapid and uniform emergence and field establishment. In any seed lot, losses of seed vigor are related to a reduction in the ability of seed to carry out all the physiological ageing that, starts before harvest and continues during harvest, processing and storage (ISTA 2009).

2.7 Effect of Storage duration on Seed quality and yield of Soybean

Soybeans can be stored through improved storage and cultural storage methods such as on the farm in round bins or regular, concrete-floor buildings. Drying is risky in flat storage because of the possibility of poor air distribution. Beans held in storage, even though dry, need periodic aeration to minimize moisture migration and break up any hot spots that might develop. Flat storage does, however, have more versatility for other uses.

Seeds are considered to be in storage from the moment they reach physiological maturity until next germination (Gokhale *et al.,* 2009). Changes associated with seed deterioration are depletion in food reserves, increased enzyme activity, increased fat acidity, and membrane permeability. As the catabolic changes continue with increasing age, the ability of the seed to germinate will be reduced. (Shelar *et al.,* 2002) reported that the germination of soybean varieties decreased during storage irrespective of varieties, threshing and processing methods and storage conditions. Soybean seed declines in quality faster than seeds of other crops (Fabrizius *et al*., 1999).

2.8 Effect of seed Source on Seed Quality

Farmers in Ethiopia can obtain seed from formal and informal sources. The formal seed source is a system composed of institutional and organizational arrangements consisting of all enterprises and organizations that are involved in the flow of modern varieties from the Agricultural Research Centers to farming communities. The informal seed source under Ethiopian context is defined as a system of seed production and distribution along with the different actors where there is no legal certification in the process (Dawit *et al.,* 2010). In Ethiopia, the informal seed source is the dominant for seed supply which accounts for 90% of the seed used by smallholder farmers (ESSP, 2006). The majority of Ethiopian farmers show a tendency of depending on the informal seed sources. This is because informally obtained seed is relatively cheaper and readily available to the farmer in villages by the time it is needed, it allows use of seeds after testing on primary adopter farmers, it is more reliable and supply sustainability is more guaranteed than seeds from the formal sources (Abebe and Lijalem *et al.,*2010). According to Cromwell (1992), five key features distinguish the informal seed system from the formal seed system. The informal system is traditional, semi-structured, operate at the individual community level, uses a wide range of exchange mechanisms, and usually deal with small quantities of seeds. Seeds are the basic agricultural inputs. Particularly, quality seeds of any preferred varieties are the basis of improved agricultural productivity since it responds nee to increasing productivity and crop use (Pelmmer *et al.,* 2005).Unavailability of quality seeds at the right place and time coupled with poor promotion system are some of the key factors accounting for the limited use of improved soybean seeds which further contributes to low agricultural productivity in Ethiopia.

2.9 Determination of seed physiological quality

2.9.1 Genetic factor

The seed storability is considerably determined by the kind or variety of seeds. Some seeds are naturally short-lived like onion, soybean, peanuts etc., whereas some like all tall fescue and annual rye grass, appear very similar but differ in storability. Genetic make-up of varieties also influences storability (Soltani *et al*., 2001). Some types of seeds are inherently long lived; others are short lived, while others have an intermediate life span owing to their differences in genetic makeup. Based on their storability behavior seeds can classified as

Orthodox and recalcitrant seeds. Orthodox seeds are those small grain cereal seeds including wheat and barley whereas recalcitrant seeds are large seeded one such as Jack fruit and avocado.

2.9.2 Seed classes

The availability of breeder seed of high genetic purity determines the success of entire seed production program. Breeder seed should be genetically so pure as to guarantee that subsequent generation i.e. foundation seed confirms to the prescribed standards of genetic purity. The production of nucleus and breeder seed is personally supervised by a qualified plant breeder, while the breeder seed is the progeny of nucleus seed, nucleus seed is itself produced by bulking the genetically pure and true to type single plant progenies. The highest norms of genetic purity can only be endured by rigorous and uniform seed production techniques. Proper class of seed should be used for seed production. The breeder seed should be used for foundation seed and foundation seed should be used for certified seed production having good genetic quality and the seed class genetic constitution governs the yield potential of variety (Soltani *et al.*, 2001).

2.9.3 Initial Seed quality

Vigorous and non-deteriorated seeds can store longer than deteriorated seeds. Seeds that have been broken, cracked, or bruised due to handling deteriorate more rapidly in storage than undamaged seeds. Cracks in seeds serve as entrance to pathogens causing consequent deterioration through infection. Seeds that have been developed under environmental stress conditions (such as drought, nutrient deficiency and high temperatures) become more susceptible to rapid deterioration.

2.9.4 Temperature

High temperature hastens the rate of biochemical process and triggers more rapid deterioration that results in rapid loss, especially in seeds with high moisture content (Shelar *et al.,* 2008). Seed's sensitivity to high temperatures is strongly dependent on their water content, loss of viability being quicker with increasing moisture content (Kibinz *et al*., 2006). Temperature is most important because it influences the amount of moisture and also enhances the rate of deteriorative reactions occurring in seeds as temperature increases.

2.9.5 Moisture content

Deteriorative reaction occurs more rapidly in seeds at higher moisture content and subsequently, this condition constitutes hazard to the longevity of seed survival (Vashistan and Nagarajan *et al,* .2009). Seeds stored at high moisture content demonstrate increased respiration, heating, and fungal invasion resulting in reduced seed vigor and viability. Seed moisture content of soybean 12% is optimum for maximum longevity of most crop species. Below 4% soybean seed moisture content, exposed to desiccation becomes a damaging factor and seeds become more susceptible to mechanical damage. The moisture content of seed during storage is the most persuasive factor affecting the longevity. Storing seeds at high moisture content enhances the risk of quicker deterioration at shorter time, seeds are hygroscopic in nature; they can pick up and release moisture from and to the surrounding air. They absorb or lose moisture till the vapor pressure of the seed moisture and atmospheric moisture reach equilibrium (Shelar *et al*., 2008).

2.9.6 Organism associated with seed

Seeds serve as source of primary inoculum, reduce yield in subsequent crop, discolor seed, make shriveling, and change biochemical status. According to Amare (2014) healthy seed with high physical purity, germination, and vigor implies the production of healthy seedlings, good crop stand establishment and thereby high yield. Prior seed health testing and other seed quality test results are indicators for the field establishment potential of the seed-borne diseases of crops are important in Ethiopia (Dereje *et al.,* (2008) as they reduce yield and quality of harvest (seed or grain) and eventually the pathogens spread to new crops and areas.

2.9.7 Fluctuating environmental condition

Fluctuating environmental conditions are harmful for seed viability. Rapid changes in seed moisture content and temperature cause deleterious effect. Recent researches on the role of a gaseous environment on seed viability indicate that increases in pressure of oxygen incline to decreases the viability period. Seed quality, including germination, vigor and viability are highly influenced by environmental factors in field and storage

2.9.8 Farmers' perception on seed quality

Perception is the process of attaining awareness or understanding of sensory information. According to Ofuoku (2011), man views his environment from the way he feels about it in his interaction with it. Depending on how he perceives and interprets the environment, he reacts to secure his comfort and future

3. MATERIAL AND METHOD

The study consisted of three different activities. The first study was household survey to assess farmers' handling practices of soybean seed; the second study was pre-planting quality assessment of seeds collected from different sources stored under different conditions in the laboratory; the third study was a field experiment to evaluate actual performances of plants grown from seed samples used in experiment two (*i.e*., pre-planting quality test in the laboratory).

3.1 Assessment of Farmers' Handling Practices of Soybean Seeds

Purposive sampling procedure with proportional random sampling technique was used to identify farmers to be included in the study area. The preparatory stage of the study involved with three Districts Agricultural Offices (Jima Arjo, Diga and Gobu Sayo District Agricultural Office) and discussions were made between the researcher and the extension department staffs as well as the subject matter specialists on crop production and plant protection. Through this consultation, major soybean producing PAs were purposely selected and PAs extension supervisors were identified, with whom the researcher worked during sample selection and data collection. Farmers from the three peasant associations (PAs), namely *Dire-tokuma*, *Meda –Jalela* and *Gambela-tare*, were those who produce soybean on their farm than others in the districts and they were identified and selected based on the importance of the soybean in the farming system. The list of soybean producing farmers from each selected PA was obtained from the respective Districts Agricultural Offices.

Proportional random sampling technique was used to select sample farmers from a list of soybean producing farmers in each PAs. In the three selected PAs, total household population of 1658 farmers were listed for the study. From these total farmers 90 sample farmers were drawn by proportional random sampling for interview purpose. To illustrate it, sample size (n) = 90, to be drawn from household population of size (N) = 1658 which was divided in to N_1= 553 (*Dire- tokuma*), N_2= 549 (*Mada Jala*), and N_3=556 (*Gambela tare*). From 90 sampled farmers, 29.85≈ 30 farmers from *Dire- tokuma*, 29.6≈ 30 farmers from *Meda Jalala* and 30.01≈ 30 farmers from *Gambela tare* PAs were considered for interview. Adopting the proportional allocation each kebele got sample size as follows:$n1 =$

$\frac{(N1-3)n}{N}$ (where n_1 3 =sample size from each kebele, N_1 3 = household population size of each kebele, n= the sample size of study, N=Household population of three kebeles).

At the same time, a structured questionnaire was presented to staffs and discussion was made on it. The questionnaire covered socio- economic data, farmers' soybean seed production, varieties and seed source available in the area, storage conditions and the soybean seed availability and accessibilities, major production constraints that hinder the farmers from producing it in quality. Individual farmers were interviewed by trained enumerators using ''Afaan Oromoo" language either on their farms or at their homes, since the questionnaire was translated to local language.

3.2 Laboratory Experiment

Eighteen certified seed samples of two varieties (*Korme* and *Didhesa*) were collected from three seed sources [two formal seed sources and one informal seed source (*i.e.*, farmer saved seed)], and from three storage durations (two months, six months and one year storage durations). The treatments consisted of factorial combinations of the three factors (2 x 3 x 3=18 treatment combinations). The experimental design used was Completely Randomized Design (CRD) in factorial arrangement with four replications. The experiment was conducted in the seed quality testing laboratory of Oromia agricultural input regulatory Authority, Nekemte branch, and partly at Ambo research center, as per the International Seed Testing Association rules and procedures (ISTA 2022).

3.2.1 Determination of seed physical quality

Moisture Content Determination

The amount of water within the seed was determined with low constant temperature oven method and the temperature was maintained at 103±2 0C and the seed was dried for 17±1 hours. The difference between the weight of fresh seeds and the dry seeds was established by the formula (ISTA, 2014)

$$MC\ (\%) = \frac{M2-M3}{M2-M1} \text{x } 100$$

Where; MC= Seed moisture content.

M1=Weight of the empty container with its cover

M2=Weight of the container with its cover and seeds before drying.

M3=Weight of the container with its cover and the seed after drying.

A seed sample of 1000 gram (g) was obtained from each experimental treatment for laboratory analysis. The 1000 g of seeds from each treatment was divided into 4 each 250 g, which was used for the different laboratory tests that include purity, moisture content determination, germination, and vigor test. Each sample was sorted into three components that include pure seed, inert matter, and other crop as suggested by the International Seed Testing Association (ISTA, 2018). Hundred seed weight (HSW) was measured from randomly taken seed samples from each experimental treatment.

3.2.2 Determination of seed physiological quality

3.2.2.1 Standard Germination test

Four hundred seeds were counted at random from the working seed samples. Then, hundred seeds were planted from each sample in sterilized sand media in three replications. The planted seeds were germinated in seed germinator at temperature of 25^0c for 4 days. On the 8^{th} day, germination boxes were removed and the seedlings were evaluated following the procedures of ISTA (2018).The percentage of normal seedlings, abnormal seedlings, fresh un-germinated and dead seeds were recorded and calculated based on the final count. The results were expressed as mean percentage of normal seedlings, for each seed lot. Therefore, normal germination percentage was taken as the average number of normal seeds germinated over the final day’s period, and it was calculated as below.

$$\text{StG} = \frac{\text{Total number of normal seedlings}}{\text{Total number of seed sown}} \text{x } 100$$

3.2.2 Speed of germination

Speed of germination was calculated from the daily germination records. In case of soybeans, speed of germination shall be obtained within 8 days of germination period; the first count was done on the 5th day. Then, speed of germination (SPG) was calculated following the procedure described by (Maguire *et al*., 1962) as follows.

$$\text{SPG} = \frac{\text{Number of normal seedlings}}{\text{Days of first count}} + \ldots\ldots + \ldots \frac{\text{Number of normal seedlings}}{\text{Days of final count}}$$

3.2.3 Seedling vigor test

Seedling vigor test was determined by measuring shoot and root length of seedlings. The seedling shoots and root length was measured after the final count of the germination test. Ten normal seedlings were randomly taken from each replicate and shoot length was measured from the point of attachment to the cotyledon. Similarly, the root length was measured. The averages of shoot and root lengths were computed by dividing the total shoot or root lengths by the total number of normal seedlings measured (Fiala *et al.,* 1987).

The seedlings' dry weight was measured after the final count of the standard germination test. Ten randomly taken seedlings from each replicate were identified and placed in envelopes and dried in an oven at 80 ^{0}C for 24 hrs. The dried seedlings were weighed by using sensitive balance and the average seedling dry weight was calculated.

For each treatment, two vigor indices were calculated. Seedling vigor index one was calculated by multiplying the number of normal seedlings with the average sum of shoot and root lengths and Vigor index two was calculated by multiplying the standard germination percentage with mean seedling dry weight. Mathematically;

Vigor Index one (VIG-I) = Average Seedling Length × Normal seedling %

Vigor Index Two (VIG-II) =Normal seedling % × Seedling mean Dry Weight.

3.3 Field Experiment

3.3.1 Description of experimental site

The study was conducted in East Wollega zone of Oromia region in Diga, district. East Wollega was intentionally selected due to early introduction and expansion of improved soybean varieties. The area is located at 9°31'9''North latitude, 36°45'27' East longitude at a distance of 328 km from Addis Ababa to western part of Oromia. It is bounded on the Southwest by Buno-bedele zone, on the west by West Wollega zone, on the northwest and north by Benishangul-gumuz region, on the north east by Horo Guduru Wollega zone, on the east by west Shewa zone and on the southeast by Jima zone and Nekemte is the town and administrative center of the zone. According to CSA (2021) population projection report, the total population was 1,764,328. The study area is found at an altitude of 1,365 m.a.s.l. and receives an average annual rainfall of 1800 mm with average annual temperatures of 21°C. The zone is known by production of major crops like cereals, legumes, oil crops, vegetable crops, fruits, root crops and coffee as cash crop.

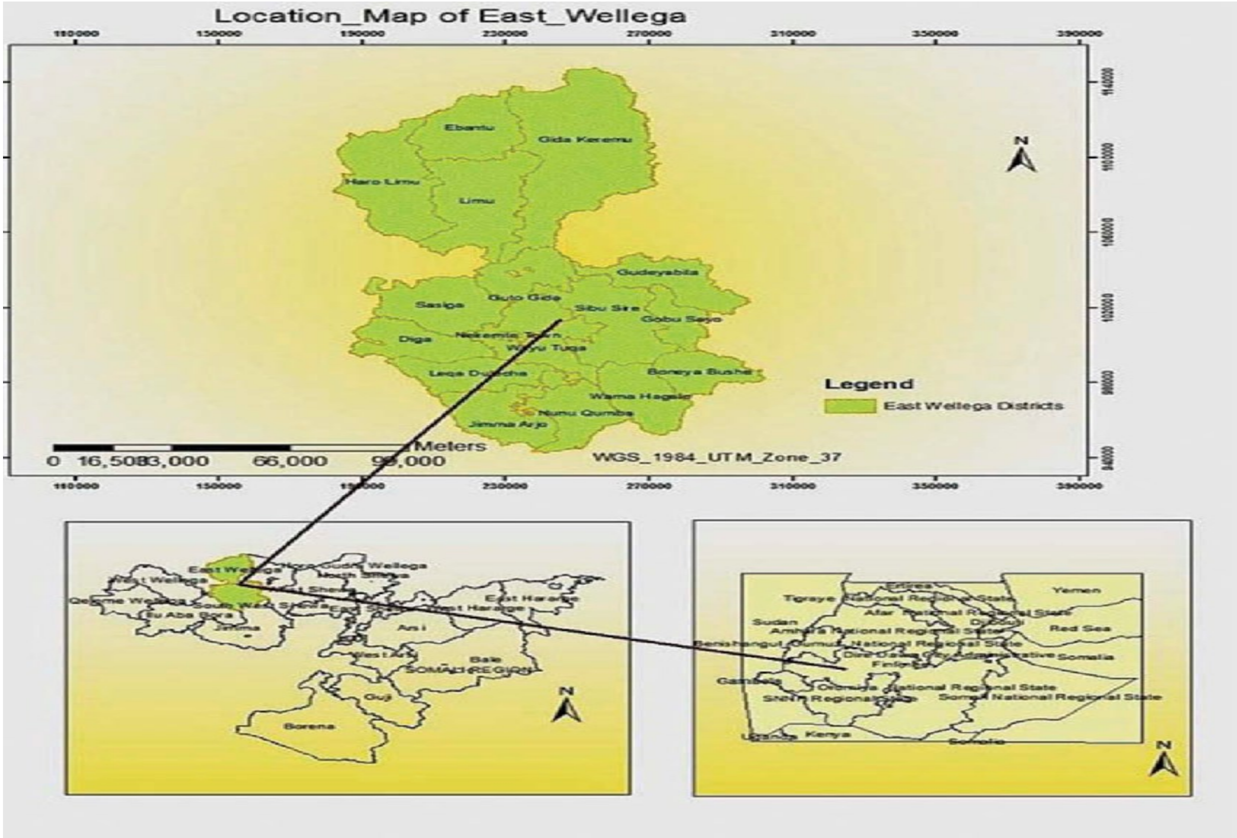

Figure 1: Map of the study area

3.3.2 Experimental materials

For the purpose of this study the researcher used household field survey data collected from the selected 90 farmers through questionnaires from the three kebeles in the districts of *Diga*, *Jima-arjo* and *Gobu-sayo* districts. The experimental materials includes a total of two medium maturity type soybean varieties, which were released in different years and stored for different storage durations from three seed sources. The varieties used in the experiment were *Korme* and *Didhesa* collected from Ano Agro industry, Haro sabu research center, and farmer saved seeds of the two varieties.

The field experiment was conducted in Diga district of East wellega zone and the treatment consisted three level of seed source, three storage duration and two soybean varieties means 3 × 3× 2 (18) treatment combinations. The treatments were laid out in Randomized Complete Block Design in a factorial arrangement with three replications. The total number of plots were 18 × 3=54. The size of individual plot was 2.4 x 3 m and intra-row and interrow spacing of 0.05 m and 0.60 m, respectively. There were four rows per plots and 60 plants per rows. The spacing between blocks and plots were 1.5m and 0.75 m, respectively. The recommended NPS fertilizer at the rate of 100 kg/ha were applied (Gurmu *et al.,* 2010). Only plants in the central rows were harvested for data collection.

Eighteen seed samples of two varieties were collected from three seed sources and three storage duration and used as treatments (2 x 3 x 3=18). The treatment was arranged in factorial combination in Completely Randomized Design (CRD) with four replications. The experiment was conducted in Oromia agricultural input regulatory Authority Nekemte branch seed quality testing laboratory and Ambo research center, as per the International Seed Testing Association rules and procedures (ISTA 2022).

Table 1: Description of the soybean varieties used for the study

Variety	Year of release	Yield t h^{-1}		Maturity	Altitude	Maintainer
		Research	Farmer	Type	(m.a.s.l.)	Center
Korme	2011	12-38	12-32		1200-1900	Bako RC
			medium			
Didhesa	2008	20-33	14 -28	Medium	1000-1200	Bako RC

Source: MoANR (2016)

3.4 Data Collection

Primary data formed the core of the data used in the study. These data were obtained from farmer respondents through interview, field observation of the performance of growing soybean seed and laboratory experiment activities. The information collected included farmer's seed source, variety selection, storage method, storage duration, management and handling practices. In addition, socio-economic data such as gender, age, educational level of interviewed farmers, family size and farm size were collected. Secondary data on socio-economic and agro-ecological characteristic of the districts were also obtained from the respective districts Agricultural offices.

Field experiment data such as days to 50% flowering, maturity date, plant height, number of primary brunches, number of pods per plant, number of seeds per pod, hundred seed weight, seed yield and laboratory data such as seed physical purity quality tests such as

Moisture content, purity analysis, standard germination, vigor indexes, shoot lengths, shoot lengths, seedling dry weight and seedling health test data were collected.

3.5 Data Analysis

The information collected from field survey were coded, tabulated and analyzed using statistical package for social science (SPSS) version 23. Simple descriptive statistics including mean, percentage and standard deviation were used to describe the socio-economic characteristics of the respondents. Data collected from laboratories and field experiments were subjected to analyses of variance using SAS (9.0).Treatment means were separated using least significance difference (LSD) test at 5% probability level.

4. RESULT AND DISCUSSION

4.1 Field Survey

4.1.1 Response rate

A total of 90 households from three districts have participated in the survey study (Table 2). All the questionnaires dispatched to the respondent households were filled and returned, which represented 100% response rate. Mugenda and Mugenda (2003) observed that a 50% response is adequate, 60% and above is very good. This implies that the response rate in the study was very good. These responses were examined for accuracy and the results were mentioned based on the data collected from each respondent.

Table 2**:** Number of respondents by district

Districts	Frequency	Percent	Cumulative percent
Gobu sayo	30	33.33	33.33
Diga	30	33.33	66.66
Jima Arjo	30	33.33	100

4.1.2 Back ground of the respondents

In this study, data from research participants were collected through enumerator-administered questionnaires. The background information sought comprised of districts, kebeles, sex, family size, age category, religion, and educational back ground of the respondents.

The composition of the respondents by sex revealed that the majority of the farm households were male (90%) while 10% of the respondents were females. The sample districts were *Gobu sayo, Diga* and *Jima arjo* and the respective kebeles were *Gambela-tare, Meda -Jalela* and *Dire-tokuma*. The household family size of the respondents in the study area ranges having 1-3 family members 255(37.17%), 4-6 family members 394(57.43%) and 7-9 family members 37(5.4%).The majority of the respondents are within the age category of 41-50 years (42.22%), and the majority of the respondents were followers of Protestant Christian (58.89%) while the rest (25.56%) and (15.55%) were Muslim and Orthodox Christian followers, respectively. Regarding the educational status of the farm households, 94.44% are literate (ranging from at least read and write to high school complete), while the rest

5.56% were illiterate. This information indicates that the respondents were comparatively able to articulate and contribute to the issues of the study (Table 3).

Table 3*:* Demographic profile of respondents

Description	Category	Frequency	Percent	Cumulative percent
Gender of Hhs	Male	81	90	90
	Female	9	10	100
Family size	1-3	255	37.17	37.17
	4-6	394	57.43	94.6
	7-9	37	5.4	100
Age category	23-30	5	5.55	55.55
	31-40	19	21.11	26.66
	41-50	38	42.22	68.88
	>51	28	31.12	100
Religion	Orthodox Christian	14	15.55	15.55
	Protestant	53	58.89	74.44
	Muslim	23	25.56	100
Educational status	Illiterate	5	5.56	5.56
	Read and write	15	16.67	22.23
	Elementary	21	23.33	45.56
	Secondary	16	17.78	63.34
	High school	26	28.89	92.23
	Above 12^{th}	7	7.77	100

4.1.3 Relative importance of major crops in the study area

Soybean is the fourth most important grain crop grown after maize, sorghum, and common bean during 2022/23 cropping season. The average size of land allocated for cereals, root and tuber crops, pulse crops and oil crops were 73%, 18%, 7% and 2%, respectively. During the same period, the unit price of soybean was higher than other common crops grown in the study area (Figure2).

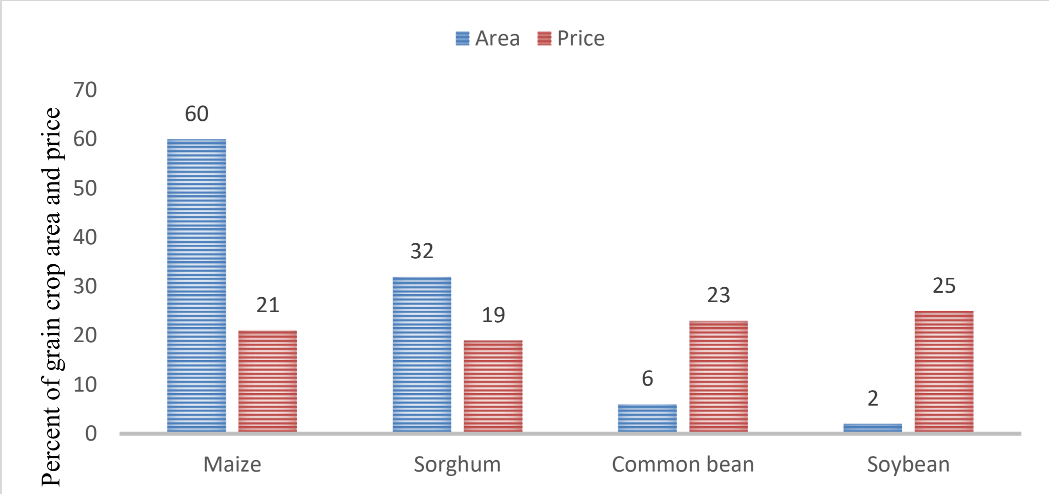

Figure 2: Comparison of area covered by major crops (%), and unit price (birr/kg) for each of the crops grown in the study area in 2022/23

4.1.3 Soybean coverage and varietal preference

The survey result revealed that out of area allocated to soybean, almost all (99%) is covered by old varieties that were distributed among the farmers long ago and still the farmers are using their generations while the remaining 1% was covered by improved varieties

4.1.4 Source of soybean seed

Among all respondents in the study area, 95.56% of the respondents were obtained soybean seed from farm saved seed source, and only about 4.44% of the respondents use formal seed sources from Oromia seed enterprise, private seed companies like Pioneer and research centers through agricultural extension services. They acquired the seed from the sources through direct purchase (80%) and through exchange of seed with different other crop varieties (20 %).

4.1.5 Farmers' preference criteria for soybean varieties

According to the obtained response, 96.67% of the respondents preferred improved varieties and the rest 3.33% show their preference for the local varieties. The reason for their preferences (*i.e.,* preference criteria) include high yield, insect resistance, potential for soil fertility improvement, food quality, seed size, and market price as depicted in

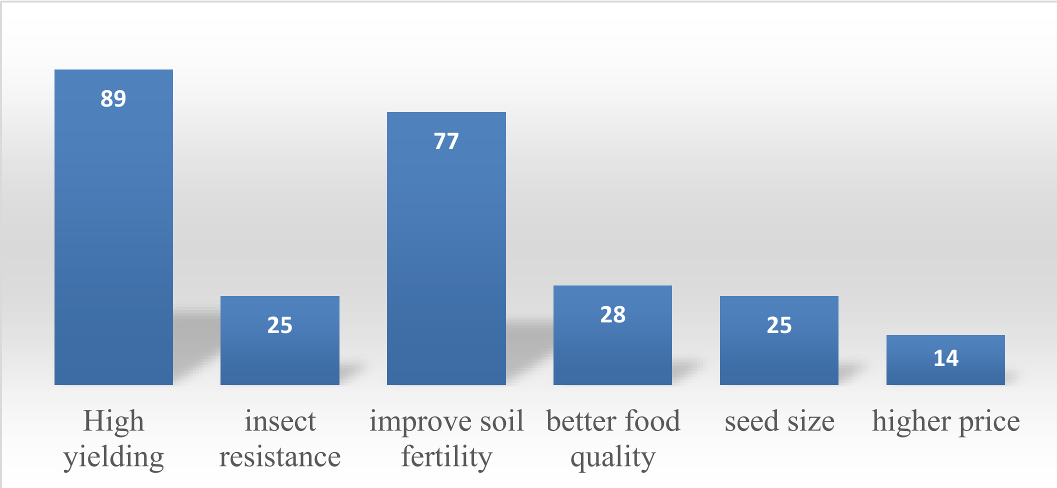

Figure 3: Reason for farmers' preference to grow improved varieties

4.1.6 Soybean varieties grown by respondent farmers

A total of four soybean varieties are grown in the area. The majority of the farmers grow the variety *Korme* (44.44%) followed by Keta (31.11%), and *Didhesa* (13.34%) (Table 3).

The majority of the respondents (79%) grew the local soybean varieties in the cropping season. In this study, the varieties categorized as local are those used by farmers for long period of time and the farmers considered them as their own. From the interviewed farmers, 21% have reported using improved soybean varieties which were introduced by private seed producers, agriculture and natural resource development office, and different NGOs. The limited use of improved varieties by the farmers was attributed to lack of improved soybean variety seed in their vicinity (33.33%), and 41.11% of the farmers reported that the seed supplied to them through the different actors were of poor quality. Lack of awareness about the benefits of the improved seed over local one was mentioned by 18.89% of the farmers as one reason for limited use of improved varieties, while 6.67% mentioned price fluctuation of improved soybean varieties and the lack of market linkage as the reason.
It was observed during the survey that improved soybean varieties were unavailable to most of the farmers. However, few farmers managed to use small quantity of improved soybean seed. Due to this 97% of the area is allocated to local varieties while the improved varieties occupy only 3% of the area. During the interview, farmers explained that they are restricted

to use their local soybean varieties because it is cheap and easily found in the area at time of planting.

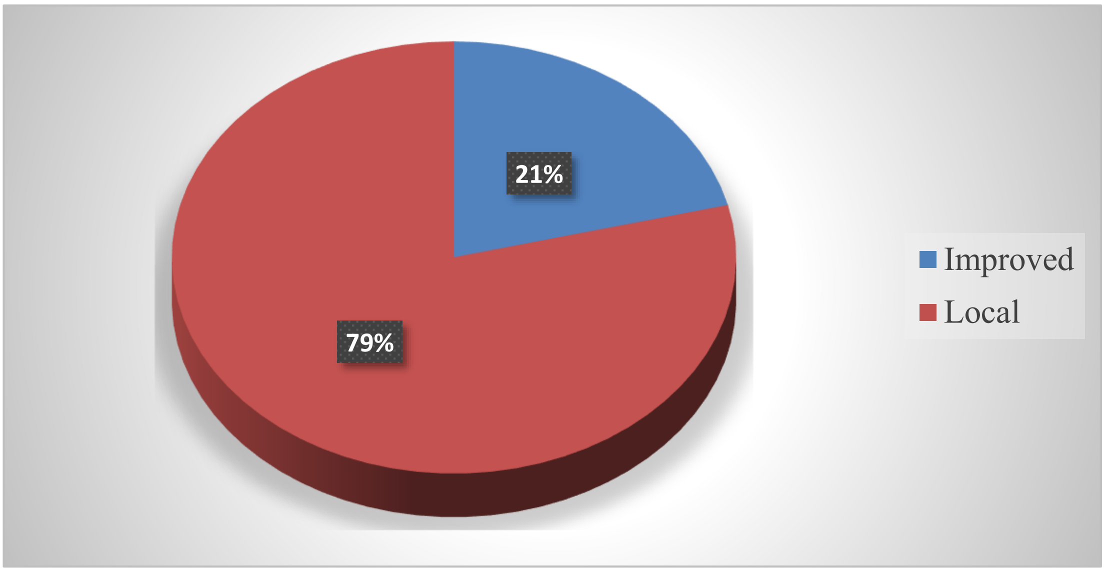

Figure 4: Proportion of improved and local soybean varieties grown in East Wollega zone, Ethiopia in 2022/23

According to the information gathered from the target households through different actors like research centers and non-governmental organizations limited soybean varieties are available in the area from the released 26 varieties in the country. Among these *Korme* variety accounts 44%, followed by *Keta* and D*idhesa* rating 31.11% and 11.11%.

Table 4: Most commonly grown improved soybean varieties in East Wollega zone, Ethiopia in 2022/23

Variety	Status of the variety	Frequency	Percent (%)	Cumulative percent
Didhesa	Improved	12	13.34	13.34
Boshe	Improved	10	11.11	24.45
Korme	Improved	40	44.44	68.89
Keta	Improved	28	31.11	100

According to the data obtained from the respondents the majority of the seed classes found in their area is old generation as farm saved (66.67%), followed by second generation seed class (22.22%) and certified seed (11.11%) (Figure 5)

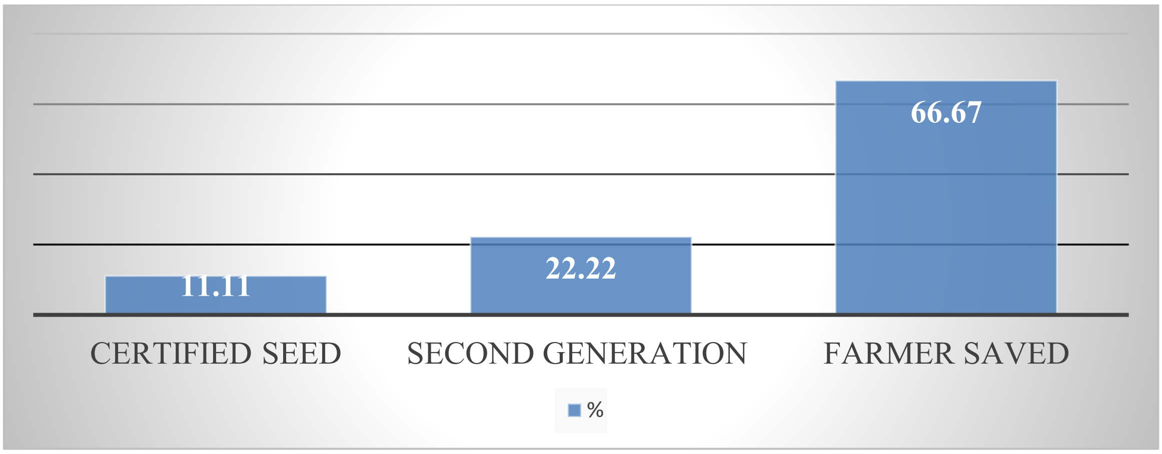

Figure 5: Seed class grown in the study area

4.1.7 Seed quality control practices

Rouging practices

Farmers were asked to indicate the number of rouging practices for soybean seed production. The results revealed that most farmers (26.67%) were undertaking rouging practices twice per season, 57.78% of them once, and the remaining 15.55% practiced 3 times rouging (Table 5). The result indicates that rouging was a common practice, but with varied frequency. Therefore, it appears that rouging practice contribute to improved seed purity by removing undesirable source of contaminants.

Table 5: Frequency of rouging by farmers during seed production

No, of rouging	Frequency	Percent	Percent	Cumulative percent
1	26	57.78	57.78	57.78
2	12	26.67	26.67	84.45
3	7	15.55	15.55	100

Based on the result obtained from the household survey in the selected three districts of the zone, 17.78% of the farmers treat their soybean seed on field by chemicals, 34.44% by ash mixing with water, 22.22% by animal dung mixing with water, 20% practice roughing infected seedling from the field, and the rest 5.56% left their soybean field without any treatment.

Soybean field inspection practices

Most of respondents (82.22%) reported that their field was not inspected by certification agency in the cropping season. The result further indicated that 5.56% of the respondents reported that their field was inspected before flowering and 12.22% respondents indicated that the inspection was done at flowering stages.

Among the respondents, only 8.89% harvest their soybean seed at the right maturity stage while the rest (91.11%) did not harvest at the right maturity stage. All the respondents used local harvesting and threshing methods by manual man power and all of the respondents indicated that they use the same threshing floor for different varieties by cementing with animal dung mixed with water and sweeping (cleaning) each time after threshing one variety before using the ground for another variety.

Regarding the productivity of soybean, 16.67% of the respondents mentioned that they obtain 800 kg/ha, 27.78% obtain 600kg/ha, while 25.55% obtain 400 kg/ha, and the remaining 30 % harvest 300kg/ha and below. The production and productivity of the crop was low because the majority of the study area uses low quality seed that they obtain from unknown seed sources and is not tested under any quality standards. The way they dry their grain and seed was so traditional method that expose the grain/seed to quality deterioration (Table 6).

Table 6: Seed drying methods in the study area

Description	Frequency	Percent (%)
On mud floor on open sun light	61	67
On mud floor under shade	8	8.89
Woven materials under shade with frequent spreading	1	1.11
By woven cloth and hung under smoke	2	2.22
Collecting in jute sacks and pile	16	17.78

4.1.8 Farmers' management/control of stored soybean

Most of the respondents mentioned that they employed different cultural practices against soybean seed storage insect and diseases. Exposing soybean grain to sun and minimizing frequent opening of storage were the major practices. Similar study conducted by Tadesse and Bascdow (2000) indicated that farmers reported less frequent storage opening and storage hygiene as means of stored soybean management. Similar practices were used by farmers in southwestern Ethiopia; where farmers used different cultural practices, such as storage hygiene, exposing sorghum grain to sun, and treatment with ash for protection of stored sorghum grains pests (Esayas *et al.,* 2007). Some cultural methods of extension advice for the control of stored grain pests in Ethiopia include drying grain sufficiently before storage, exposing grains to sun, mix with ash and sand for the grains used for seed purpose at the ratio of 5:1, and placing sorghum heads and maize cobs in smoke over fire (Tessema *et al* ., 2006).

All of the respondent farmers mentioned that they did not have access to chemicals or pesticides to control stored soybean pests and diseases, mainly because of unavailability (40.8%), lack of awareness about the chemicals (29.2%) and fear of any side effects from chemicals like pollution/health hazards (30%). Only about 12.22% of the respondents store soybean seed separately from the grain, while the remaining 87.78% do not separate seeds from grains for storage. In terms of storage duration, about 55% of the respondents store their soybean seed for one year, 36.67% of them store for 2 years, and the left 7.78% store the seed for three years.

The farmers in the study area mostly use storage materials that increase the rate of seed deterioration. Among the respondents, 85.56% suggested their idea as the storage materials they use expose soybean seed for quality deterioration while the remaining (14.44%) suggests as the storage material that the use did not cause soybean seed quality loss. Soybean producing farmers in the study area uses different storage materials. The information gathered from the respondents indicate that 43% of them use plastic bags, 36% of them use fertilizer sacks and 21% of them use picks bag to store their soybean seed.

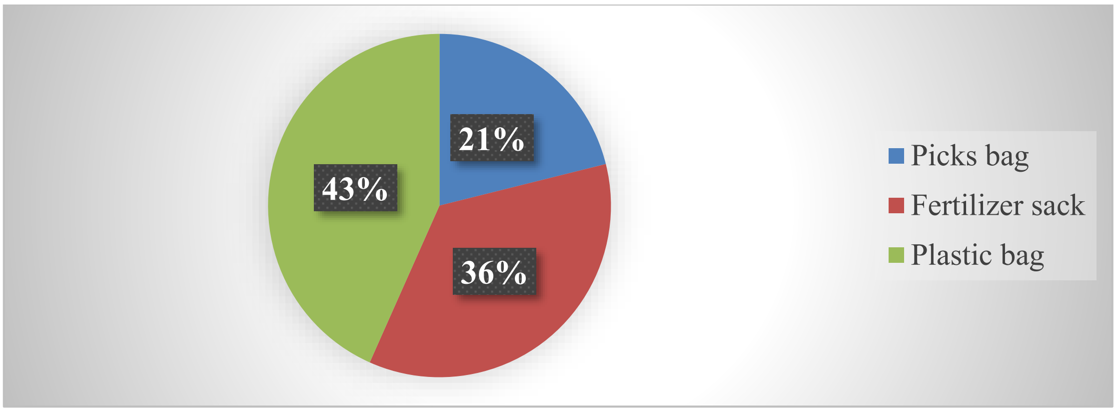

Figure 6: Common storage materials in the study area

Farmers' seed testing practice

The quality of the seed should be assessed before marketing. In the study area, most of the seed producers (100%) did not provide their product to seed regulatory bodies for seed certification. Only seed purity, germination, and moisture content were considered as seed quality parameters by seed regulatory bodies. In line with this, Hampton (2002) reported that over 80 to 90% of seed are tested based on physical and physiological seed quality parameters. According to Dereje (2008), quality seed production should be made in pest free areas where effective pest management is practiced. He also suggested that regular field inspection and seed quality test should be included in the seed inspection and certification system of Ethiopia. But in the case of the study area, they produce soybean seed and sell to the local market without any laboratory test, grading, labeling and packaging.

4.1.9 Farmers' perception on seed quality

From the data collected from household survey and focus group discussion held at the three districts, farmers perceive seed quality in relation to physical seed qualities, such as pure seed with no impurities (42.5%), seed size (21.7%), not damaged by insects and diseases (16.7%), no mixture of other varieties (10.8%), and free from weed seed and other crops (8.3%). A similar study made by Abdisa (2001) indicated that the criteria used by farmers to define seed quality included freedom from impurities, disease, and adaptation to local conditions.

4.1.10 Major soybean production problems identified

Besides the specific production problems discussed in the above sections issues such as lack of quality seed, unavailability of chemicals on time to control diseases and pests, and lack of information and training were among the major constraints mentioned by soybean seed producers in the study area. Based on the questionnaires provided for the households and the focus group discussion participants, 41.11% of the respondents indicated poor quality seed source, while 33.33% have mentioned lack of preferred variety, 18.89% indicated lack of practical training, and the rest 6.7% of the respondents mentioned price fluctuation of the soybean seed in their locality were the major soybean production problems mentioned by the farmers in the study area (Table 7). All of the respondents mentioned these as common major problems or challenges that need priority and need attention for quality soybean seed production in the study area.

Table 7: Common problems identified by the households and focus group discussion

Description	Frequency	Percent (%)	Cumulative percent
Poor quality seed source	37	41.11	41.11
Lack of preferred variety	30	33.33	74.44
Lack of practical training	17	18.89	93.33
Price fluctuation	6	6.7	100

4.2 Seed Quality Test

4.2.1 Seeds physical quality test

Analysis of variance revealed that the interaction effect of seed source x storage duration had significant ($P< 0.05$) influence on pure seeds and inert matter percentage while the main effect of storage duration had significant effect on seed moisture content *Appendix Table 2). This indicated that the seed physical quality of soybean varieties has been affected by storage duration and interaction of seed source x storage. In agreement to the results of this study, it was reported that the moisture content of soybean seed lots was affected by duration of storage in the cold room, warm room, and warehouse (Gladys *et al.,* 2012).

The higher pure seed proportion was 98.93% estimated from Haro sabu seed source and stored for six months with statistical parity with seed sample from Ano Agro industry which was stored for six month and one year. According to the Quality and Standards Authority of Ethiopia (QSAE, 2000) for basic seed, all the collected seed samples recorded higher than the minimum standard (98%) pure seed component and below the maximum standard for inert mater content (Table 8).

Table 8: Interaction effect of seed source x storage duration on pure seed and inert matter of soybean varieties during pre-sowing test in East Wallega Zone in 2022/23

Treatment		Seeds physical quality	
Seed source	Storage duration	Pure seed %)	Inert matter (%)
Ano Agro industry	2month	98.63b	1.36a
	6month	98.79ab	1.20ab
	1 year	98.73ab	1.26ab
Haro Sabu	2month	98.86a	1.14b
	6month	98.93a	1.06b
	1 year	98.64b	1.35a
Farmer saved	2month	98.62b	1.37a
	6month	98.65b	1.35a
	1 year	98.87a	1.12b
LSD (0.05)		0.20	0.20
CV (%)		0.204	16.17

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at $P<0.05$ and CV (%) = percentage coefficient of variation.

The highest moisture content (9.53%) was registered for seeds of soybean stored for two months while the lowest moisture content (8.75%) was registered for seeds of soybean stored for one year (Table 9). This showed that the prolonged storage duration of soybean varieties decreases moisture content. One of the major constraints to the production of soybean in the tropics is the rapid loss of seed viability and vigor during storage under ambient conditions (Nkang and Umho *et al.,* 1996).

Table 9: Effect of storage duration on moisture content of soybean during pre-sowing test in East Wallega Zone in 2022/23

Storage duration	Moisture Content
Two months	9.53a
Six months	9.24b
One year	8.75c
LSD (0.05)	0.207
CV (%)	3.90

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage coefficient of variation.

4.2.2 Seeds physiological quality test

4.2.2.1 Proportion of dead seeds, abnormal seedlings, and germination

Percentage of germination, abnormal seedling, and dead seeds were significantly influenced by variety, seed source, storage duration, interaction of variety with seed source, and interaction of seed source with storage duration. In addition, proportion of abnormal seedlings was significantly influenced by interaction of variety with storage duration and by the three factor interaction (variety x seed source x storage duration). This indicated that the seed physiological quality (dead seed, abnormal seedlings, and percentage of germination) of soybean varieties were affected by the genetic factor, seed source, and storage period, and interaction effects of these factors. Wine and Kuenema (1981) reported that the variation in speed of seed deterioration of soybean varieties is a genetic character and soybean genotypes differ in their ability to maintain seed longevity.

The highest germination percentage (80.04%) was registered for seeds of *Didhesa* variety while the lowest (75.13%) germination percentage was estimated from *Korme* variety. On the other hand, the highest percentage of abnormal seedling (6.55%) was estimated from seed sample of *Korme* variety while the lowest (5.60%) percentage of abnormal seedling was registered from sample seed of *Didhesa* variety. The highest percentage of dead seed (18.36%) was estimated from seed sample of *Korme* variety while the lowest (14.31%) percentage of dead seed was registered from sample seed of *Didhesa* variety (Table 10). This indicated that germination percentage was influenced by varietal variation.

The highest germination percentage (83.50%) was registered for Haro sabu seed source while lowest (72.27%) germination percentage was estimated from Farmer saved seed source. On other hand, the highest percentage of abnormal seedling (8.77%) was estimated from Farmer saved seed source while the lowest (4.23%) percentage of abnormal seedling was registered from Haro sabu seed source. The highest percentage of dead seed (17.81%) was estimated from seed source of Ano Agro industry while the lowest (12.26%) percentage of dead seed was registered from Haro sabu seed source (Table 10). This indicated that seed source from Haro sabu had higher germination percentage and lower abnormal seedlings.

The highest germination percentage (80.83%) was registered from two months storage duration while the lowest (72.94%) germination percentage was estimated from one year storage duration. However, the highest percentage of abnormal seedling (8.48%) was estimated from one year storage duration while the lowest (4.27%) percentage of abnormal seedling was registered from two months storage duration. The highest percentage of dead seed (18.56%) was estimated from one year storage duration while the lowest (15.57%) percentage of dead seed was registered from six months storage duration which had statistical parity with dead seed from two months storage duration (Table 10). This showed that the prolonged storage duration of soybean varieties retarded seed germination and increased the proportion of dead seeds. Bailly(2004) reported decreasing of germination percentage in aged seeds of sorghum, which he attributed to reduction of α amylase activity and carbohydrate content. The use of good quality seeds with high genetic potential, as well as the adoption of adequate cropping techniques, is crucial to obtain higher yields per unit area (Fraga *et al.,* 1980).

Table 10: Effect of variety, seed source, and storage duration on standard germination, abnormal seedling, and dead seed fractions during pre-sowing test in East Wollega Zone in 2022/23

Variety	Standard germination (%)	Abnormal seedling (%)	Dead seed (%)
Korme	75.13b	6.55a	18.36a
Didhesa	80.04a	5.60b	14.31b
LSD (0.05)	1.008	0.47	0.94
Seed source			
Ano Agro industry	77.00b	5.22b	17.81a
Haro Sabu	83.50a	4.23c	12.26b
Farmer saved	72.27c	8.77a	18.95a
LSD (0.05)	1.23	0.58	1.15
Storage duration			
Two months	80.83a	4.27c	14.89b
Six months	78.98b	5.47b	15.57b
One year	72.94c	8.48a	18.56a
LSD (0.05)	1.23	0.58	1.15
CV (%)	2.74	16.48	12.15

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage coefficient of variation.

The percentage of seed germination was highest (88.08%) for *Didhesa* variety sampled from Haro sabu seed source while the lowest (71.5%) germination percentage was registered for *Korme* variety sampled from Farmer saved seed source. The proportion of abnormal seedling was significantly highest for *Korme* and *Didhesa* varieties sampled from Farmer saved seed source; however, it was significantly lowest (3.72) for *Didhesa* variety sampled from Haro sabu seed source which had statistical parity with *Korme* and *Didhesa* varieties sampled from Ano Agro industry and *Korme* variety sampled from Haro sabu seed source. Highest (19.85) dead seed proportion was obtained from *Korme* variety sampled from Ano Agro industry seed source with statistical parity with dead seed from *Korme* and *Didhesa* varieties sampled from Farmer saved seed source but lowest (8.18) dead seed percentage was obtained from *Didhesa* variety sampled from Haro *sabu* seed source (Table 11).

Table 11: Interaction effect of Variety and Seed source on standard germination, abnormal seedling and dead seeds during pre-sowing test in East Wollega Zone in 2022/23

Treatment		physiological quality		
Variety	Seed source	Standard germination (%)	Abnormal seedling (%)	Dead seed (%)
Korme	Ano Agro industry	74.9c	5.27b	19.85a
	Haro Sabu	78.91b	4.75b	16.3b
	Farmer saved	71.5c	9.64a	18.91a
Didhesa	Ano Agro industry	79.04b	5.18b	15.77b
	Haro Sabu	88.08a	3.72b	8.18c
	Farmer saved	73.02c	7.89a	19.00a
LSD (0.05)		3.63	1.91	2.52
CV (%)		5.74	14.87	18.94

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage coefficient of variation.

The highest (9.47%) percentage of abnormal seedling was obtained from *Korme* variety stored for one year with statistical parity with abnormal seedling from *Didhesa* variety stored for one year. In agreement to the results of this study, Kurdikeri *et al.,* 1996) reported that the seed germination and seedlings vigor declined with increasing storage period (Table 12).

Table 12: Interaction effect of variety x seed source x storage duration on abnormal seedling of soybean varieties during pre-sowing test in East Wollega Zone in 2022/23

Treatment		Storage duration		
Variety	Seed source	Two months	Six months	One year
Korme	Ano Agro industry	2.81jk	3.87hij	9.12cd
	Haro Sabu	2.75jk	4.18hij	7.31ef
	Farmer saved	6.12fg	10.81ab	12.00a
Didhesa	Ano Agro industry	5.25gh	3.750ij	6.56fg
	Haro Sabu	3.50j	2.00k	5.68g
	Farmer saved	5.18ghi	8.25de	10.25bc
LSD (0.05)		1.43		
CV		16.69		

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

4.2.2.2 Seedlings shoot length, root length, dry weight and vigor index

Analysis of variance revealed that main effect of soybean varieties, main effect of storage duration, interaction of variety*seed source and interaction of variety*seed source*storage duration had significant differences for root length, seedling dry weight, vigor index one and vigor index two. Shoot length was significantly influenced by main effect of storage duration, interaction of seed source* storage duration and three factor interaction (variety*seed source*storage duration). Also shoot length was significantly influenced by interaction of variety* storage duration and seed source* storage duration. Main effect of seed source and interaction of seed source* storage duration had significant differences for vigor index one and vigor index two (Appendix 2).

The highest shoot length (16.50cm) was estimated from sample seeds of *Didhesa* variety sampled from Ano Agro industry seed source and stored for six months storage duration and lowest (12cm) shoot length was obtained from *Korme* variety sampled from Haro sabu seed source and stored for one year. The highest root length (7.95cm) was estimated from sample seeds of *Didhesa* variety sampled from Ano Agro industry seed source and stored for six months storage duration and lowest (3.65cm) root length was obtained from *Korme* variety sampled from Ano Agro industry seed source and stored for one year. The highest seedling dry weight (1.670gm) was registered from sample seeds of *Didhesa* variety sampled from Haro sabu seed source and stored for six months storage duration but lowest (1.405cm) seedling dry weight was obtained from *Korme* variety sampled from Haro sabu seed source and stored for one year This showed that that prolonged storage duration decrease seedlings shoot length of soybean varieties at both seed source. In agreement with this study results, (Kapoon *et al.*, 2010) found significant declining of seedling length and vigor as the storage period increased in seeds of chickpea varieties.

Table 13: Interaction effect of variety and seed source and storage duration on Shoot length, Root length and Seedling dry weight, during pre-sowing test in East Wollega Zone in 2022/13

Treatment			SL	RL	SDW
Variety	Seed source	Storage duration			
Korme	Ano Agro industry	2month	14.87bcd	5.95bcd	1.45cd
		6month	14.75bcd	5.25ef	1.48bcd
		1 year	14.50cd	3.65h	1.49bcd
	Haro Sabu	2month	14.97bcd	5.75cde	1.517bc
		6month	15.70ab	5.55cdef	1.42cd
		1 year	12.50e	5.17f	1.405d
	Farmer saved	2month	14.25cd	5.45def	1.46bcd
		6month	14.50cd	5.20f	1.530bc
		1 year	15.00bcd	4.52g	1.44cd
Didhesa	Ano Agro industry	2month	14.32cd	6.42b	1.50bcd
		6month	16.50a	7.95a	1.45cd
		1 year	14.00d	4.20g	1.45bcd
	Haro Sabu	2month	15.77ab	6.00bc	1.51bc
		6month	14.75bcd	5.62cdef	1.670a
		1 year	14.20cd	6.02bc	1.50bcd
	Farmer saved	2month	15.32bc	7.42a	1.50bcd
		6month	14.75bcd	5.65cdef	1.56b
		1 year	14.00d	4.52g	1.46bcd
LSD (0.05)			1.15	0.54	0.10
CV (%)			5.53	6.87	5.04

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at $P<0.05$ and CV (%) = percentage of coefficient of variation.

The highest vigor index one (1405.80) was registered from sample seeds of *Didhesa* variety sampled from Haro sabu seed source and stored for two months storage duration which had statistical parity with vigor index one from *Didhesa* variety sampled from Haro sabu seed source and stored for six months but lowest (931.28) vigor index one was obtained from *Korme* variety sampled from Haro sabu seed source and stored for one year which had non-significance differences vigor index one from *Korme* and *Didhesa* varieties sampled from Ano Agro industry and stored for one year, *Korme* and *Didhesa* varieties sampled from farmer saved seed source and stored for one year, *Korme* varieties sampled from farmers saved seed source and stored for six months.

The highest vigor index two (156.89) was obtained from sample seeds of *Didhesa* variety sampled from Haro sabu seed source and stored for six months storage duration. However, lowest (100.07) vigor index two was obtained from *Korme* variety sampled from farmers saved seed source and stored for one year (Table 14). This showed that the prolonged storage duration decreases vigor index one. Sterlic, 2010 observed the reduction in vigor index of two wheat varieties which were stored for varying storage periods up to 360 days and the reduction in seedling length were attributed to the decline in vigor through storage

Table 14: Interaction effect of variety and seed source and storage duration on Shoot length, Root length, Seedling dry weight, Vigor index one and Vigor index two during pre-sowing test in East Wollega Zone in 2022/23

Treatment			VI1	VI2
Variety	Seed source	Storage duration		
Korme	Ano Agro industry	2month	1196.63cd	116.52def
		6month	1122.25def	112.88fgh
		1 year	993.00gh	102.62ij
	Haro Sabu	2month	1219.57bcd	123.63cd
		6month	1269.14bc	115.16defg
		1 year	931.28h	104.67hij
	Farmer saved	2month	1065.63efg	109.43fghi
		6month	1022.25fgh	107.67ghij
		1 year	1039.00fgh	100.07j
Didhesa	Ano Agro industry	2month	1195.98cd	125.88c
		6month	1320.93ab	116.27def
		1 year	1029.00fgh	107.10ghij
	Haro Sabu	2month	1405.80a	134.54b
		6month	1387.00a	156.89a
		1 year	1153.63de	122.27cde
	Farmer saved	2month	1162.24cde	113.83efg
		6month	1069.50efg	113.09fgh
		1 year	989.63gh	103.76ij
LSD (0.05)			111.17	8.52
CV (%)			6.86	5.18

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

4.3 Seed Yield and Yield Related Traits of Soybean Varieties

4.3.1 Phenology and growth of soybean varieties

Days to 50% flowering, plant height and number of primary branches were significantly influenced by main effect of variety. In addition, Days to 50% flowering, days to 90% physiological maturity, plant height and number of primary branches were significantly influenced by main effect of seed source and storage. Plant height and number of primary branches was significantly influenced by interaction of variety with seed. Days to 90% physiological maturity, Plant height and number of primary branches was significantly influenced by interaction of seed source with storage. This indicated that phenology, plant height and number of primary branches of soybean varieties were significantly influenced by the genetic factor; seed source storage duration and partly it was influenced by the effects of the two factors. No other individual cropping factor influences soybean development and production so much as the sowing season interaction to soybean genotypes (Marcos *et al*., 1986 and Rocha *et al*., 1996). Since these factors are operative regardless of the storage phase or period, anyone concerned with storage of soybean seed-or other kinds of seed-must understand their effects and interactions as they relate to maintenance of quality (Delouche *et al*., 1977).

Longest duration (69 day) to 50% flowering took for both *Didhesa* variety while shortest duration (67 day) to 50% flowering took for *korme* variety (Table15). The earliness to days to flowering might be due to the higher competition to resources as the result plants no longer to stay in vegetative stage. This indicated that the soybean varieties had significant difference for inherent characteristics of days to flowering. Significant difference observed between the varieties might be attributed to the fact that days to flowering in soybean are considered to be varietal characteristics, which is genetically controlled and individual varieties have different growing habit, flowering and maturity days (Tadesse and Sentayehu *et al.,* 2015). Longest duration (72) day to 50% flowering took for Farmer saved seed source while shortest (65) day to 50% flowering was estimated from Haro Sabu seed source. Also seed stored for one year (70) had longest days to flowering. This might be justified that the delayed germination of seeds stored for long period increased delayed emergence of seedlings and thereby delayed flowering of plants. This might be supported by the findings of Ryszard and Dortota (1989) that reported a reduction in field emergence of timothy grass varieties when seed storage period was increased to five years.

Table 15: Variation of soybean varieties for days to50% flowering.

Variety	Days to 50% flowering (%)
Korme	67b
Didhesa	69a
LSD (0.05)	2.06
Seed source	
Ano Agro industry	68.33b
Haro Sabu	65.50c
Farmer saved	72.38a
LSD (0.05)	2.52
Storage duration	
2 months	67.66b
6 months	67.94b
1 year	70.61a
LSD (0.05)	2.52
CV (%)	2.03

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

Tallest plant (51.7) was registered for plants grown from *Didhesa* variety and sampled from Haro sabu research center with statistical parity with *Didhesa* variety and sampled from Ano Agro industry while the lowest plant (45.78) was observed from plants grown from *Korme* variety and sampled from farmers saved (Table 16). This indicate that use of *Didhesa* variety from Haro sabu research center increase plant height. This result in agree with that Hassan et al. (1998) also reported that variation in plant height among soybean cultivars. This might be the genetic improvement of soybean varieties influence the height of the plant and create variation. The present study agreed with Kibebew (2001) who had indicated that plant height is highly influenced by the varietal variation.

Higher number (3.55) of primary branches per plant was registered for plants grown from *Didhesa* variety sampled from Haro Sabu seed source while the lower number (1.92) of primary branches per plant was observed in plants from *Didhesa* and *korme* varieties from farm saved seed source with statistical parity *Korme* variety from Ano seed source (Table 16). This result is agreed with the report of (Amir et al., 2007) that the minimum grains spike-1 in farmer's wheat seed category might be due to aging of the seed, which resulted from poor quality seedling and poor management practices during its development

Table 16: Interaction effect of variety x seed source on plant height, number of primary branches of soybean varieties

Treatment		Yield component	
Variety	Seed source	plant height	No of primary branches
Korme	Ano Agro industry	47.28cd	2.01c
	Haro Sabu	49bc	2.94b
	Farmer saved	45.78d	1.92c
Didhesa	Ano Agro industry	50.9ab	2.76b
	Haro Sabu	51.7a	3.55a
	Farmer saved	47.28cd	1.92c
LSD (0.05)		2.49	0.41
CV (%)		5.41	17.18

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

Highest plant height was obtained from plants grown from sample seed of *Didhesa* variety stored for two months with statistical parity with *Didhesa* variety stored for six months. Least plant height was obtained from plants grown from sample seed of *Korme* variety stored for one year with statistical parity with *Didhesa* variety stored for one year (Table 17). This indicated that prolonged storage duration decreases plant height which is similar to the study result of Kibebew (2001) who had indicated that plant height is highly influenced by the varietal variation.

Table 17: Interaction effect of variety x storage duration on plant height of soybean varieties

Treatment Variety	 Storage duration	Yield component plant height
Korme	2month	48.16b
	6month	48.32b
	1 year	45.58c
Didhesa	2month	52.74a
	6month	51.26a
	1 year	46.11c
LSD (0.05)		2.01
CV (%)		4.35

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

The longest days to physiological maturity (142days) was estimated from Farmers saved seed source and stored for one year duration statistical parity with seed from Farmer saved source and stored for two and six months. However, highest plant height (52.21cm) and Number of Primary branch (3.8) was registered from Haru sabu seeds source and stored for six months. Lowest (44.26) plant height and Number of Primary branch (1.73) was estimated from sample seed from Farmers saved and stored for one year duration which had non-significant difference with Farmers saved and stored for six month and sampled from Ano Agro industry and stored for one year which is agreed with the result of (Tadesse and Sentayehu *et al.,* 2015) (Table 18).

Table 18: Interaction effect of seed source x storage duration on Days to 90% physiological maturity, plant height, number of primary branches of soybean varieties

Treatment		Yield component		
Seed source	Storage duration	Days to physiological Maturity	Plant height	No Primary branch
Ano Agro industry	2month	136.17c	50.68ab	2.76bc
	6month	125.83d	50.46ab	2.43cd
	1 year	138.67bc	46.16de	1.96e
Haro Sabu	2month	126.83d	51.85a	3.21b
	6month	123.33d	52.21a	3.81a
	1 year	136.5c	47.11cd	2.71c
Farmer saved	2month	140.33ab	48.83bc	2.16de
	6month	140.83ab	46.7cde	1.86e
	1 year	142.83a	44.26e	1.73e
LSD (0.05)		3.72	2.46	0.46
CV (%)		2.37	4.35	15.74

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

4.3.1.1 Seed yield and its components

Analysis of variance revealed that main effect of soybean varieties had significant differences for number of pods per plant, hundred seed weight and seed yield and main effect of seed source had significant differences for number of pods per plant, number of seed per pod and seed yield. Number of pods per plant and seed yield was significantly influenced by main effect storage duration. In addition, analysis of variance showed that number of seed pods and seed yield was significantly influenced by interaction of variety with seed source. Number of seed per pods and seed yield was significantly influenced by interaction of variety with storage duration. Also analysis of variance revealed that interaction of seed source with storage duration had significant differences for number of pods per plant (Table1 25). This indicated that seed yield and yield of soybean varieties were significantly influenced by the genetic factor; seed source, storage duration and their interactions. Karkannavar et al., (1991) also suggested that seed yield and components of yield were genetically heritable.

The higher (17.76cm) number of pods per plant was recorded for both seeds from Haro sabu seed source and stored for six months. Least (11.86cm) number of pods per plant was estimated from sample seed from farm saved seed source and stored for one year. Highest number of seed per pod (2.12) was obtained from plants grown from Haro sabu seed source and stored for six months with statistical parity with number of pods per from Haro sabu seed source stored for two months and one year. Least seed yield (629.89) was obtained from plants grown from *Korme* variety stored for one year (Table 19). This indicated that prolonged storage period decreases number of pods per plant at both seed source. This is because of that the seed stored for a longer time the vigor of the seedling and the branch of the plant reduced and finally the number of seed per pod, number of pod per plant and total seed per plant reduced. This result was in agreement with the results reported by (Amir *et al.*, 2007) that the minimum grains spike-1 in farmer's wheat seed category might be due to aging of the seed, which resulted from poor quality seedling and poor management practices during its development.

Table 19: Interaction effect of seed source x storage duration on number of pods per plant

Treatment		**Yield component**	
Seed source	Storage duration	No of pods per plant	No of seed per pod
Ano Agro industry	2month	14.75b	2.01bcd
	6month	14.51bc	2.01bcd
	1 year	12.05d	1.97cd
Haro Sabu	2month	15.6b	2.06abc
	6month	17.76a	2.12a
	1 year	14.71b	2.08ab
Farmer saved	2month	14.71b	2.01bcd
	6month	13.11cd	2.03abcd
	1 year	11.86d	1.94d
LSD (0.05)		1.56	0.09
CV (%)		9.35	3.99

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

The highest (10.45gm) hundred seed weight was registered for *Didhesa* variety while least (9.44) hundred seed weight was obtained from *Korme* variety. This result might be supported by other workers; Noor-Mohammadi et al.(2000); and Cordazzo (2002) that noted high seeds weight will increase germination percent, seedling emergence, tillerring, density, spike and yield (Table 20).

Table 20: Variation of soybean varieties for hundred seed weight

Variety	Hundred seed weight (gm)
Korme	9.44b
Didhesa	10.45a
LSD (0.05)	0.58
CV (%)	2.03

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

The highest (2.14) number of seed per pod was estimated for *Didhesa* variety sampled from Haro sabu seed source. Lowest (1.97) number of seed pod per plant was estimated for *Didhesa* variety sampled from Ano Agro industry seed (Table 21). The highest (1317.11) seed yield was registered for *Didhesa* variety sampled from Haro sabu seed source. Lowest (677) seed yield was estimated for *Korme* variety sampled from Farmer saved seed sources. This indicated that prolonged storage period decreases number of seed per pod at both seed source. The suggestion may be supported by Biabani *et al*., (2011) who reported that Hashem variety was much more resilient to deterioration treatment than Arman variety with increasing age and less reduce yield and yield component of chickpea. Muhammad *et al*., (1999) also reported significant differences in seeds per spike among different wheat varieties (Table 21).

Table 21: Interaction effect of variety x seed source number of seed per pod and seed yield

Treatment	Yield component

Variety	Seed source	No of seed per pod	Seed yield (kg/heck.)
Korme	Ano Agro industry	2.03b	826.11bc
	Haro Sabu	2.03b	914.4b
	Farmer saved	1.99b	677.00c
Didhesa	Ano Agro industry	1.97b	910.56b
	Haro Sabu	2.14a	1317.11a
	Farmer saved	2.00b	854.11bc
LSD (0.05)		0.07	182.15
CV (%)		11.03	20.96

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at P<0.05 and CV (%) = percentage of coefficient of variation.

Highest seed yield (1137.56) was obtained from plants grown from *Didhesa* variety stored for six months with statistical parity with seed yield from *Korme* and *Didhesa* varieties stored for two months. Least seed yield (629.89) was obtained from plants grown from *Korme* variety stored for one (Table 22). This indicated that prolonged storage period decreases seed yield and varietal variation influence grain yield. In agreement to the results of this study, Morrison *et al.,* (2000) reported that soybean yield was impacted by cultivars.

Table 22: Interaction effect of variety x storage duration on number of seed per pod and seed yield of soybean varieties

Treatment		Yield component
Variety	Storage duration	Seed yield (kg/heck.)
Korme	2month	966.26abc
	6month	821.33cd
	1 year	629.89d
Didhesa	2month	1058.11ab
	6month	1137.56a
	1 year	886.11bc
LSD (0.05)		210.64
CV		24.24

Mean values followed by different letters within column had significant difference at 5% probability levels. LSD (5%) = least significant difference at $P<0.05$ and CV (%) = percentage of coefficient of variation.

5. SAUMMARY AND CONCLUSSION

Soybean is among the important legume crops produced in Ethiopia including the northwestern part of the country for home consumption and as domestic and export commodity. However, the availability of quality seeds is one of production constraints. The production of seeds from improved varieties from the right seed source and stored for shortest possible duration period are among the requirements of quality seed production. Therefore, this study was conducted to evaluate farmers' handling practices and effects of seed source and storage condition on quality parameters of soybean varieties in East Wollega, Ethiopia and its subsequent effect on growth, yield and its components and seed quality of soybean. The survey study in the three kebeles included ninety farm households. The treatments for the field and laboratory studies consisted of two varieties (*Didhesa* and *Korme*) x three seed sources (Ano farm, Haro sabu and farm saved) x three storage duration (two month, six month and one years stored under room temperatures) arranged in factorial combinations. Completely randomized design with four replications in laboratory and randomized complete block design with three replications for the field experiment were used to evaluate treatments at East Wollega zone experimental laboratory and site during 2022/2023 cropping season.

The result from the survey data showed that the existing seed system of soybean in all sample districts is dominated by the informal seed sources and a very limited supply of soybean seed variety was available from limited activity of the formal seed system. The continuous use of seeds of farmers' cultivars from the informal seed system due to lack of certified seed source, unavailability of selected and high yielding varieties, extended storage duration, and poor storage management are the major factors for low quality soybean production and productivity in the study area. Low efficiency of the current soybean formal seed system and poor support to strengthening the informal seed system were the major reasons why most of the farmers in the study districts produce the crop from farm saved seeds of farmers' cultivars.

The results from pre-sowing test revealed that seed quality parameters were significantly influenced by one or more main factors (variety, seed source and storage period).The proportions of pure seeds and inert matter were significantly affected by main effects of storage period. Moreover, moisture content, abnormal seedling, shoot length, root length, and vigor index two were significantly influenced by interactions of variety x seed source x storage period. Hundred seed weight was significantly influenced by interaction of variety x seed source. Germination percentage of seeds was significantly influenced by interaction of seed source x storage period, and variety x seed source whereas speed of germination was significantly influenced by interaction of variety x storage duration and seed source x storage period.

The highest moisture content (9.53%) was estimated from seeds of *Didhesa* variety from Haro sabu seed source and stored for two month while lowest moisture content (8.75%) was estimated from seeds of *Didhesa* variety from Ano farm seed source and stored for one year. The highest germination percentage (83.5%) was estimated from seeds of *Didhesa* variety from Haro sabu seed source stored for two month while lowest germination percentage (72.27%) was estimated from seeds of *Korme* variety from Farm saved seed source stored for one year.

The effect of soybean seeds as influenced by three main factors (variety, seed source and storage duration) and all possible two and three factors interactions on phenology, growth, yield components and seed yield was evaluated at field condition. The results of field experiment indicated that days to flowering and plant height were significantly influenced by varietal difference. One or more main factors had significant influence on other phenology, growth, seed yield and its components. Besides, the interactions of variety x seed source had significant effect on days to physiological maturity and number of pod per plant whereas; interaction of variety and storage period had significant influence on seed yield. The growing of *Didhesa* variety from seeds of Haro sabu seed source stored six month produced higher seed yield of 11.38 Qt/ha while growing of *Korme* varieties from seeds of farm saved stored for one years produced significantly lower seed yield 6.3 Qt/ha. Most of the seed quality parameters from pre-sowing test had significant and positive correlation with seed yield and related traits. Moreover, the proportion of pure seeds, germination percentage of seeds, seedling vigor index one and two had positive and significant correlation with seed yield.

The results from the experiments showed that after growing the soybean seeds of different quality influenced by variety, storage duration, seed source and interaction of the two and/or three factors had significant effect on seed yield, yield related traits and seed quality parameters. The use of seeds from Ano and farm saved sources and stored for one year not lead to produce high seed yield and quality seeds of soybean. Thus it is suggested to consider variety; seed source, and seed storage duration to produce high yield and quality seeds to improve the productivity of soybean. However, to come with a conclusive recommendation, additional experiments should be conducted at different locations using more number of varieties, seed sources, and storage durations.

6. REFERANCES

Abush Tesfaye, Asrat Asfaw, Sintayehu Alamire and Mulgeta Atnaf. 2006. Soybean Genetic Improvement in Ethiopia. Pp 95 -102. In: Food and Forage Legumes of Ethiopia: Progress and Prospects. Proceeding of the workshop on food and forage legumes 22-26 September, 2003, Gehion Hotel, Addis Ababa, Ethiopia.

Adam B, Birhanu, and Yalew M., (2018). "Analysis of Cost and Return of Soybean Production under Small holder Farmers in Pawe District, North Western Ethiopia at Ethiopian Institute of Agricultural Research".

Agrawal,P.K 1987. Concept of seed vigor and its measurement .*In:* P.K. Agrawal and M. Dadlani. Pp.90-99. *Techniques in Seed Science and Technology*. ICARDA. Private Limited Company, New Dehali.

Alemu, D. and Spielman, D. (2006) 'the Ethiopian Seed System: Regulations, Institutions and Stakeholders'. Paper presented at ESSP Policy Conference, 6-8 June 2006, Addis Ababa

Amare Belay. 1987. Progress and future prospect in soybean research in Ethiopia. Pp.252-265. In: Proceeding of the 19th National Crop Improvement Conference, Addis Ababa Ethiopia, 22-26 April, 1987, IAR, Ethiopia.

Amare Degene Jemal Haidar, and Gugsa Abate, 2003. Nutrition survey report in Habru and Kobo woreda, North Wollo Zone, Ethiopia

Amare M., Asfaw S., and Shiferaw B.2012.Welfare Impacts of Maize–Pigeon pea Intensification in Tanzania. Agricultural Economics 43 (1): 27–43.

Amir, Arya, A., Kapoor, R., M.A., Kumar, H. and Siddiqui, 2010. Seed Deterioration in Chickpea (*Cicer arietinum* L.) under Accelerated Ageing. Asian J Plant Sic, 9(3.): 158-162.

Anandajayasekeram, P, Bekele, E., and Kisamba-Mugwera, W. (2006) Review of Agricultural Extension Impacts in Ethiopia. IFPRI paper prepared for World Bank, Addis Ababa.

ARC (Awassa Research Center). 2004. Improved soybean varieties and cultural practices protection manual, ARC and EARO (Ethiopian Agricultural Research Organization).Awassa, Ethiopia.

Arunkumar Hosamani, Basavegowda, and Gururaj Sunkad 2013. Effect of Commercial Cold Storage Conditions and Packaging Materials on Seed Quality of Chick pea (*Cicer arietinum*. L.) International Journal Research, 12 (2).

Asfaw, Bekele, Ferede, S, Muricho, T, Setetaw, and Sheferaw 2010. Socio-economic assessment of legume production, farmer technology choice, market linkages, institutions and poverty in rural Ethiopia. Pp .18-20

Asnake, F, Dadi, L., Mitiku, D and Regassa, S. 2005. Adoption of chickpea varieties in the central highlands of Ethiopia. Ethiopian Agricultural Research Organization Research report. P.62

Barton, L.V.1961. Seed Preservation and Longevity, International books and periodicals supply service 216 p London and New York.

Bass, L.N and Justice, O.L.1979. Principles and practices of seed storage, Castle House publication Ltd. London.

Baharathi, R, Vanangamudi. K., N. Natarajan, A. Umarani, K.Natarajan, and T. Saravanan, 2006, *Advances in seed science and technology*. 21p.

Belay, G., Tefera, H, Tadesse, B, Metaferia, G, Jarra, D. and Tadesse, T. (2006) 'Participatory variety selection in the Ethiopian cereal tef (Eragrostis tef)'. Experimental Agriculture 42: 91-101.

Beyene, H., Veruijl, H. and Mwangi, W. (1998) Farmers' Seed Sources and Management of Bread Wheat in Wolmera Woreda, Ethiopia. Mexico, DF: CIMMYT and IAR.

Bishaw, Z. (2004) Wheat and Barley Seed Systems in Ethiopia and Syria, PhD thesis, Wageningen University.

Bolin, P, Godsey, C and Pratt, P, 2009. Soybean production guide. Oklahoma Cooperative Extension Service. Extension of Agricultural Sciences and Natural Resources, Oklahama State University. Pp. 12-114.

Chaluma .T (2020) Effects of Seed Source and Storage Duration on Seed Quality, Yield and Yield Related Traits of Soybean [*Glycine max* (L) Merrill] Varieties at Pawe, Northwestern Ethiopia

CGIAR, 2004. Soybean: Statistics, Research and Impact Consultative Group in International Agricultural Research, Washington, DC

Chongo,G and Gossen, B.D. 2001. Effect of plant age on resistance to *Ascochyta rabiei* in chickpea. Canadian Journal of Plant Pathology, 23:358-363.

CSA (Central Statistical Agency of Federal Democratic Republic of Ethiopia), 2001-2017. Annual report.

CSA. 2014. Report on Area and production of major crops (Volume I). The Federal Democratic Republic of Ethiopia. Central Statistical Agency, May 2014, Addis Ababa.

CSA. 2016. Agricultural sample survey 2015/16 (2008E.C): volume v- report on area, production and farm management practice of belg season crops for private peasant holdings. Statistical Bulletin, Central Statistical Agency, Addis Ababa, Ethiopia.

CSA (Central Statistical Authority of Ethiopia), 2017/2018. Area and production of crops volume I Statistical Bullet. Central Statistical Authority, Addis Ababa, Ethiopia.

Cromwell, E. 1990. Seed diffusion mechanisms in small farmer communities: Lessons from Asia, Africa and Latin America. ODI, London, UK.P.57

Dashiell, Jackai, L.E. and, D.A. Shannon and W.R. Root, 1984. Soybean production and utilization in sub-Sahara Africa. In: proceedings World Soybean Research Conference III. (R. Shibbes ed).Boulder Colorado, USA. Pp: 1193-1202.

Dashiell, K.E, Rachie, K.O and Singh, S.R.1987. Soybean for the Tropics: Research, production and Utilization, IITA, John Wiley-Science publication.UK.

Dawit Tadese and Hirut kebede, 1995. Germplasm collection, conservation and characterization of teff. Plant Genetic Resources center/Ethiopia. Internal Report. Addis Ababa, Ethiopia.

Dawit Alemu.2010. *The political Economy of Ethiopia Cereal Seed Systems.* Pp. 223-289. Market Liberalization and Decentralization. Addis Ababa, Ethiopia.

De Bruin, J., and P. Pedersen, 2009. Growth, yield, and yield component changes among old and new soybean cultivars. *Agronomy Journal,* 101:124-130

Delouche, J.C. 1972. Harvesting, handling and Storage of soybean seed. Pages 17-22 in proc.1972 short course for seed men, volume vol.15.Mississippi state University.

DSHC.2009. Danishes Seed Health Center (DSHC), Seed System in Developing Countries. Maria Charlotte Arup Busch.

Ethiopian ATA & USAID Investment Support Program (2013). "Immediate opportunity to invest in soybean meal processing for Ethiopia's booming livestock and poultry sectors".

Ellis, F. (1992) Agricultural Policies in Developing Countries. Cambridge: Cambridge University Press

Ellis RH, Hong, T.D., Roberts, E.H. 1985. Handbook of seed Technologies for Gene Banks. Vol.1. IBPGR, Rome. Pp 518-537

ESSP (Ethiopian Sees Strategies Program). 2006. Ethiopian Seed system Regulation and Stakeholders: 6-8 June, 2006.Addis-ababa, Ethiopia. Pp 109-115.

Fabrizius, E., Tekroni, D.M., Egli, D.B. and Rucker, M. 1999. Evaluation of viability model for prediction soybean seed germination during warehouse storage. Crop science, 39: 194-201.

FAO/WFP Crop and Food supply assessment mission to Ethiopia, 24 February, 2006.

FAO (2010). Food outlook. Oil Seeds Business Opportunities Ethiopia, 2009; J.H.M. Wijnands, J. Biersteker, E.N. van Loo. FAOSTAT (2015). Food and Agriculture Organization of the United Nations Statistical Database available.

Gebeyehu AB., (2015). "Major Agricultural Trade Volume in Ethiopia". Trade Balance and Exchange Rate Relations a Structural Break Analysis.

Geletu Bejiga, Million Eshete and Yadeta Anbessa.1996. Improved cultivars and production technology of chickpea in Ethiopia. Debre Zeiet Agricultural Research center (DZARC), Debre Ziet, Ethiopia.

Gokhale, D. 2009. Post-harvest seed storage/handling. Syngenta Foundation for Sustainable Agriculture. STAK Conference, Nairobi. Pp. 1-11.

Green, D.C., L.E, Cavanash, and E.L pinnel. Effect of seed moisture content, field weathering and combine cylinder speed on soybean seed quality, Crop Sci.11:531-535

Greenberg, P and Hartung, H.N. (1998). The whole soy cookbook: 175 delicious, nutritious, easy to prepare recipes featuring tofu, tempeh, and various forms of nature's healthiest bean. Three Rivers Press, New York.

Gurmu, F. 2010. Overview of Soybean Research in Ethiopia. Hawassa: SARI.

GTP II (Growth and Transformation Plan II) (2015). Ministry of Agriculture and Rural Development Second Growth and Transformation plan, Addis Ababa, Ethiopia.

Hampton, J.G.1992. Vigor testing with laboratories of the International Seed Testing Association: *A survey. Seed Sci. and Technology*, 20:1999-203

Hampton, J.G. 1998. Seed quality standards, their use, misuse and the future. Journal of Applied. Seed Prod, 16: 31-48.

Harrington, J.F. 1972. Seed Storage and Longevity. In: Kozlowski, T.T. (ed.): Seed Biology, 3: 145-245.

IITA (International Institute of Tropical Agriculture). 2009. Soybean overview. Summary. 5 pp.

ISTA, 1976. International Rules for Seed Testing. Seed Sci. and Tech., 4:51-177.

ISTA, 1999. International Rules for Seed Testing. Seed Sci. and Tech., 27:1-333.

ISTA, 2014. International Rules for Seed Testing. Seed Sci. and Tech...

Kaleb K. and Mekonnen H. (2014). "Trends in Soy Bean Trade in Ethiopia at Ethiopian Institute of Agricultural Research".

Kirenga, G, Malema, B. Myaka, F. A, (Eds) (2005). Proceeding of the First National Soybean Stakeholders Workshop, 10 - 11 November 2005, Morogoro, Tanzania.

Lamp, B.J, Harkness, W.H., Johnson, H. and Smith, P.E.1962. Soybean harvesting approaches to improved harvesting differences. Ohio Agr. Exp. Sya.Res.Bull.899.

McDonald, M.B. 1980. Assessment of seed quality: Journal of Horticultural Science.15:784-788.

McDonald M.B., 1998. Improving our understanding of vegetable and flower seed quality. Seed Technology, pp.121-124.

Maguire, J.D.1962. Speed of germination, an aid in seed selection and evaluation for seedling emergence and vigor. *Journal of Crop Science*, 2:176-177.

Ministry of Agriculture and Rural Development (MOARD).2005. Crop variety Registration Crop Development Department. Sepember.2004. Addis Ababa, Ethiopia.

MOARD (2007) Crop Variety Register, Issue No. 10. Addis Ababa: MOARD, Crop Development Department.

MOARD (2008) Crop Variety Register, Issue No. 11. Addis Ababa: MOARD, Crop Development Department.

MOARD (2009) '2001/2002 Seed Multiplication Plan', MOARD [translated from the Amharic version]

Monti, W.1972.How to minimize damage in handling, processing and shipping soybean seed. In Proc. 2nd soybean Conference. American Seed Trade Association, Washington. D.C

Ngeze, P.B.1993. Learn How to Grow Soybean. Nairobi, Kenya. CTA Publ. 21 pp.

Nkang, A. and Umbo, E.O.1996. Six month storability of five soybean cultivars as influenced by stage of harvest, storage temperature and relative humidity. Seed Science and Technology, 25:93-99.

Osafo, D.M.1977. Effect of population density on soybean varieties in Gahana's forest Zone. Exp. Agric.13: 235-340.

Osho, S.M. (1995). "Soybean processing and utilization research at International Institute of Tropical Agriculture". Processing from SOYAFRICA'95: Johannesburg, South Africa, 4-5 October 1995.

Oxley, T. A.1 948. The Scientific principles of grain storage, northern publishing Co. Liver pool, England.

PARC (Pawe Agricultural Research Center). 2010. Annual Report, Pawe Agricultural Research Center Agricultural Economics, Extension and Gender Research Process, unpublished.

P. Thoenes, "Soybean International Commodity Profile, Markets and Trade Division Food and Agriculture Organization of the United Nations", (2014), pp. 1-25.

QSAE (Quality and Standards Authority of Ethiopia). 2012. Soybean seed- Specification, Ethiopian Standards. Ref. No. ES 427: 2012. Addis Ababa .Ethiopia.

Roberts, E. H. 1972. Storage environment and control of viability. In: Viability of Seeds, Ed. E.H Roberts, Chapman and Hall Ltd., London. Pp .14-18

Ryszard. J, Gorecki, D.M, 1989.The vigor of timothy of (*Phuleum pretense* L.) seed stored up to 5 years. *Acta societastis botanicorum poloniae*.

Samson Seife. 2013. Assessment of Seed Quality Standards Implementation in Local Seed Business of *Tef* [*Eragrostis Tef (Zucc*.)Trotter] seed production: The case of Halaba special and Mesken Woredas, South Ethiopia, MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

Scott, D.J.1980. The role of seed testing. In: Lancashire, J.A. (ed.) *Herbage seed production. Seed Science and Technology,* 18:721-729.

Shelar VR. 2008. Role of mechanical damage in deterioration of soybean seed quality during storage- a review. *Agric. Rev*., 29 (3: 177-184)

Shelar. V.R, Shakih R.S and Nikam A.S.2008. Soybean seed quality during storage.

Sisman, C, and Delibas, L. 2004. Storing sunflower seed and quality losses during storage. Journal of Central European Agriculture, 4:239-250.

Strelec, R.P, Ilonka, Vlatka, J, Zorica, J, Zaneta, U. and Mirjana. S. 2010. Influence of temperature and relative humidity on grain moisture, germination and vigor of three wheat cultivars during one-year storage, faculty of food technology, Franje Kuha 20, HR-31000 Osijek. (2) 20-24.

Tadese Ghiday, Sentayehu A (2015) Genetic Divergence Analysis on Some Soybean (*Glycine max* L. Merrill) genotypes Grown in Pawe, Ethiopia. American –Europian J. Agric and Environ Sci 15(10):1927-1930.

Tekrony, D.M, Egil. D.B. 1987. Seed production and technology in soybean.

Tekrony,D.M, Egli, D.B 1991.Relationship of seed vigor to crop yield . *Crop science,* 31:816-822.

Urgessa T. (2014). "Empirical Review of Production, Productivity and Marketability of Soybean in Ethiopia" at Oromia Agricultural Research Institute.

Verma, S.S, Tomer R.P.S. and Urmil, V. 2003. Loss of viability and vigor in Indian mustard seed stored under ambient conditions. *Journal of Seed Research*, 31 (1):98-101.

Wilcox, J.R.2004. World distribution and trade of soybean, In H.R. Boerma and J.E. Specht. eds. Soybeans: *improvement , production and uses, Agronomy* No.16.3rd ed.

7. APPENDICES

Household Survey Questionnaire for MSc Thesis Defense

This questionnaire will be used for data collection for MSc thesis defense as ‘‘Evaluation of Farmers’ Handling Practices, Seed source, and Storage Condition on the Quality parameters of Soybean (Glycine Max (L) Varieties in East Wollega Zone, Ethiopia’’.

The purpose of this questionnaire is to collect primary data that will be used only for my MSc thesis defense. I am requesting your kind cooperation and patience in providing accurate and reliable responses to the questions. Your response is anonymous, completely confidential, and only summary information will be reported in the study results. I would like to appreciate your courage and kind responses.

General Instruction for Enumerators

1. Please administer this tool to the head of the household in the study area.
2. Introduce yourself, greet warmly and tell the respondent the purpose of the survey.
3. Respect each respondent’s knowledge and words while you are conducting the survey.
4. Ask the respondent each question with his/her own local language.
5. Make sure that all questions are correctly filled before closing each interview.
6. Please, thank each respondent before your departure.

Thank you very much for your kind cooperation!!

General Information

I. Household Identification

1. Region ______________________
2. Zone_______________________________
3. District __________________________

5 Kebele_____________________________

6 Village /Group Name____________________

7 Name of household head/Organization________________________

8 Sex of household head 1=Male 0= Female (Encircled your choice)

9 Name of the respondent_______________________________

10 Sex of the respondent1=Male 0= Female (Encircled your choice)

11 Cell phone Number______________________

12 Name of enumerator____

II. Farm Characteristics (2013/2014 EC)

1. Land holding (ha)

1.1 Own land _____________ha 1.2 Rented in _____________ha

1.3 Shared in _____________ha 1.4 Rented out ___________ ha

1.5 Shared out ___________ ha

2 Cropping pattern

2.1 Maize area _______________ ha 2.2 Sorghum area ______________ ha

2.3 Tef area __________________ ha 2.4 Finger Millet area __________ ha

2.5 Wheat area _______________ ha 2.6 Faba bean area ____________ ha

2.7 Common bean area__________ ha 2.8 Soybean area ______________ ha

2.9 Ground Nut area ___________ ha

3 Household Characteristics

S.N	Name of household member, start with head	Sex 1=Male 0=Female	Relationship to the Hh head CODE 1	Age(complete years)	Marital status CODE 2	Education(years) CODE 3	Primary Occupation CODE 4

Justification of Codes

CODE 1	CODE 2	CODE 3	CODE 4
1 Household head	1. Married	1. None/ Illiterate	1. Crop production
2. Spouse	2. Single	2. Read and write	2. Only poultry farming
3. Son/Daughter	3. Divorced	3. Elementary (1- 6)	3.Crop and livestock production
4. Maid person	4.Widowed	4. Secondary (7-8)	4. Domestic work 5.Retired
5. Hired labor		5. High School (9-12)	6. Unemployed college
6. Relatives		6. Above 12 grade	7.Agriculture wage labor
		7. University graduate	8.Student 9. Business
			10. Other, specify

IV. Agronomy management, cultural practice and land distribution during 2013/2014 E.C

Land distribution

Crops	Name of variety		Total Area in hectare		Total Amount produced in Qt		Productivity (Kg/ha)		Price per kg	
	Local	Impro ved	Local	Impro ved	Local	Impro ved	Local	Impro ved	Local	Impro ved
Maize										
Sorghum										
Tef										
Finger Millet										
Wheat										
Faba bean										
Common bean										
Soybean										
Ground Nut										
Others										

2.2 Agronomy and Cultural practice (Encircle your choice)

2.2.1 Which type of Soybean seed sources are widely found in your area?

1. Formal seed source 2. Informal seed source 3. Both are equally found

2.2.2 What types of Soybean seed varieties found in your locality?

1 Local Variety 2. Improved variety 3. Both are equally found

2.2.3 Which variety you prefer to grow on your farm?

1 Local Variety 2. Improved variety 3. Both equally

4.2.4 Why you prefer producing improved soybean varieties? Because it is;

1. High yielding 2. Insect pest resistance 3. Long Storage life 4. Improve soil fertility 5. Better food quality 6. Seed size 7. Higher price 8. Others (specify

2.2.4 What is the most commonly improved soybean variety grown in your area?

1. *Cheri* 2. *Didhesa* 3.*Ethio-Ugozlavia* 4. *Boshe* 5. *Korme* 6. *Keta*

4.2.6 What are the major site selection criteria for Soybean seed production?

1. Agro climatic condition should be considered.

2. Soil fertility status should be checked

3. Prevalence and absence of weed and disease should be considered.

4. Previous crop grown on the field should be checked.   5. Others (specify)

4.2.7 How did you plough Soybean field last year?

1. By Oxen 2. Manually 3. By Tractor 4. By Oxen and manually 5. Others (specify)

4.2.8 How many you repeatedly plough the land to sow Soybean seed? ___________

4.2.9 Do you apply rouging on your Soybean field?   1. Yes   2. No

4.2.10. If yes how many times you applied? _____________

4.2.11. At what stage did you practice roughing? 1. before flowering 2. At maturity

3. At flowering 4. At harvesting

4.2.12 Do you think seed source determines the Soybean seed quality? 1. Yes 2. No

4.2.13 If yes, which Soybean seed source maintain the quality of seed in better condition?

1. Research centers 2. Private farm companies 3 Farm saved seed by farmers

4.2.14 Can storage duration affect the quality of Soybean seed? 1 Yes 2. No

4.2.15 If yes, which storage duration is mostly viable as a source of good quality soybean seed? ________Month.

4.2.16 Which types of storage condition are commonly practiced to store Soybean seed in your area?

________________________________,___________________________,__________

_________________________________,______________________________,_______

4.2.17. Did you treat your Soybean seed with chemicals to prevent insect pest attack at storage?   1. Yes   2. No

4.2.18. If No, Why? 1. Lack of chemicals 2. I do not know how to treat 3. I also use it for family consumption. 4. It Resist insect pest attack.

4.2.19 Can you use second generation of Soybean seed for cultivation? 1. Yes 2. No

4.2.20 If yes, why you practice this condition? Because it is;-

1. Easily found in our locality 2. It is high yielding.3. It is cheap. 4. It has good quality.

4.2.21 .Did you replace Soybean seed from source to improve your production?

1. Yes 2. No

4.2.22 If yes, at what frequency? 1. Every one year 2. Every two years 3. From 3-5 years

4.2.23. Did you use crop rotation pattern in Soybean seed production? 1. Yes 2.No

4.2.24. If yes, with which crop you mostly rotate with Soybean? ___, rotation cycle ___ years.

4.2.25. Among different Soybean seed sources found in your area, whom you trust regarding to the quality of the seed?

1 Cooperative unions 2. Agricultural extension units 3. Research centers

4. Local Market 5.ESE 6. Farmer saved source 7. OSE

4.2.26. What criteria are there that you use to categorize the Soybean seed as quality seed?

1. High Yielder 2. Disease free 3. Germination percentage 4. Moisture content

5. Physical purity 6. Marketability/ price 7. Producer preference 8. Others, specify.

4.2.27. Did you harvest Soybean seed at its right maturity stage? 1. Yes 2. No.

4.2.28 If no, why?

___

4.2.29 How you harvest Soybean seed 1. Manually by human power

2. By mechanized machine 3. By Both

4.2.30 How you dry Soybean seed to maintain moisture content?

1. Spreading on mud floor on open sun light.
2. Spreading on mud floor under shade.
3. Spreading on plastic materials under ventilated air.
4. Spread on woven materials under shade with time based stirring
5. Putting in woven clothes and hanging under fire smoke.
6. Simply collecting the seed in sisal sack and putting in pile.

4.2.31. What are the most Soybean storage structures you mostly use to keep its quality?

1, ______________________________ 2.______________________________

3.______________________________ 4.______________________________

4.2.32. Are the mostly used Soybean seed storage structures found in your area cause seed quality deterioration? 1. Yes 2. No

4.2.33 If yes how? ____

4.2.34. As soybean seed producer how you tries to overcome this problem?

____

4.2.35. Did you observe disease and fungi that attack Soybean seed on field caused due to storage duration and condition? 1. Yes 2.No

4.2.36. If yes, mention them____

____

4.2.37 How you estimate the yield loss and further effect?

____

4.2.38 what measures you would take to overcome the problem?

____

4.3 Soybean production of seed and grain during 2013/14 E.C

Crop	Variety	Area	Sowing Date	Planting method		Seed rate (Kg/ha)	Seed Class	Amount produced Qt	Price/kg	Purpose of production	
				Broadcast	Row					Seed	Grain
Soybean											

4.4 Input requirement for Soybean production

Input type	Input description Kg/ha	Unit	Amount applied		Acquired from 1= ESE 2=OSE 3=Research center 4=Coop/union 5=Seed producers 6=Another farmers 7=Local market 8=Others(Specify)	How acquired? 1=Gift/free 2= Purchase 3=Exchange 4=Loan in Cash 5=Loan in kind 6=Others	Price in ETB	
			Local	Improved			Local	Improved
Seed	Seed							
Fertilizer	NPS							
	Urea							
	Compost							
	Manure							
	Pesticide							
Chemical	Herbicides							
	Insecticides							

5. Major problems encountered in seed production activities (Rank within the crop type; 1=most)

Problems encountered	Soybean
1=Poor quality of source seed	
2= Lack of preferred variety of source seed	
3= Delay in seed collection	
4=Low price	
5=Lack of training/Advise	
6=Lack of inputs (fertilizer, chemicals)	
7= High cost of inputs	
8=Ineffectiveness of inputs	
9=Late payment for seeds	
10=Price Fluctuation	
11 = Lack Storage materials	
12= Others (specify)	

6. Labor and input utilization for soybean production

6.1 Labor requirement for cultural practices

Cultural practice	Frequency	Labor (man/day)	Price for labor				
			Family member	Labor Exchange	Hired labor		Other Labor
					Male	Female	
Site selection							
Land preparation							
Sowing							
Fertilization							
Weeding							
Field inspection							
Rouging, thinning							
Chemical Application at field							
Harvesting							
Threshing							
Cleaning and chemical application							
Storing							
Marketing							
Seed conservation							

7. Training (Agricultural Information)

7.1. Have you or your family ever participated in quality Soybean seed production training in the last three years? 1. Yes 2. No

7.2. If your answer for above question is no, Why_______________________________

7.3. If your answer for the above question is yes, on which aspect, by whom and for how long you have got the training on quality Soybean production?

Training type	By Whom	Number of days	Is the training is understandable and practicable (1=Yes 2=No)	Did you apply the training on your farm (1= Yes 2=No)	Remark
Soybean seed production					
Crop management					
Soybean pre and post-harvest handling					
Fertilizer/ compost application					
Harvesting					
Soybean marketing					

7.4. Did you have information about improved Soybean package technologies such as? (Blackened the answer)

	Yes	No
Agronomy	(1)	(0)
Fertilizer	(1)	(0)
Herbicides	(1)	(0)
Pesticides	(1)	(0)
Varieties	(1)	(0)
Storage materials	(1)	(0)

8. Soybean seed harvesting and processing

8.1 Which harvesting method did you use? 1. Manual 2. Combine harvester 3. Others (specify)

8.2 Which type of threshing methods and yard did you use?

1. Common yard and animal power 2. Separate yard and animal power 3. Combine harvesters

8.3 What is the condition of your threshing floor?

1. Prepare new floor for all crop 3. Prepare new floor for each crop

2. Same for each year 4. Same for different varieties

5. Different for different crop

8.4 What was the average Soybean yield per hectare in quintals?

8.5 What method of Soybean seed cleaning did you use?

1. Hand sieving at planting 3. Wind winnowing at threshing

2. Seed cleaning machine 4. Others (specify)

8.6 Why you clean Soybean seed?

1. To improve quality 2. To remove small/damaged seed 3. To remove weeds (Other crops) 4. Remove insect damaged/ diseased seeds 5. Others (Specify)

9. Storage facility and structure

9.1 Which storage type/ structure did you use?

1. Gotera inside the house 4. Sack/Polyethylene bag

2. Sack/ bags and *gotera* 5. Concrete wall and floor with ventilator

3. Mud wall and concrete floor 6. Others (specify)

9.2 How is your storage structure capacity? ……………..Qt

9.3. Did you separately manage seed and grain? 1. Yes 2. No

9.4. Did you store Soybean seed for long period of time 1. Yes 2. No

9.5. If your answer for the above question is yes. How many longest did you stored? ____

10. Field inspection and certification

10.1 Is your field inspected by external regulatory experts for certification? 1. Yes 2. No

10.2 If yes, at what stage____________________________. How many times__________

10.3. Is your produced seed tested for laboratory seed quality parameter? 1. Yes 2. No

10.4. If yes for the above question, for which quality parameter? ___________________

10.5. Is your organization have employed seed or related professionals for internal field management and inspection? 1. Yes. 2. No

10.6 If your answer for the above question is no, who inspect and manage your field internally? ____

11 Packaging and labeling

11.1 Do you packed and labeled your Soybean seed? 1. Yes 2. No

11.2 Did you treated your Soybean seed before planting and marketing? 1. Yes 2. No

11.3 If your answer for the above is no, why____________________________________

12. Seed marketing and distribution

12.1. Who is your Soybean seed buyer? 1. OSE 2. ESE 3. Research centers 4. NGO

5. Agricultural office 6. Local farmers 7 Others____________________________

12.2. Is Soybean seed marketing is a problem for you? 1. Yes 2. No

12.3 If your answer for the above question is yes, what are the major reasons? _________

13. Did you have improved Soybean seed supply problem/shortage for production?

1. Yes 2. No

14. Do you have other problem/shortage for production? 1. Yes 2.No

15. What are the main problems of quality Soybean seed production? _______________

16. Farmer's general opinion in your own observation, what can you suggest that could help for quality improvement of Soybean seed production and management in your locality? ____

Tables in the Appendix

Appendix Table 1: Mean squares from analysis of variance for phenology, growth, yield components and seed yield of soybean varieties

Parameter	Replication (2)	Variety (1)	Seed Source (2)	Storage Duration (2)	V*Ss (2)	V*Sd (2)	Ss*Sd (4)	V*Ss*Sd (4)	Error (34)	CV (%)
DF	5.6ns	58.07*	215.79**	47.5*	3.35ns	10.6ns	5.9ns	13.5ns	3.72	5.42
DPM	10.35ns	7.4ns	711.40**	392.29**	3.62ns	0.96ns	87.49*	8.26ns	3.39	2.52
PH (cm)	0.60ns	97.06**	67.01**	111.62**	4.58*	18.73**	3.59*	3.31ns	1.14	2.34
NPB	0.28*	2.80**	8.16**	1.96**	0.72**	0.02ns	0.55**	0.05ns	0.24	9.64
NPP	1.01ns	38.5**	39.56**	29.09**	1.63ns	1.82ns	5.67**	0.91ns	0.93	6.54
NSP	0.001ns	0.006ns	0.04**	0.014ns	0.034*	0.018*	0.0041ns	0.004ns	0.069	3.41
HSW	3.46ns	13.64*	1.79ns	0.66ns	0.96ns	1.83ns	1.85ns	2.05ns	1.04	10.54
SY (kg ha^{-1})	45822.7ns	661879.7**	583259.2**	344182.7**	120583.9*	60735.7*	21317.3ns	41867.8ns	134.8	14.7

ns, * and **= non-significant, significant at P<0.05 and P< 0.001 probability level, respectively. V= Variety, Ss= Seed source, Sd= Storage duration and CV (%) = Coefficient of variation. Number in parenthesis represents degree of freedom for the respective source of variation. DF=Days to 50% flowering, DPM=Days physiological maturity, PH (cm) =Plant height (cm), NPB=Number of primary branches, NPP=Number of pods per plant, NSP=Number of seed per pod, HSW (g) =Hundred seed weight (g) and SY (kg ha^{-1}) =Seed yield kg per hectare.

Appendix Table 2: Mean squares from analysis of variance for pre-sowing seed quality parameters of soybean varieties

Parameter	Replication (3)	Variety (1)	Seed source (2)	Storage Duration (2)	V*Ss (2)	V*Sd (2)	Ss*Sd (4)	V*Ss*Sd (4)	Error (51)	CV (%)
Pure seed (%)	0.078	0.005	0.06	0.043	0.018	0.004	0.016*	0.067	0.198	0.20
Inert matter (%)	0.078	0.005	0.06	0.043	0.018	0.004	0.016*	0.067	0.19	15.9
Moisture content (%)	0.31	0.19	0.13	3.71**	0.001	0.007	0.09	0.11	0.35	3.90
Standard germination (%)	4.31	435.12**	762.83**	408.32**	91.29**	10.75	49.23**	8.01	2.13	2.7
Abnormal seedling (%)	1.46	16.29*	136.21**	113.28**	4.18*	13.21**	10.88**	2.73*	1	16.48
Dead seed (%)	7.49	295.04**	308**	91.36**	101.58**	9.74	45.88**	5.89	1.98	12.15
Shoot length (cm)	1.16	1.47	0.26	8.43**	0.26	0.22	2.99*	4.51*	0.79	5.41
Root length (cm)	0.046	11.92**	0.30	14.79**	1.08*	0.58*	4.66**	2.53**	0.39	7.01
Seedling dry weigh (gm)	0.008	0.038*	0.005	0.019*	0.022*	0.005	0.007	0.016*	0.074	4.97
Seedling vigor index one	11675.4	162432.90**	172778.40**	261104.6**	32395.98*	3998.38	35925.05*	17587.24*	76.31	6.67
Seedling vigor index two	60.65	2265.99**	2091.91**	1509.29**	671.36**	142.70*	160.90*	202.45*	5.89	5.08

Ns, * and **= non-significant significant, significant at P<0.05 and P< 0.001 probability level, respectively. V= Variety, Ss= Seed source, Sd= Storage duration and CV (%) = Coefficient of variation. Number in parenthesis represents degree of freedom for the respective source of variation

Appendix Table 3: Main effects of storage duration, seed source and variety on days to physiological maturity, plant height, number of primary branches, number of pods per plant, number of seed per pods, seed yield in East Wallega Zone in 2022/23

Treatment	**DPM**	**PH**	**NPB**	**NPP**	**NSP**	**SY**
2month	134.44b	50.45a	2.71a	15.02a	2.03a	1012.20a
6month	130c	49.79a	2.70a	15.13a	2.05a	979.44a
1 year	139.33a	45.85b	2.13b	12.87b	2.00bc	759.00b
LSD (0.05)	2.29	0.77	0.16	0.63	0.046	91.36
Ano Agro industry	133.56b	49.10b	2.38b	13.77b	2.00b	868.33b
Haro Sabu	128.89c	50.39a	3.25a	16.02a	2.08a	1115.75a
Farmer saved	141.33a	46.60c	1.92c	13.23b	1.99b	765.56c
LSD (0.05)	2.29	0.77	0.16	0.63	0.046	91.36
Korme	134.96a	47.35b	2.29b	13.50b	2.01a	805.84
Didhesa	132.22a	50.04a	2.74a	15.18a	2.04a	1027.26
LSD (0.05)	1.87	0.63	0.13	0.51	0.03	74.60
CV (%)	2.52	2.34	9.64	6.54	3.41	14.71

Means followed by the same letter along columns in each seed yield parameter are not significantly different from each other at 5% probability level.LSD (5%) =least significant difference at 5 % level of significance

Appendix Table 4: Main effects of storage duration, seed source and variety on pre-sowing standard germination, abnormal seedling, dead seed, shoot length, root length, seedling dry weight, vigor index one and vigor index two

Treatment	SG	ABN	DS	SL	RL	SDW	VI1	VI2
2month	80.83a	4.27c	14.89b	14.92a	6.16a	1.49ab	1207.6a	120.64a
6month	78.98b	5.47b	15.57b	15.15a	5.87b	1.52a	1198.5a	120.32a
1 year	72.94c	8.48a	18.56a	14.03b	4.68c	1.46b	1022.5b	106.75b
LSD (0.05)	1.23	0.58	1.15	0.46	0.22	0.043	44.22	3.41
Ano Agro industry	77.00b	5.22b	17.81a	14.82a	5.57a	1.47a	1142.96b	113.54b
Haro Sabu	83.50a	4.23c	12.26b	14.65a	5.68a	1.50a	1227.73a	126.19a
Farmer saved	72.27c	8.77a	18.95a	14.63a	5.46a	1.49a	1058.04c	107.97c
LSD (0.05)	1.23	0.58	1.15	0.46	0.22	0.04	44.22	3.41
Korme	75.13b	6.55a	18.36a	14.56a	5.16b	1.46b	1095.41b	110.29b
Didhesa	80.04a	5.60b	14.31b	14.84a	5.98a	1.51a	1190.41a	121.51a
LSD (0.05)	1.008	0.47	0.94	0.37	0.18	0.035	36.11	2.78
CV (%)	2.74	16.48	12.15	5.41	7.01	4.97	6.67	5.08

Means followed by the same letter along columns in each seed quality parameter are not significantly different from each other at 5% probability level .LSD (5%) =least significant difference at 5 % level of significance

Appendix Table 5: Interaction effect of variety x seed source on abnormal seedling, root length and seedling dry weight

Treatment				
Variety	Seed source	ABN	RL	SDW
Korme	Ano Agro industry	5.27b	4.95c	1.47b
	Haro Sabu	4.75b	5.49abc	1.44b
	Farmer saved	9.64a	5.05bc	1.47b
Didhesa	Ano Agro industry	5.18b	6.19a	1.47b
	Haro Sabu	3.72b	5.88a	1.56a
	Farmer saved	7.89a	5.86ab	1.50ab
LSD (0.05)		1.91	0.82	0.067
CV (%)		14.87	18.1	5.52

Means followed by the same letter along columns in each seed quality parameter are not significantly different from each other at 5% probability level. LSD (5%) =least significant difference at 5 % level of significance

Appendix Table 6: Interaction effect of variety x seed source on vigor index one and vigor index two

Treatments			
Variety	Seed source	Vigor index one	Vigor index two
Korme	Ano Agro industry	1103.96bc	110.67bc
	Haro Sabu	1139.99bc	114.49b
	Farmer saved	1042.29c	105.72c
Didhesa	Ano Agro industry	1181.97b	116.42b
	Haro Sabu	1315.48a	137.90a
	Farmer saved	1073.79c	110.22bc
LSD (0.05)		104.09	8.21
CV (%)		11.17	8.69

Means followed by the same letter along columns in each seed quality parameter are not significantly different from each other at 5% probability level .LSD (5%) =least significant difference at 5 % level of significance

Appendix Table 7: Interaction effect of variety x storage duration on abnormal seedling, root length and vigor index two

Treatments				
Variety	Storage duration	Abnormal seedling	Root length	vigor index two
Korme	2 months	3.89d	5.71b	116.53bc
	6 months	6.29bc	5.33bc	111.90cd
	1 year	9.47a	4.45d	102.45d
Didhesa	2 months	4.64cd	6.61a	124.75ab
	6 months	4.66cd	6.40a	128.75a
	1 year	7.50ab	4.91cd	111.04cd
LSD (0.05)		1.98	0.63	9.48
CV (%)		15.24	13.88	10.03

Means followed by the same letter along columns in each seed quality parameter are not significantly different from each other at 5% probability level. LSD (5%) =least significant difference at 5 % level of significance

Appendix Table 8: Interaction effect of seed source x storage duration on abnormal seedling, root length, vigor index one and vigor index two

Treatment					
Seed source	Storage duration	ABN	RL	VI1	VI2
Ano	2month	4.03e	6.18ab	1196.30cd	121.20bc
Agro	6month	3.81e	6.60a	1221.59bc	114.57cd
industry	1 year	7.84c	3.92d	1011.00f	104.86de
Haro	2month	3.12e	5.87abc	1312.69ab	129.09ab
Sabu	6month	3.09e	5.58bc	1328.07a	136.02a
	1 year	6.50cd	5.60bc	1042.45ef	113.47cd
Farmer	2month	5.65d	6.43a	1113.93de	111.63cde
saved	6month	9.53b	5.42c	1045.88ef	110.38de
	1 year	11.12a	4.52d	1014.31ef	101.91e
LSD (0.05)		1.36	0.72	100.52	10.27
CV (%)		22.47	13.05	8.80	8.86

Means followed by the same letter along columns in each seed quality parameter are not significantly different from each other at 5% probability level. LSD (5%) =least significant difference at 5 % level of significance