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Seed System and quality Analysis of Finger Millet (Elusine Coracana L. Gaertn) in Dera, Mecha, and Sekota Districts of Amhhara Region, Ethiopia

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GRADUATE PROGRAM

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M.Sc. Thesis

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THESIS APPROVAL SHEET

As a member of the Board of Examiners of the Master of Sciences (M.Sc.) thesis open defence examination, we have read and evaluated this thesis prepared by **Mr. Getasew Msganaw** entitled **"Seed System and Quality Analysis of Finger Millet (***Elusine coracana L. Gaertn***) in Dera, Mecha, and Sekota Districts of Amhara Region, Ethiopia"**. We here by certify that, the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Sciences (M.Sc.) in **Seed Science and Technology**.

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DECLARATION

This is to certify that this thesis entitled **"Seed System and Quality Analysis of Finger Millet (***Elusine coracana (L.) Gaertn***) in Dera, Mecha, and Sekota Districts of Amhara Region, Ethiopia"** submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in "Seed Science and Technology" to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by **Mr. Getasew Msganaw** (ID No. BDU1500172) is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for an award of any degree or diploma to the best of our knowledge and belief.

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ACRONYMS AND ABBREVIATIONS

AARC	Adet Agricultural Research Center
ACET	African Centre for Economic Transformation
AGP	Agricultural Growth Program
ANOVA	Analysis of Variance
ASE	Amhara Seed Interprise
CBSS	Community-Based Seed System
CGIAR	Consultative Group on International Agricultural Research
CRD	Completely Randomized Design
CSA	Central Statistical Agency
CSP	Contractual Seed Production
DWAO	Dera Worda Agricultural Office
EIAR	Ethiopian Institute of Agricultural Research
ESE	Ethiopian Seed Enterprise
FAO	Food and Agriculture Organization
FGD	Focused Group Discussion
GOT	Grow Out Test
GSMMCU	Guna Seed Multiplication and Marketing Cooperative Union
IBM	International Business Machines Corporation
ISTA	International Seed Testing Association
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
KIRDI	Kenya Industrial Research Development Institute
LSD	Least Significance Difference
NGO	Non-Governmental Organization
SAS	Statistical Analysis System
SVI	Seed Vigor Index
SWAO	Sekota Worda Agricultural Office
SPSS	Statistical Package for Social Science
TLU	Tropical Livestock Units
WFO	World Food Organization

SEED SYSTEM AND QUALITY ANALYSIS OF FINGER MILLET (*Elusine coracana L. Gaertn)* **IN DERA, MECHA, AND SEKOTA DISTRICTS OF AMHARA REGION, ETHIOPIA**

Getasew Msganaw and Wossen Tarekegn (Ph.D)

ABSTRACT

Finger millet, a nutritious crop grown in Africa and India, holds significant cultural and economic value in Ethiopia. Despite its importance, research on its seed systems is limited, emphasizing the need to improve productivity and food security. This study evaluates seed quality and assesses the existing seed system for finger millet in the Dera, Mecha, and Sekota Districts of the Amhara Region, Ethiopia, to provide recommendations for developing an effective seed system. The data were gathered from 264 farmers using a semi-structured questionnaire, along with 18 key informant interviews and six focus group discussions. Various finger millet seed samples, stored using different methods, were obtained from both formal (3 samples) and informal (24 samples) seed sources for laboratory testing. The data were analyzed using descriptive statistics and independent t-tests with SPSS V22.0, while ANOVA was used to check the existence of significance differences and LSD to compare mean differences between seed samples from informal sources using SAS software V9.0. The results indicated that farmers mainly rely on informal seed sources, with formal sources being underutilized. Significant differences in seed quality attributes were observed, with formal seed samples demonstrating superior physical purity, physiological quality, and thousand seed weight (TSW) compared to informal ones. Additionally, formal seed samples showed better physiological traits, including higher normal seedling emergence, seedling dry weight, and fresh seed weight. ANOVA results revealed significant variations in physical purity and physiological quality between seed samples from informal sources. While smallholder farmers mainly rely on informal seed sources, formal seeds showed superior quality. Limited access, inadequate extension services, and a lack of awareness restrict the use of formal seeds. To enhance finger millet production in the Amhara Region, it is crucial to strengthen the formal seed system.

Key words: assessment, finger millet, seed samples, seed system, seed quality, seed vigor

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Chapter 1. INTRODUCTION

1.1.Background and Justification

Finger millet (Eleusine coracana subsp. coracana, 2n=4x=36), a member of the Poaceae family, subfamily Chloridoideae, is a neglected and underutilized crop in Africa (Haftom Brhane *et al*., 2017). Despite its potential, finger millet is often overlooked in favor of other cereals. The crop is well-adapted to a variety of climates and thrives particularly in the tropical and subtropical regions of Africa and India. Finger millet has historically played a crucial role in food security, often helping sustain poor farmers during periods of severe drought (Masresha Fetene *et al*., 2011). It is indigenous to Ethiopia, where it is widely cultivated in the eastern and southern highlands of the country.

In Ethiopia, finger millet is extensively grown, especially in the Amhara, Tigray, Oromia, Benishangul-Gumuz, and Southern Nations, Nationalities, and Peoples' Regions, covering approximately 456,057.31 hectares, with a production volume of 10,308,231.53 tons. This accounts for 4.46% of the national cereal crop area and 3.85% of national production. According to the 2019 report from the Central Statistical Agency (CSA), the Amhara Region is the largest producer, contributing 38.6% of the total area planted and 39.4% of national production. Within Amhara, West Gojam, Awi, and Central Gondar Zones are the primary contributors, producing 35.12%, 36.71%, and 17.03%, respectively (CSA, 2019).

Finger millet is recognized as an important food security crop, particularly for subsistence farmers, due to its high nutritional value and excellent storage qualities (Okolo *et al*., 2021). It complements staple cereals like rice and wheat by offering a superior nutritional profile, particularly in terms of calcium, iron, manganese, copper, and essential amino acids, compared to maize (National Research Council, 1996). With a protein content of 7.4%, which is comparable to rice (7.5%), finger millet plays an essential role in preventing malnutrition, especially among vulnerable populations. It also has medicinal properties and is used to treat ailments such as measles, anemia, and diabetes. In Ethiopia, finger millet is used to prepare various traditional foods, including "injera," "genfo," "tella," "arakie," and "borde," and is also utilized as animal feed and roofing material (Mulualem Tafere and Melak Adane, 2013).

Despite its significance, finger millet faces numerous challenges in production, particularly regarding its seed systems. Access to high-quality seeds is one of the major limitations to improving productivity. Many farmers rely on saved seeds from previous harvests, which often results in poor seed quality and reduced germination rates. A study by Abate *et al*. (2019) highlighted that the adoption rate of improved finger millet varieties in Ethiopia remains low, with only 20-30% of farmers using improved seeds, which significantly limits yield potential.

Yield gaps are also a persistent problem. Research shows that the potential yield of finger millet in Ethiopia is much higher than what is currently being achieved under farmers' conditions. For instance, the average yield reported by the Central Statistical Agency (CSA) in 2019 was about 2.2 tons per hectare, while experimental yields under optimal conditions can exceed 4 tons per hectare (CSA, 2019). This yield gap is attributed to a variety of factors, including poor seed quality, limited access to improved varieties, inadequate agronomic practices, and environmental challenges such as drought and erratic rainfall.

Furthermore, the seed system for finger millet in Ethiopia remains underdeveloped. The lack of a well-established seed production and distribution system has led to the widespread use of low-quality seeds. This is compounded by insufficient research and extension services, which have failed to provide farmers with adequate training on seed quality management and modern cultivation techniques. A study by Kebede *et al*. (2020) noted that 60-70% of farmers rely on saved seeds, which are often contaminated with pests and diseases, further reducing crop yields.

The importance of improving seed quality cannot be overstated. Research on seed moisture content has shown that maintaining an optimal moisture level of 8-10% is critical for preserving seed viability (Kumar *et al*., 2021). Additionally, genetic variability plays a crucial role in seed quality, with certain finger millet genotypes showing superior seed size, germination rates, and seedling vigor (Srinivasan *et al*., 2023). Addressing these challenges by improving the seed system and increasing the adoption of improved varieties is essential for enhancing finger millet production and ensuring its sustainability.

1.2. Statement of the Problem

Finger millet, a vital crop for food security in Ethiopia, particularly in the Amhara region, faces several challenges that significantly hinder its productivity. Despite its importance, the average yield in the region remains low, largely due to environmental stresses, socio-economic factors, and a poorly functioning seed system. According to Adane Gebreyohannes *et al*. (2021), the average yield of finger millet in the Amhara region falls far below the crop's potential, with the yields ranging from 531 to 2688 kg/ha compared to the global average of 5000 kg/ha and the national average of 2200 kg/ha (CSA, 2018). One of the major contributors to this low productivity is the poor quality of seeds used by smallholder farmers. Local landraces of finger millet are often of low quality, characterized by small seed size, low germination rates, and high susceptibility to diseases, such as blast disease (Magnaporthe grisea), which significantly reduces yields during the growing season (Getachew Mulugeta *et al*., 2023; Mgonja *et al*., 2007).

In addition to poor seed quality, the finger millet seed system faces several limitations that hinder its improvement and adoption of better technologies. The lack of improved seed varieties, limited extension services, and the absence of a well-structured seed system are key barriers to enhancing productivity. As noted by Masresha Fetene *et al*. (2011) and Birhanu Ayalew *et al*. (2017), finger millet has been neglected in terms of research and development, resulting in several biotic, agronomic, and extension service constraints that limit its production and productivity. The weak seed system further exacerbates this issue, as smallholder farmers have limited access to high-quality seeds of improved varieties, which directly impacts their adoption of better farming practices and technologies. Shimelis Altaye (2021) further emphasizes the minimal influence and participation of farmers, extension agents, and researchers in the generation, transfer, and adoption of new finger millet technologies, hindering progress in the sector.

Despite research efforts on seed systems for other crops, such as tef, sorghum, wheat, and maize (Melkam Anteneh and Firew Mekbib, 2013; Abdi Teshome *et al*., 2020; Mesfin Tesfaye *et al*., 2023), there is a significant research gap regarding the seed system of finger millet in Ethiopia. The lack of comprehensive studies on finger millet’s seed system and seed quality specifically for the study area limits our understanding of the challenges faced by farmers and their need for improved seed systems. Additionally, the informal seed system, where farmers save, select, and exchange seeds, delays their access to modern technologies for crop improvement. Louwaars and De Boef (2012) suggest that a sustainable integrated seed system, combining both formal and informal systems, is essential for enhancing agricultural productivity. Therefore, understanding the dynamics of the finger millet seed system, seed quality factors, and farmer preferences is critical to developing a more efficient and community-based seed system that can drive higher productivity and improve the livelihoods of farmers in the study areas.

1.3. Objective of the Study

1.3.1. General objective

The general objective of this study was to evaluate the seed quality parameters and analyze the existing finger millet seed system, focusing on seed production, distribution, and accessibility, to provide strategic recommendations for developing a more efficient and sustainable seed system for finger millet in the Dera, Mecha, and Sekota district, Amhara Region.

1.3.2. Specific objectives

- To identify the existing finger millet seed systems, in terms of seed production and provision to provide options for effective finger millet seed system development.
- To assess farmers' finger millet seed management practices on their quality of seed.
- To analyze the seed qualities parameter of different finger millet varieties collected from different sources.

Chapter 2. LITERATURE REVIEW

2.1. Origin and Distribution of Finger Millet

Finger millet (*Eleusine coracana (L.)* Gaertn) is a tetraploid species with 2n = 36 chromosomes which belongs to the family *Poaceae (Gramineae)* (FAO/WFP, 2008). It is an annual plant widely grown in the arid and semi-arid areas of Africa and Asia. Although debate exists in its origin, FAO (1961), Hilu *et al. (*1979), de Wet *et al*. (1984) and D'Andrea *et al*. (1999)reported that finger millet is indigenous to Ethiopia and occupies diverse agro-ecological regions. It is widely distributed along the eastern and southern highlands of Africa (Phillips, 1972) and it was introduced into India at least 3,000 years ago (Vishnu-Mittre, 1968). In addition, it spread from India it spread across South-East Asia to China and Japan.

India is the largest producer of finger millet globally, with the crop being widely grown in states such as Karnataka, Andhra Pradesh, Tamil Nadu, Odisha, and West Bengal. In India, finger millet is known as ragi and is a staple food, often consumed in the form of flour, porridge, or flatbreads. It is a key crop in semi-arid regions and plays a significant role in food security (NAAS,2020). According to Wang**,** W., and Haug**,** W. (2020) as a resilient, highly nutritious crop, finger millet plays a critical role in ensuring food security in low-rainfall regions of the world.

2.2. Morphology of Finger Millet

Finger millet is a highly tillering annual grass, which has two groups of cultivars, namely (a) the African highland types with grains enclosed within the florets and (b) Afro-Asiatic types with mature grains exposed out of the florets (Hulse *et al*., 1980). The cultivars vary in many characters, including height, ranging from dwarf types (40 cm) to tall types of about one meter. The color of the vegetative organs varies from green to purple. The inflorescence may have straight and open spikes, incurved or closed spikes, and branched spikes. The length of spikes may range from 3 to 13 cm; the color of grains may vary from white through orange-red, deep brown, purple to almost black. In floral structure, the inflorescence consists of a cluster of a variable number of spikes called fingers. The florets are hermaphrodite, perfect except for the terminal florets. The floret is covered by two large glumes, enclosed between a pair of palea. The florets are in the axils of the lemma.

The androecium consists of three stamens. The gynoecium is bicarpellary, unilocular with a superior ovary. Near the base of the ovary, two lodicules are present. There is a wide range of variation in the length of an anther, filament, stigma, and style. The inflorescence takes 7 to 8 days to complete anthesis; its time of anthesis and peak period in the opening of the flower is between 1.00 to 6.00 am and 3.00 to 5.00 a.m., respectively. In each spike the order of opening is from the top to bottom but, in each spikelet, the opening of the floret is from the base to top and one floret in each spikelet opens per day (Dhonukshe and Dodake, 1998).

2.3. Production, Constraints, and Importance of Finger Millet

Finger millet is an important cereal for subsistence agriculture in the dry areas of Eastern, Central, and South Africa, India, and Asia. In eastern Africa, it is produced in Ethiopia, Uganda, Kenya, Tanzania, Rwanda, Burundi, the Democratic Republic of Congo, Sudan and Somalia (Oduori, 2005). This traditional cereal crop is mainly produced in different regional states of Ethiopia: such as Tigray, Amhara except North Shewa, East Gojam and Oromia zone, Oromia (kelem Wellega, West and East Wellega, Illubabour, Jimma, West Harerge and West Arsi), South Nation, Nationalities and Benishangul Gumuz (CSA, 2020). In the 2013 report by Mulualem Tafere and Melak Adane, the statement mentions that Gambella Regional State in Ethiopia is involved in the production of finger millet, alongside other regions of the country. The total area coverage in Ethiopia was 453,909.38 ha with a production of 0.915 million tons and with average productivity of 2016 kg per hectare (CSA, 2015). According to CSA (2015), It has a large area coverage in the Amhara region, with 242,894.75 hectares of land and giving 0.49 million tons, which is 53.55% of the total national production. According to CSA (2023) and a more recent field survey by Abdi Teshome *et al*. (2024), the cultivation of finger millet in West Gojam has expanded due to increased awareness of its benefits, such as drought tolerance and resilience to soil degradation. According to CSA (2022), the finger millet production in Waghimera, South Gondar, and West Gojam zones of Amhara faces significant challenges that limit their overall productivity. West Gojam stands out for its expansion in cultivation area, driven by its suitability for finger millet production, but yields remain low due to constraints like soil degradation and limited access to improved varieties. South Gondar and Waghimera face similar issues, including soil fertility and access to modern farming techniques. The total area under finger millet cultivation in West Gojam has increased from about 35,000 hectares in the 2010s to 42,000 hectares in recent years. However, the average yield per hectare in Ethiopia particularly in the West Gojam zone is quite low mainly due to a lack of improved varieties and agronomic packages.

Finger millet could be the key to providing cheap and nutritious foods throughout the tropics for solving malnutrition in terms of minerals (e.g. Calcium, Iron, Manganese, and Copper), and essential amino acids than maize. The grain's protein content (7.4 %) is comparable to that of rice (7.5%). The main protein fraction (eleusinin) has high biological value, with good amounts of tryptophan, cystine, methionine, and total aromatic amino acids, which are all crucial to human health and growth and are deficient in most cereals (National Research Council, 1996). In addition, Dida *et al*. (2007) argued that finger millet is a hardy crop that serves as a supplement for the main cereal crops such as rice and wheat with high nutritional content and excellent storage quality. Malleshi and Hadimani (1993) also considered that the protein of finger millet possesses a fairly high biological value, which is needed for the maintenance of nitrogen equilibrium in the body. The higher fiber content of finger millet helps in many ways as it prevents constipation, high cholesterol formation, and intestinal cancer. Moreover, people suffering from diabetics are advised to eat finger millet and other small millet instead of rice.

In Ethiopia finger millet has a variety of uses. It is the major food and beverage crop such as "*injera"* (flat bread), bread, "*genfo*", "*tella*" (local beer), and "*arakie"* (local sprit) and "*borde"* for small holder farmers. It is also used for making thin and pancake-like bread. The straw is used for animal feed and thatching roofs. Finger millet is one of the few special species that currently support food supplies in arid and semi-arid areas. It is much harder and less susceptible to pests and diseases than other grain crops. Its seeds can be stored for years without insect damage, which makes it perfect for drought-prone areas. It requires 2.5 to 6 months to mature from germination (National Research Council, 1996).

2.4. Agroecology of Finger Millet

Finger millet has a high level of regional or local adaptation to different growing environments. The altitude limits of the species are unknown, but most of the cultivated finger millet in the world is found from 500 to 2400 meters above sea level (masl) elevation (National Research Council, 1996). It is grown in a wide ecological range of up to 3000 masl elevation. The cultivated finger millet on average more commonly requires 500 to 1000 mm of rainfall year^{-1}, which should be well-distributed throughout the growing season and with an absence of prolonged droughts. But in the wild form of finger millet the rainfall in South Africa is found as low as 300 mm annum^{-1}, (National Research Council, 1996). It can also be grown in any soil type as long as the rainfall is higher than 800 mm annum^{-1} (Van Wyk and Gericke, 2000). Cultivated varieties of *E. coracana* are frequently produced on reddish-brown lateritic soils with good drainage but with reasonable water-holding capacity (National Research Council, 1996). The crop normally requires fairly hot conditions to grow well and can grow where temperatures are as high as 35 ^{o}C. However, it tolerates cool climates and dry spells in the early stages of growth and then grows rapidly but will not tolerate flooding (National Research Council, 1996).

2.5. Seed System

Seed system represents the entire complex organizational, institutional, and individual operation associated with the development, multiplication, processing, storage, distribution, and marketing of seed in any country. The seed system includes informal and formal systems. The formal seed sector was set up and organized with the principal goal of multiplying and supplying quality seeds of improved varieties developed by formal breeding programs. A formal seed system is structured to ensure the production and distribution of high-quality seeds, as well as support farmers to adopt improved agricultural practices. The system is typically more organized and regulated compared to informal systems, but its success relies on coordination among government bodies, research institutions, and the private sector. The principal sources of materials for formal breeding programs are the ex-situ collections of gene banks. A study by Munyua *et al*. (2022) highlights the challenges related to finger millet seed systems, focusing on seed availability and distribution in East Africa, including Ethiopia. The research found that traditional seed systems, primarily involving farmer-saved seed, dominate the region, but this often leads to declining seed quality due to genetic erosion, poor storage conditions, and seed contamination. The study recommended strengthening formal seed systems through improved seed production techniques, enhanced distribution networks, and farmer training to improve the quality and availability of certified seeds.

According to Mugo *et al*. (2023), one of the primary challenges in finger millet production in Kenya and Ethiopia is the limited access to quality seed. The study found that farmers often resort to recycled seed from previous harvests, leading to low germination rates and poor productivity. The research emphasized the need for community-based seed production programs that could improve access to certified finger millet seeds. This would help in scaling the adoption of improved finger millet varieties that are drought-resistant and high-yielding.

The informal seed system is integral to the agricultural systems of many smallholder farmers, especially in developing countries. While it offers resilience, flexibility, and local adaptation to environmental and socio-economic conditions, it faces challenges in seed quality, limited access to improved varieties, and vulnerability to external shocks. Mulugeta Kebede *et al*. (2021) focused on the farmer seed systems for finger millet in Ethiopia, particularly in Amhara and Oromia regions. They noted that although farmers have a high level of seed saving and exchange practices, these systems face significant challenges, including inbreeding depression, pests and diseases in stored seed, and low genetic diversity. Their study suggested the introduction of hybrid varieties and improved community seed banks to help mitigate these constraints and promote genetic diversity for better adaptation to climate change. A recent study by Gowda *et al*. (2024) investigated the factors influencing farmers' preferences for finger millet seed in India. It was found that farmers prefer seeds that are drought-tolerant, early maturing, and high-yielding. The study also emphasized that farmers often prioritize local seed sources over formal ones, due to better familiarity and trust. The study concluded that improving seed quality assurance systems, alongside local seed production networks, could increase adoption rates of improved varieties in areas with poor access to formal seed systems. Strengthening the informal seed system through better storage techniques, farmer education, and connecting it with formal systems could improve its efficiency and sustainability.

Research by Chirwa *et al*. (2023) has explored the role of gender in finger millet seed systems in East Africa, particularly in Kenya and Ethiopia. The study highlighted that women are key players in seed saving and local seed exchange, but they often face barriers to accessing improved seeds due to gender-based inequalities in access to information and resources. The study recommended the inclusion of women in formal seed systems, such as training in seed production and quality control, to improve overall productivity and ensure the sustainability of the seed system.

In Uganda, Semwanga *et al*. (2022) studied the impact of community-based seed banks on improving the availability of finger millet seed. The study concluded that community seed banks have proven to be an effective means of ensuring seed security in rural areas. They facilitate the local production and storage of quality seeds, especially in areas with poor access to commercial seed markets. Additionally, the community-based approach helps in preserving traditional varieties of finger millet, which are better adapted to local conditions.

Understanding seed systems is crucial for managing crop biodiversity in different agroecologies that suit for benefits of individual farmers and communities at social and economic levels for future crop improvement and the resilience of the farming system. It is well-recognized that, agriculture and food security is based on the seed system. Though this is the predominant system for food crops in subsistence agriculture, information is lacking on finger millet. Hence, to provide sound information as a base for future efforts, a study of factors that have contributed to the informal seed system and identification of attributes of finger millet that farmers prefer to improvement is needed. It is also imperative to better understand the evolving interactions between formal institutions related to the delivery of modern varieties of seeds and informal systems for maintaining traditional seeds. In this aspect, survey instruments were designed to elicit the target information about both seed systems.

A recent study by Beyene Tadele *et al*. (2024) found that one of the major challenges facing farmers in regions like Amhara, Tigray, and Oromia is limited access to certified or improved finger millet seeds. Most farmers rely on farmer-saved seed from previous harvests, which often leads to poor-quality seed due to degeneration over time. This results in reduced yields and quality of the crop, particularly in areas where pests and diseases are prevalent. The CSA **(**2023**)** report indicates that the adoption rate of improved varieties in the Amhara Region remains low.

2.6. Seed System in Ethiopia

There are large regional differences in the growth of the seed industry in Africa. A few nations, including Egypt, Kenya, and Zimbabwe, have gradually developed and are operating rather efficient and diverse seed businesses. The seed supply and production systems in an increasing number of other nations (such as Malawi and Zambia) have progressed fairly successfully in some regions for some crops. To serve the best way possible the seed system in Ethiopia has been widely studied in cereal crops. For instance, Zewdie Bishaw (2004), Firew Mekbib (2008), Dawit Alemu *et al*. (2008) and Melkam

Anteneh and Firew Mekbib (2013) reported on barley and wheat; sorghum, maize, and tef seed systems, respectively. In the case of sorghum and maize the establishment of community-based seed systems, combined with extension services, improved farmers' access to high-quality seeds and led to increased productivity, particularly in areas where these crops are staple foods.

Finger millet has been a traditional crop in many regions of Ethiopia, but improved seed systems have been underdeveloped compared to other cereals. Research on the finger millet seed system has shown that local farmers still rely heavily on farmer-saved seed from previous harvests, which may suffer from deteriorating quality over time. Recent studies, like those by Munyua et al. (2022) and Abdi Teshome *et al*. (2024), have reported some positive trends in improving the seed system for finger millet. For example, the establishment of community-based seed banks and the promotion of improved drought-resistant varieties have begun to improve access to quality seed.

Ethiopia's economy is mostly driven by agriculture, which provides 85% of the country's livelihoods, accounts for 46% of GDP, and accounts for 80% of export value. A robust seed system that offers high-quality seed to farmers to meet their demands is a crucial facilitator for Ethiopia's continuing economic and social development given the substantial current and future roles of the agricultural sector (CGIAR, 2010).

The Ethiopian seed system is a complex integration of all organizations, institutions, and people involved in the production, multiplication, processing, storage, distribution, and marketing of seeds. In Ethiopia, informal, formal, and alternative seed systems coexist with low and medium-quality contributions to crop output, respectively. Community-based seed production by cooperatives, model farmers, and/or independent business people constitutes an alternative seed system. Lack of a clear seed strategy, ineffective extension services, limited collaboration within the seed sector, private companies' propensity to focus on lucrative crops for their own pockets, lack of awareness and knowledge gaps regarding seed production, inadequate basic seed supply, budgetary constraints, and a lack of effective large-scale seed systems were the main challenges facing Ethiopia's seed system. Although many organizations are currently reviewing their strategies, government investments in rural infrastructure and general agricultural policies, strong national and regional initiatives in seed production, the availability of development agents and various cooperatives in every region of the country, and the presence of high seed demands with a limited seed supply were the best opportunities to minimize seed system constraints (Dejen Bekis Fentie, 2021).

Farmers, especially smallholder farmers, are involved in a variety of seed systems that can ensure they will get the amount and quality of seeds they need and that they will be able to sell their produce. The formal system and the informal system (also known as the local or farmers' seed system) are the two main categories of seed systems in Ethiopia. It is challenging to distinguish between the two systems because they are both active at the same time throughout the nation. However, the better seeds in the informal system indeed originated from the formal system. An additional system is the integrated seed system. There are further types of seed systems that function in both systems, such as the Community-Based Seed System (CBSS). Despite being underdeveloped, Ethiopia also has a few official commercial seed programs that are in operation (Abebe Atilaw and Lijalem Korbu, 2011).

One of the most crucial decisions to make is selecting the best seed source because it can have a significant impact on seed quality, productivity, and early growth (Taju Mohammednur and Tesfaye Megersa, 2021). National seed policies must fully acknowledge the contributions of both the formal and informal sectors and encourage the development of an integrated seed system that meets the demands of a varied range of farmers (Zewdie Bishaw *et al*., 2012). The seed system development strategy prepared by the Ethiopian Agricultural Transformation Agency has recognized the three seed systems formal, informal, and intermediary(Sisay Argaye, 2019). The public and private organizations the Institute of Biodiversity Conservation, the Ethiopian Institute for Agricultural Research, Regional Agricultural Research Institutes, Universities, the Public Seed Enterprise, private seed producers, several small-to-medium-sized businesses, and farmers are all included in the seed sector that is supported by state governments. The Ministry of Agriculture and Rural Development, the Bureaus of Agriculture and Rural Development, farmers' cooperative unions, and NGOs are additional pertinent parties. They contribute significantly to the development of farmer-based quality seed production out-grower schemes, variety demonstration, and ensuring the security of household food supplies. Seed systems play a central role in the productivity of crops, influencing the availability and quality of seeds, as well as the adoption of improved varieties. The seed system for finger millet in Ethiopia, especially in regions like the Amhara and Tigray, is characterized by a mix of formal and informal mechanisms. The formal system includes government and research institutions that distribute improved seed varieties, while the informal system relies heavily on farmer-saved seeds (CSA, 2020). However, the informal seed system in Ethiopia often faces limitations, such as a lack of access to high-quality seed, inadequate storage practices, and the slow dissemination of new, improved varieties (Shimelis Altaye, 2021). The Integrated Seed System combines the best elements of both formal and informal seed systems, enhancing seed availability, quality, and access for farmers. By leveraging the strengths of both systems and promoting collaboration among stakeholders, the integrated seed system aims to provide a sustainable, diversified, and locally adapted seed supply that improves agricultural productivity, resilience, and food security.

Several studies (Masresha Fetene *et al*., 2011; Birhanu Ayalew *et al*., 2017) argue that finger millet has been neglected in research and development, which directly affects seed production and availability. This neglect has led to significant gaps in knowledge, particularly regarding the management of seed quality in informal systems and how these systems can be formalized or improved to increase the adoption of better varieties. Conversely, other studies (Dida *et al*., 2007; Mgonja *et al*., 2007) emphasize the resilience of finger millet in drought-prone areas and suggest that improved seed systems could harness the crop's potential for better productivity.

2.6.1. Formal seed system

The formal seed system, which meets less than 20% of Ethiopia's total seed demand and only includes a small selection of crops and types, is the main focus of seed policies. The development of seed laws, as well as the organizations and mechanisms necessary for their execution, had varied degrees of success. Through official methods, several vegetable seed varieties are developed and distributed. Private local and international seed corporations participate in the official systems, but individual entrepreneurs dominate the informal ones (Amsalu Ayana *et al*., 2014). Although it makes a substantial contribution to the availability of quality seed, the official seed sector is unable to meet local farmer demand, necessitating the local production and distribution of quality seed with the help of farmers (Rishipal Singh and Ramesh C. Agarwal, 2018). In a study conducted by Mekonnen Moges *et al*. (2022**,** it was found that while the government and NGOs have been distributing certified seed varieties (for crops like wheat and maize**)**, the supply is insufficient and inequitable, with major gaps in availability and timely distribution**.** Accord ing to the study, the formal seed system contributes approximately 40-50% of the seed used in maize cultivation and 35-45% in wheat cultivation. This contribution is largely attributed to government programs such as the Agricultural Growth Program (AGP) and various public-private partnerships, which have focused on providing certified seeds of high-yielding and disease-resistant varieties. However, the contribution of formal seed systems to teff production remains lower than that of maize and wheat, primarily because of the crop's extensive reliance on informal seed systems. Recent data from Girma Adugna *et al*., (2023) found that formal seed systems contribute about 30% of the total teff seed used in the country.

In contrast to maize and wheat, crops like sorghum and finger millet have seen slower progress through the formal seed system. Sorghum, for example, benefits from a formal seed system contribution of about 25-30%, primarily in regions prone to drought. While the adoption of certified sorghum seed is growing, it still lags behind more widely grown crops. Research by Abdi Teshome *et al*., (2022) on the formal seed system for sorghum showed that the formal seed supply has contributed to increased productivity in regions affected by drought, with certified seed contributing approximately 28% of total seed use. Similarly, finger millet (though not widely studied in Ethiopia's formal seed systems) has seen modest growth in the adoption of improved varieties, with formal seed systems contributing around 20% to total production. However, for other cereal crops such as barley, faba bean, and chickpeas, the formal seed system contribution remains quite low, with less than 15-20% of seeds coming from certified sources (ICRISAT, 2021).

Recent research on the formal seed system for finger millet in Ethiopia has shown both progress and persistent challenges. One of the major issues raised by CSA (2020) and Dawit Alemu *et al*. (2008) is the lack of effective seed distribution networks for finger millet. While there have been some efforts to establish regional seed banks and farmer cooperatives, many areas still face challenges in accessing certified seeds. This gap between seed availability and farmer demand has slowed the adoption of improved varieties. Another challenge facing the formal seed system for finger millet is the limited awareness and training among farmers regarding the benefits of improved varieties and the importance of seed quality. Even in regions where improved varieties are available, farmers are often not fully aware of their advantages or the need to invest in certified seeds. Studies like those by Munyua *et al*. (2022) and Abdi Teshome *et al*. (2024) point out the need for more extension services and training programs to raise awareness and provide the necessary knowledge to farmers.

The formal seed system for finger millet has traditionally been underdeveloped in comparison to other major cereals, but there have been several efforts in recent years to enhance seed availability, quality, and distribution. In recent years, significant strides have been made in finger millet variety development to meet the needs of smallholder farmers in Ethiopia. Research has led to the development of varieties that are drought-tolerant, high-yielding, and resistant to diseases. For instance, the Ethiopian Institute of Agricultural Research (EIAR) has developed improved varieties like Bako and Wama, which have shown superior yield potential and resilience under Ethiopian farming conditions.

2.6.2. Informal seed system

More than 80% of farmers in developing nations utilize seeds from the informal seed supply that are of uncertain quality status, have low physical purity, have less vigor, and are contaminated with seed-borne diseases. A study by Birhanu Alemu *et al*., (2022) found that in the Amhara region, nearly 40-50% of the seeds exchanged within local communities were found to have low germination rates, often resulting in poor crop establishment. In informal seed systems, seed storage and handling are often a challenge. Most farmers in the Amhara region store their finger millet seeds in traditional storage containers which do not always protect the seed from moisture, pests, and diseases. These storage practices contribute to a decline in seed quality over time, and seed deterioration becomes a major concern for farmers using saved seeds. A study by Biruk Yohannes *et al*., (2024) found that improper seed storage practices in the Amhara region led to significant losses in seed viability, especially during rainy seasons when humidity levels are high. The study reported that about 25-30% of finger millet seed in informal systems was lost due to pest infestation and fungal contamination during storage.

To increase food and nutrition security and lessen the sensitivity of smallholder farmers to the effects of climate change, local seed systems should be strengthened. The farmer obtained seed from a variety of sources, including the local market, gifts from friends and family, and seed exchanges. A positive aspect of the informal seed system is its ability to maintain genetic diversity. Many finger millet landraces adapted to the local agro-ecological conditions are preserved through informal seed exchanges. In 152 studied households, 32.9% of farmers used their own saved seed, according to a study on the seed system analysis of soybeans in South Western Ethiopia (Taju Mohammednur and Tesfaye Megersa, 2021). The contribution of the informal seed system for finger millet in the Amahara region is significant, with recent studies estimating that up to 80-85% of finger millet seed comes from informal sources (Abdi Teshome *et al*., 2023). This system is primarily driven by farmers saving seeds from their harvests or exchanging seeds with neighboring households. Compared to the formal seed system, it is more guaranteed to be sustainable, relatively less expensive, and easily accessible in farmer's villages (Dejen Bekis Fentie, 2021). According to Mesfin Tesfay *et al*, (2023), informal seed systems contribute significantly to the availability of finger millet seed but several challenges like limited access to modern seed technology limit their effectiveness. A recent field study by Tewodros Solomon and Sisay Berhanu **(**2024**)** highlighted that in areas like Mecha, Sekota, and Dera, farmers continue to rely heavily on informal seed systems. This includes farmer-to-farmer seed exchange and the use of traditional seed-saving practices. While this system ensures that farmers can access seeds locally, it often results in the deterioration of seed quality over time due to the lack of proper storage and disease pressure.

2.7. Seed Quality

The term "seed" refers to vegetative propagation materials, including cuttings, setts, slips, all sorts of grafts, healthy seedlings, tubers, bulbs, rhizomes, and roots. Quality seed is described as being varietal pure, having a high germination rate, being free of illness and disease organisms, and having the right weight and moisture content (Ethiopian Seed Proclamation, 2016). It is regarded as a crucial element for raising yield. Recent efforts to improve seed quality in Ethiopia have had some positive outcomes, particularly for finger millet in certain areas. A study by Tadesse Assefa *et al*. (2023) in the Mecha and Dera districts found that certified seed production and quality seed management practices have been gradually improving due to government and NGO interventions aimed at strengthening formal seed systems. The formal seed systems, through Ethiopian Seed Enterprise (ESE) and regional seed multiplication programs, have contributed to an increase in the availability of improved varieties of finger millet. According to Gregg and Billups (2010), quality seeds can utilize inputs like fertilizers and irrigation effectively. A farmer's output can rise by roughly 20–30% when using high-quality seeds that are physically and genetically pure, meet health criteria, and have high germination and optimum moisture percentage (Myer G. Mula, 2014).

Aspects of seed quality include genetic and mechanical purity, seed vigor and germination, and seed health testing. Another area where seed quality is being examined more extensively is the continual development of seed enhancements. Although several of these seed quality traits are often assessed by seed experts (Amir and Hamid, 1997; McDonald, 1998). Article 29 Ethiopian Seed Regulation 375/2016 mandates that all officially recognized seed producers submit their seed products for inspection by a seed laboratory service that has been authorized by the law.

However, a decline in seed quality remains a significant challenge in areas like Sekota district and other drought-prone districts. Studies from Sekota district (Biruk Yohannes *et al*., 2023) indicate that despite the widespread use of locally saved seed for finger millet, poor seed storage practices, and pest infestations have led to a decline in seed quality over time. Prolonged dry periods in Sekota have led to poor seed formation and lower seed viability, especially for finger millet, a crop that is highly sensitive to water stress during seed formation. Studies have indicated that in such conditions, seed viability drops dramatically, especially for locally saved seeds (Abdi Teshome *et al*., 2024). As compared to sorghum and teff, finger millet still suffers from lower rates of adoption of improved seeds and faces challenges related to seed quality. Recent studies by Birhanu Alemu *et al*. (2024) have pointed out mixed progress in improving seed quality for these crops in Mecha, Dera, and Sekota. While formal interventions for sorghum and teff have led to better seed quality in some districts, finger millet remains neglected compared to these major crops.

2.7.1. Physical purity

The percentage of pure seed from the appropriate crop in a seed lot is referred to as the physical seed quality. According to Gregg and Billups (2010), it encompasses analytical purity, moisture content, size, appearance, color, insect bites, and the presence of other unwanted components. Recent research on the physical purity of finger millet seeds in Ethiopia has shown that the seed lots, especially those from informal seed systems, often fail to meet the required purity standards for certified seed production. Informal seed sources, which dominate in rural areas, tend to have higher levels of contaminants, including seeds of weeds, other crops, and damaged seeds, which lower the overall physical purity of the seed lot. A study by Abdi Teshome *et al*. (2024) assessed seed samples from several districts in the Amhara region and found that: Physical purity in informal seed lots ranged from 80% to 90%, with significant levels of foreign seeds (such as weeds or seeds from other cereal crops like sorghum). The impurity levels in formal seed lots were found to be lower, typically around 95% to 98%, indicating that certified seed systems have better standards for seed cleaning and sorting. However, even formal seed lots occasionally showed minor impurities, mostly due to inadequate seed processing equipment and handling practices. A study by Birhanu Alemu *et al*. (2023**)** evaluated the physical purity and its influence on germination and plant establishment in sorghum and teff seed lots. In a study conducted by Tesfaye Mulugeta *et al*. (2023), teff seeds had impurity levels around 5-10% in some informal seed lots, especially in remote areas like Sekota and Mekele, the impurities mostly consisted of weed seeds and broken seeds, and Sorghum seeds, had fewer contaminants (typically around 3-5%), but still showed significant variation across regions and seed systems.

In response to concerns about seed purity in the Amhara region, there have been several efforts to improve the standards for seed production, particularly for finger millet, teff, and sorghum. Initiatives such as community seed banks, improved seed cleaning facilities, and capacity-building programs for farmers have helped to improve the physical purity of seeds (Tesfaye Mulugeta *et al*., 2024).

2.7.2. Physiological purity

The intrinsic qualities of seeds that determine their ability to germinate, emerge, and produce a uniform stand of healthy plants under a variety of field circumstances that can be present at planting time are referred to as physiological seed quality. Physiological seed quality can perhaps be best understood as the performance capabilities of seed since the purpose of crop seed is to propagate the crop and fulfillment of this function necessitates that the seed performs in specific ways under greenhouse and field conditions that can vary over time and among locations during the planting season (Delouchel, 2016). A study by Sileshi Tesfaye *et al*., (2024) examined the physiological purity of finger millet seeds across different districts in the Amhara region, including Mecha, Dera, and Sekota, focusing on how storage conditions affect seed viability. In regions like Sekota, seeds saved by farmers often had lower physiological purity, with germination rates as low as 50-60% but Certified finger millet seeds from seed multiplication centers showed higher physiological purity, with germination rates averaging 85-90%. This is due to the use of improved storage conditions, such as cool**,** dry storage, and cleaned seed treatments, significantly improved seed vigor and viability. In a study conducted by Tadesse Assefa *et* *al*., (2023) on sorghum and teff seeds in Mecha and Dera districts, the age of seed lots was found to significantly affect the physiological purity of seeds. Older seed lots, especially those retained for more than one planting season, exhibited poorer germination rates and seedling vigor due to declining seed viability.

A study by Birhanu Alemu *et al*. (2023) examined how environmental stress, such as drought and high temperatures, affects the physiological purity of seeds, particularly for finger millet and sorghum, which are grown in the Amhara region. The research found that seeds exposed to drought stress during development had lower germination rates and poorer seedling vigor compared to seeds developed under more favorable conditions. Research by Abdi Teshome *et al*. (2024) has shown that communities that have access to high-quality seeds, particularly those with high physiological purity.

Chapter 3. MATERIAL AND METHODS

3.1. Description of the Study Areas

The study on finger millet seed systems was conducted in three major finger millet-producing districts in the Amhara Region of Ethiopia during the 2023/24 cropping season: Dera, Mecha, and Sekota. These districts are located in the South Gondar Zone, West Gojjam Zone, and Waghimra Zone, respectively, and are known for their diverse agro-ecological conditions, making them ideal for studying the dynamics of finger millet production and seed systems.

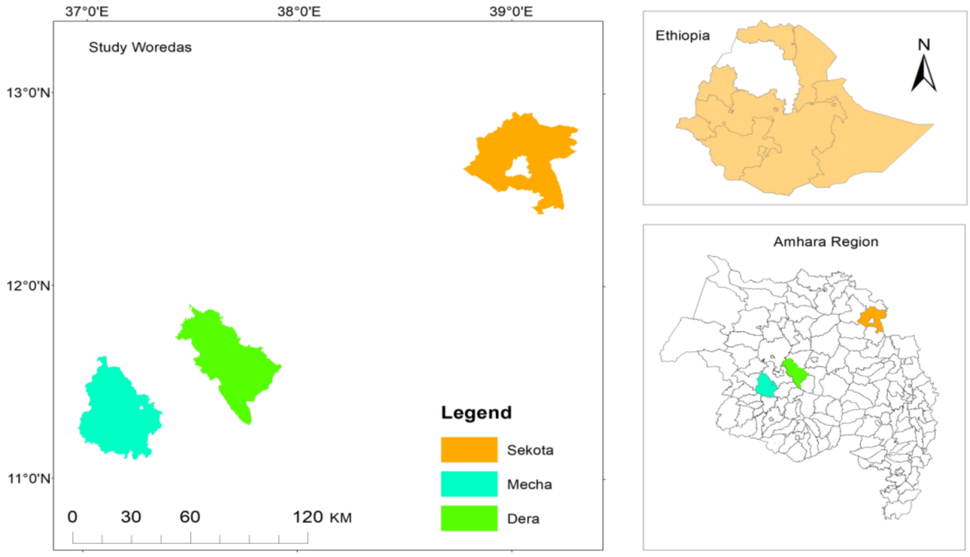

Figure 3.1. A location map of the study districts in the Amhara Regional State, Ethiopia

Dera district is a part of the south Gondar Administrative zone, bordered on the south and west by Bahir Dar city and about 35km west of Bahir-Dar city. Dera district lies between the capital cities of Debre Tabor, the South Gondar zone, and Bahir Dar, the capital of Amhara Regional State, about 79 km away. It is bordered on the west by Lake Tana, and on the north by Fogera. The Abbay River divides it from the West Gojjam Zone on the south. Rainfall in the area is bimodal; the short rainy season (*belg)*is from March to April followed by more substantial rainfall between June and September *(kiremt)*. The district falls under the Woina Dega agro-ecological zone. It primarily grows maize, teff, wheat, and finger millet (DWAO, 2023). Despite its favorable climate for farming, finger millet production in Dera is constrained by limited access to improved seed varieties and soil degradation, with farmers relying heavily on informal seed systems.

Mecha is one of the 14 districts found in the Amhara National Regional State of West Gojjam Zone. It is divided into 32 rural kebeles and 6 urban towns including the district capital; Merawi which is located 35 km far from the regional capital, Bahir Dar, and 530 km from Addis Abeba. North Mecha district shared boundary with Bahir Dar Zuria woreda in the North, Yilmana Densa district in the East, South Achefer district in the West, and South Mecha district in the South. The total populations of North Mecha district is 331,061 out of which 282,902 reside in rural and 48,159 reside in urban areas. The topography of the district is divided into two main parts, namely the highlands (2.9%) and the semi-highland (97.1%). The majority of the district is characterized by plateaus. The highest rainfall occurs during the summer season, which starts in mid-June and ends in early September. It has a total area of 1,421,300 km^2 out of which 107, 210, 00 km^2 is arable land that is irrigable and suitable for agriculture. It benefits from irrigation schemes like the Koga irrigation project, supporting large-scale agriculture. Koga is one of the large-scale dams with a 7,000-hectare irrigation capacity found in the region and is located in the district (Merawi town government communication, 2019). The district grows maize, teff, wheat, and finger millet, with some farmers adopting modern agronomic practices, while others rely on traditional farming methods. Despite the availability of irrigation, finger millet yields remain low due to limited access to improved seeds and agronomic packages.

Sekota district is located in the Waghimera zone about 120Km and 500Km from Lalibela city and Bahir Dar respectively. The district has a total area of 53,531.95 hectares about 48.8%, 18.2%, and 33% are cultivated land, grazing land, and buildings respectively. Sekota district consists of 25 rural Keble administrations with 22,496 households and a total population of 157,745 and over 98% of the population is involved in agriculture. From the total 25 rural administrative Keble, 14 is low land and 11 are midland. Rainfall in the area is unimodal; there is substantial rainfall between June to September *(kiremt)* and it is the dry land part of the Amhara region. This makes it highly reliant on drought-resistant crops like finger millet. The area faces challenges such as soil degradation and low access to modern farming practices, which limit productivity. Most farmers in Sekota depend on the informal seed system, saving and exchanging seeds within their communities. Sorghum and teff are the major crops grown in the area (SWAO, 2023).

Across all three districts, finger millet plays a crucial role in food security, yet the seed systems remain fragmented, with significant challenges in seed quality and access to improved varieties. The agro-climatic conditions in these areas underline the importance of finger millet as a resilient crop, but the need for enhanced seed systems, better agricultural practices, and improved access to modern farming technologies remains a critical focus.

Table 3.1. Geographical description and weather data of study districts

Location	Elevation (masl)	Latitude	Longitude	ARF (mm)	AT (°C)
Mecha	1960	11° 25'20″N	37°10'20″E	1200-1800	17.5-20
Dera	1560-2600	11°23'15″ -11°53'30″N	37°25'45″-37°54'10″E	1000–1500	13-30
Sekota	2200	12 ^{o} 26' 01″N	38 ^{o} 41'44.71″E	400-900	15-28

(Source: SWAO, 2023), ARF= Annual rainfall, AT=Annual temperature

3.2. Sampling Procedures, Sample Size and Participants

The study was done based on the data obtained through multi-stage sampling techniques. Three-stage sampling techniques were used to select sites and to draw sample farmers. The administrative levels were selected from higher to lower purposively. First, three districts were selected from Waghimera, south Gondar, and west Gojam zones through purposive sampling technique, this is due to their high potential for finger millet production. Second, six peasant associations were selected based on their potential for finger millet production purposively. Hamusit and Wal peasant association were selected from the Sekota district, Wenchit and Geregera peasant association from the Dera district, and Enamert and Enguti from the Mecha district were selected for individual household surveys. Third, a total number of finger millet-growing farmers was selected with random sampling techniques. The sample size in each peasant association was determined according to the proportion of farmers' population in each peasant association. The sample size was, therefore, determined according to the formula provided by Yamane (1967) to determine the sample size of the study, using 0.05 sample error and 95% level of confidence.

$$N=\frac{N}{1+N(e)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(Equ. 1)$$

Where: n is the sample size, N=Number of total house hold in the peasant association, and e is the level of precision considered. The minimum level of precision is acceptable at 10%. However, for this study, a 5% precision level was used.

In addition, six focus group discussions and individual interviews were conducted using 18 key informants who had in-depth knowledge about the areas, the farms, crops, and local conditions and problems in the peasant association. Selection of this group was done in consultation with development agents and a peasant association leader who resided in the area and had knowledge of the farmers around. Key informants included males and females, as well as young and old farmers who planted many crop varieties. Additional information was also collected from relevant governmental organizations to back up information captured through individual interviews and group discussions.

Table 3.2. Number of sampled households in the study district

Study District	Sample size (n)
Dera	110
Mecha	63
Sekota	91
Total	264

3.3. Data Types and Sources

The data for this study were collected from multiple sources using various instruments. Specifically, primary data were gathered through semi-structured household-level surveys and questionnaires, which focused on understanding farmers' practices, seed management, and challenges in finger millet production. Data collected through these surveys included both quantitative and qualitative information on seed quality, production practices, and adoption rates. In addition to the surveys, six focus group discussions were held to gain deeper insights into local experiences and perceptions related to finger millet farming and seed systems. These discussions also provided qualitative data on farmer preferences and the socio-economic aspects affecting seed use. Individual interviews with key informants such as agricultural extension officers, local agricultural experts, and community leaders were conducted to gather detailed information about the agricultural context, including the availability of improved seed varieties, the functionality of the seed system, and existing gaps. Supplementary data were collected from relevant governmental organizations to validate and support the information gathered through interviews and focus groups. Furthermore, laboratory analysis of seed quality parameters (germination rate, seed vigor, and moisture content) was carried out on finger millet samples to objectively assess seed quality from different sources. Enumerators, fluent in the local language, were trained to ensure accurate data collection, and the questionnaire was pre-tested and refined based on feedback from a small sample of respondents.

3.4. Seed Sampling for Laboratory Experiment

Based on the survey results on seed management practices, seed samples were collected from both formal and informal sources to evaluate the quality of finger millet seeds. For the formal source, three samples of Necho, Adet 05, and Mecha varieties were obtained from the Adet Agricultural Research Center (AARC), which provides certified seeds. For the informal source, 24 samples of three local varieties (Necho, Keyo, and Tikur) were collected from farmers' saved seeds, where the seed class was unknown. To ensure broad representation, 1 kg of seed was collected from ten model farmers in each peasant association within the study areas (Yenus Ali, 2017). Farmers were selected from three districts; Dera, Mecha, and Sekota based on their involvement in finger millet cultivation, seed saving, and storage methods. Seed samples were gathered from lots intended for planting in the 2023/24 cropping season. Samples were collected from six peasant associations, with each providing one composite sample. These composite samples were created by mixing seed lots from different farmers within each association. The samples were carefully labeled, mixed, and subdivided into working samples for laboratory testing. A portion (50%) of each composite sample was used to assess seed quality, following seed testing standards (ISTA, 2014). This approach allowed for a comparison of seed quality across both formal and informal seed systems.

3.5. Treatments and Design of Laboratory Experiment

The laboratory experiment was designed to evaluate the seed quality of different finger millet varieties collected from both formal and informal seed sources. The primary treatments for this experiment included seed samples collected from model farmers in different peasant associations and from the formal seed source, Adet Agricultural Research Center (AARC). A Completely Randomized Design (CRD) with three replications was used for the experiment, ensuring the reliability of the results. Each treatment was repeated three times to minimize bias and variability. A total of 24 seed samples were collected from various finger millet varieties (black, red, and white) from informal seed sources, representing different seed storage types and conditions. Additionally, three seed samples were collected from AARC, representing the formal seed system, which served as the control treatment. These seeds were certified and thus expected to demonstrate high seed quality. The control treatment allowed for comparison with the informal seed sources to assess quality differences.

The key seed quality parameters assessed in the laboratory included physical seed purity, which involved measuring other crop seed content, weed seed content, and inert matter. Additionally, physiological seed quality was evaluated through tests for seed moisture content and germination rate. The moisture content was measured to assess seed storage potential, while the germination rate indicated seed viability. All testing followed the International Seed Testing Association (ISTA, 2014) standards. Seed samples from the informal seed sources were collected from six different peasant associations, where composite samples were created by mixing seed lots from different farmers within each association. This approach allowed for the representation of diverse seed storage and management practices across the study area, providing a comprehensive view of the seed quality in both formal and informal systems.

Table 1.3. Treatments setup for laboratory test

No.	Treatment	Storage type	Keble	District	Variety
1	S1	Sacks in the house	Hamusit	Sekota	Nechi (White)
2	S2	Sacks in the house	Hamusit	Sekota	Keyo (Red)
3	S3	Sacks in the house	Hamusit	Sekota	Tikur (Black)
4	S4	Sacks in the house	Wale	Sekota	Nechi (White)
5	S5	Sacks in the house	Wale	Sekota	Keyo (Red)
6	S6	Sacks in the house	Wale	Sekota	Tikur (Black)
7	S7	Sacks in the house	Geregera	Dera	Nechi (White)
8	S8	Sacks in the house	Geregera	Dera	Keyo (Red)
9	S9	Sacks in the house	Geregera	Dera	Tikur (Black)
10	S10	Sacks in the house	Wenchite	Dera	Nechi (White)
11	S11	Sacks in the house	Wenchite	Dera	Keyo (Red)
12	S12	Sacks in the house	Wenchite	Dera	Tikur (Black)
13	S13	Gotera in the house	Wenchite	Dera	Tikur (Black)
14	S14	Gotera in the house	Geregera	Dera	Keyo (Red)
15	S15	Sacks in the house	Enamert	Mecha	Nechi (White)
16	S16	Sacks in the house	Enamert	Mecha	Keyo (Red)
17	S17	Sacks in the house	Enamert	Mecha	Tikur (Black)
18	S18	Sacks in the house	Enguti	Mecha	Nechi (White)
19	S19	Sacks in the house	Enguti	Mecha	Keyo (Red)
20	S20	Sacks in the house	Enguti	Mecha	Tikur (Black)
21	S21	Gotera in the house	Enguti	Mecha	Keyo (Red)
22	S22	Gotera outside the house	Enguti	Mecha	Keyo (Red)
23	S23	Underground pit	Enguti	Mecha	Keyo (Red)
24	S24	Underground pit	Enamert	Mecha	Nechi (White)
25	S25	Cold store	AARC		Mecha
26	S26	Cold store	AARC		Necho
27	S27	Cold store	AARC		Adet-05

Where: S1-S27 indicates samples (treatments)

3.6. Data Collection Method

3.6.1. Survey data collection

Primary social data was collected through focus group discussions and individual interviews, focusing on various household characteristics such as household type, distribution of households by educational status, age, and family size. The data also explored household resource base characteristics, farmers' adoption and seed source, agronomic practices and perceptions, contractual seed production practices, and the involvement of partners and coordination within the farming community. A questionnaire was designed to collect data through both closed-ended and open-ended questions. Closed-ended questions were included to gather quantitative data, allowing for predefined answer choices that could be easily analyzed, offering a structured way to measure variables like household size or educational status. In contrast, open-ended questions were used to capture qualitative data, providing respondents with the opportunity to express their attitudes, perceptions, and experiences in their own words. This combination of question types allowed for a well-rounded understanding of both the measurable and subjective aspects of the social data, facilitating deeper insights into the farming practices and household dynamics under investigation. Additionally, secondary data was collected from various secondary data sources.

Finger millet seed samples collected from finger millet-growing households were subjected to laboratory experiments. The biological data collected from these experiments contributed to the laboratory data analysis.

3.6.2. Laboratory data collection

3.6.2.1. Physical purity test

The purity test measured the percentage of pure seed in the sample, excluding other crop seeds, weed seeds, and inert materials. A sample of finger millet seeds was cleaned, and the different components of the seed lot were separated and weighed. The percentage of pure seed was calculated based on the total weight of the sample and the weight of the pure seed. This test ensured that the seed lot was free from contamination and met the required standards for seed purity. The working sample was separated into the following four parts: pure seed, other seeds, inert matter, and weed seed, and the percentage of each part was determined by weight. All varieties of seed and each kind of inert matter present were identified as far as possible, and their percentage by weight was determined. Following the protocol for the purity test, 100g (weight of working sample) of seeds were taken from the working sample (ISTA, 2014). Apparatus-like magnifiers reflected light, and sieves were used to separate the working sample into its parts. Weigh the "pure" seed fraction, and then express purity as the ratio of pure seed weight to the working sample's overall weight and calculated, as illustrated below.

$$\mathrm{P}(\%) = \frac{\mathrm{WPS}}{\mathrm{TWWS}} * 100 \ldots\ldots\ldots\ldots\ldots \text{ (Equ. 2)}$$

Where P (%) = percentage of pure seed; WPS =Weight of pure seeds (g); TWWS=Total weight of the working sample (g).

3.6.2.2. Moisture content (%)

The moisture content is a critical factor affecting seed viability and storage. For finger millet seeds, maintaining a moisture level below 13% is essential to ensure long-term storage and preserve seed viability, as higher moisture content can lead to seed deterioration and increased risk of fungal growth (ISTA, 2014). Immediately after collection, the moisture content of each seed sample was measured using a digital moisture meter (G.WouHitech Co. Ltd., S/N: HD-1450, GMK, Made in Korea). Three readings were taken per sample, with the average moisture content displayed as a percentage. According to ISTA (2014), the formula for calculating the average moisture content of the seeds from the three digital moisture meter readings was:

$$\text{Average moisture content} = \frac{\mathrm{M1} + \mathrm{M2} + \mathrm{M3}}{3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.(Equ.3)$$

Where: M1, M2, and M3 were the first, the second, and the third moisture reading, respectively.

3.6.2.3. Germination percentage (%)

The germination test for finger millet was conducted to assess the seed's ability to produce healthy seedlings under optimal conditions. A sample of 100 pure finger millet seeds was placed on moist filter paper in a germination tray and maintained at a consistent temperature of 25°C. The seeds were regularly inspected for germination over 7-14 days, depending on the expected germination time. After 4 days, the first count was taken to record the number of seeds that had germinated, and by the 8th day, the final count was made. Germinated seeds were classified into normal and aberrant seedlings, while ungerminated seeds were considered dead. The 50% rule was applied to evaluate the cotyledons and primary roots when necessary. All observations and germination percentages were recorded and analyzed to determine seed viability and quality, per the guidelines of the International Seed Testing Association (ISTA, 2014). Normal seedling: shows the potential for continued development into satisfactory plants when grown in good quality soil under favorable conditions of moisture, temperature, and light. It includes intact seedlings, seedlings with slight defects, and seedlings with secondary infection. Abnormal seedling: seedling that does not show the potential to develop into an abnormal plant when grows under favorable conditions. It includes damaged, deformed/unbalanced, and decayed seedlings. Hard seeds: seeds those remain hard at the end of the test period. Fresh seed: seeds that can imbibe water but fail to germinate or the germination process is blocked. Dead seedlings: seedlings which at the end of the germination test are neither hard nor fresh nor have produced any part of seedling. The percentage of normal seedlings is used to represent it. In the same manner, the percentages of aberrant (abnormal) seedlings, hard, fresh and dead seeds were determined (Mangure, 1962).

$$Germination\ \% = \frac{\text{Total number of normal seedlings}}{\text{Total number of seeds planted}}\ x\ 100 \dots\dots\dots\dots\dots.(Equ.4)$$

3.6.2.4. Speed of germination

The standard germination tests only distinguish between normal and abnormal seedlings. The germination rate is calculated at the same time as the germination percentages. Still, there is probably going to be some fluctuation in the size and vigor of "normal seedlings." The speed of germination was tested by taking 100 seeds from each sample and planting them separately on a germination paper to separate the variation among normal seedlings. Until no more germination occurred, the seeds were stored at room temperature. Every day from the fourth to the eighth day after planting, normal seedlings were counted and removed. The number of normal seedlings per 100 seeds collected at each counting in the standard germination test is divided by the number of days that the seeds stay in the laboratory to determine the germination rate. The germination rate is calculated by adding the values acquired at each count after the germination test (Mangure, 1962).

$$GR = \frac{NNS}{DFC} + \frac{NNS}{DFF} \dots\dots\dots\dots(Equ.5)$$

Where: GR =Germination Rate; NNS =Number of Normal Seedling; DFC =Days to First Count; DFF= Days to Final Count

Seedling shoot length (cm) - was measured in centimeters (cm) starting from the basal part to the tip of the seedling.

Seedling root length (cm) - was measured in centimeters (cm) starting from the tip of the seedling root upward up to the end of the root part.

Seedlings dry weight (g): Seedling dry weight was determined from ten randomly selected seedlings after the final count in the standard germination test. Ten seedlings were randomly selected from each sample and the seedlings were placed in paper bags, dried in an oven at 80 ^{o}C, for 24 hours, and weighed.

Seedling vigor indexes I and II: The two vigor indices (SVI I and SVI II) were computed for the two seed sources (formal and informal). The seedling vigor index is expressed in numbers. The seedling vigor index I was calculated by multiplying the standard germination percentage with the average sum of shoot length and root length after 8 days of germination. Seedling vigor index II was also calculated by multiplying the standard germination percentage with the mean seedling dry weight.

SVI- I = $\mathrm{SD\% \times MSL\ (Roots\ +\ Shoots\ length) \ldots \ldots \ldots \ldots \ldots \ldots . . (Equ. 6)}$

SVI- II = $\mathrm{Standard\ germination\ \% \times\ +mean\ seedling\ dry\ weight \ldots \ldots \ldots \ldots (Equ. 7)}$

Where: SVI- I = Seedling vigor indexes I, SVI- II = Seedling vigor indexes II, SD = Standard germination, MSL = Mean Seedling Length

Thousand seed weight (g); is the weight of 1000 seeds from the pure seed fraction that was taken from the working sample.

Seedling height (cm) – was measured in centimeters starting from the ground part to the tip of the seedling.

3.7. Methods of Data Analysis

Data analysis was performed in two main stages: social data analysis and laboratory data analysis. Social data, collected through the household survey, was analyzed using the

Statistical Package for Social Sciences (SPSS) Version 22 (IBM, 2012). The data were coded, tabulated, and analyzed using descriptive statistics, including frequencies, means, percentages, and standard deviations, to summarize the socioeconomic characteristics of the respondents. The relationships between variables were explored through these descriptive statistics. The t-test was used to compare the seed quality characteristics, including physical quality and physiological quality between the formal and informal seed sources. The t-test was selected due to its ability to assess whether there were statistically significant differences between the means of the two independent groups, ensuring that the comparison between the seed sources was valid. Additionally, One-way ANOVA was used to compare the mean differences among seed samples from the informal seed system. This method was appropriate for comparing multiple groups and identifying if there were significant variations in seed quality characteristics across different seed sources.

To meet the assumptions of the t-test and ANOVA, the data were checked for normality and homogeneity of variance. Data transformations for seedling shoot and root length were applied square root to satisfy these assumptions. For laboratory data analysis, which focused on seed quality parameters, SAS Version 9.0 (2008) was used to determine statistically significant differences between treatments. The Least Significant Difference (LSD) test was employed to identify which specific treatments showed significant differences from one another. The LSD test is particularly useful in post-hoc analysis following ANOVA, as it allows for pairwise comparisons while controlling for Type I errors. The formula for the independent t-test is:

$$t = \frac{\bar{X}1 - \bar{X}2}{\sqrt{\frac{s^2 1}{n1} + \frac{s^2 2}{n2}}} \text{ -- (Equ. 8)}$$

Where:- $\bar{X}1$ and $\bar{X}2$ are the sample means of the two groups, $s^2 1$, and $s^2 2$ are the sample variances of the two groups, and n1 and n2 are the sample sizes of the two groups.

$$LSD = t\,\alpha/2 \times \sqrt{\frac{2MSE}{n}} \text{ -- (Equ. 9)}$$

Where:- t $\alpha/2$ is the critical value from the t-distribution for a given significance level (α), MSE is the Mean Square Error from the ANOVA table, n is the sample size.

The One-Way ANOVA calculates the F-statistic using the ratio of the variance between groups to the variance within groups. The formula is:

$$F = \frac{MSB}{MSW} \text{ -- (Equ. 10)}$$

Where: - MSB (Mean Square Between) is the variance between the group means, and MSW (Mean Square Within) is the variance within the groups.

Chapter 4. RESULTS AND DISCUSSION

4.1. Socioeconomic and Demographic Attributes of Sampled Households

The data in Table 4.4 reveals a clear gender disparity in household headship across the three districts. Accordingly, the household distribution in the district obtained male-headed 94.5%, 100%, and 84.5%, as well as female-headed 5.5%, 0%, and 15.5% were found in order of Sekota, Mecha, and Dera. Hence, the overall gender distribution was 91.7% and 8.3% male and female-headed households, respectively. This data suggests that women in these districts, particularly in Sekota and Mecha, may face significant challenges in decision-making and economic empowerment within their households. The high proportion of male-headed households could potentially limit women's access to resources and opportunities. The average age of 47 years suggests that the majority of respondents are within their prime working age. This aligns with the general understanding that individuals between 25 and 64 years are typically considered the economically active population.

The average number of family members over 15 years of age differs across the three districts. Sekota, Mecha, and Dera districts indicate data of females: 1.55, 1.97, and 1.25 as well as data of males represented 1.89, 1.83, and 1.78, respectively. This variation in family size has significant implications for agricultural labor and productivity. As noted by Wossen Tarekegne *et al*. (2021), older family members are crucial for crop production, while younger members often contribute to livestock herding. Larger family sizes can provide a more substantial labor force, which can be beneficial for labor-intensive agricultural practices, as highlighted by Menale Kassie *et al*., (2015). However, it's important to consider that larger family sizes may not always translate to increased productivity. Factors such as land availability, access to technology, and education levels can also influence agricultural outcomes. The provided data highlights the importance of education in shaping farmers' decision-making and agricultural practices in the study areas of Sekota, Mecha, and Dera. The findings of literacy rates were: Dera (56.4%), Sekota (42.7%), Mecha (100%), and overall showed (62.1%). Additionally concerning this formal education has seen Dera: 15.9%, Sekota: 3.3%, and Mecha: 27% numerical points. Literacy and formal education enable farmers to access and understand agricultural information, such as weather forecasts, market prices, and best practices. As noted by Benyam Tadesse *et al.* (2021) and Duressa and Bonso (2022), education is positively correlated with the adoption of technology, which can significantly enhance agricultural outcomes.

Table 2.4. Demographic characteristics of the sample households (n=264)

Variables		Dera district		Sekota district		Mecha district	
		Mean	Std.	Mean	Std.	Mean	Std.
Family members	Males > 15 years old	1.89	1.31	1.78	1.55	1.83	0.70
	Female > 15 years old	1.55	0.96	1.25	1.17	1.97	0.53
	Male <15 years old	0.82	0.84	0.85	0.96	0.68	0.69
	Female <15 years old	1.05	1.05	1.07	1.11	0.68	0.56
	Total	5.33	1.74	4.96	1.47	5.19	1.06
Age of HH	Male	44.26	11.22	46.26	9.61	51.97	9.23
	Female	45.53	7.71	43.4	8.9	0.0	0.0
The education level of the HH		Freq.	%	Freq.	%	Freq.	%
	Illiterate	48	43.6	52	57.3	0	0.0
	Read and Write	36	32.7	28	30.8	41	65.1
	Adult education	9	8.2	8	8.8	2	3.2
	Completed Primary	0	0.0	0	0.0	2	3.2
	Non completed primary	16	14.5	3	3.3	15	23.8
	completed secondary	1	0.9	0	0.0	0	0.0
	Non completed secondary	0	0.0	0	0.0	3	4.8
	Total	110	100	91	100	63	100

(Source: survey data, 2023/24), the family member indicates the number of individuals per household

4.2. Household Economic Base of Respondents

4.2.1. Area allocated and livestock ownership (TLU)

On average, farmers cultivated 1.52 hectares of land for finger millet during the 2022/2023 cropping season, likely due to their access to relatively larger landholdings. A significant portion (74%) of this land is owned by the farmers themselves, while the remaining is acquired through hiring and share cropping arrangements. The average farmer has 26 years of experience in cultivating finger millet, indicating a high level of expertise and knowledge. At the same time, the average livestock ownership, measured in Tropical Livestock Units (TLU), is 3.96. This suggests that livestock plays a significant role in the farming system, providing manure for fertilizer, draft power, and additional income.

The findings showed that Mecha district farmers had, on average, more livestock in TLU than those in Sekota and Dera districts. Mecha district has the highest livestock holdings, with a larger deviation suggesting more variation in livestock ownership compared to the other districts. To mitigate issues about the uniqueness of finger millet farming, experience plays a crucial role in seed production. According to Tekeste Kifle (2023), greater agricultural experience is associated with higher levels of farming knowledge and proficiency.

The average farming experience is relatively high, particularly in the Mecha district (30.25 years), with a smaller deviation compared to the other districts. Mecha district has on average the largest area of land (1.76 hectares) cultivated by farmers on their farms. However, Farmers in the Sekota district tend to hire more land (0.22ha) compared to those in Dera or Mecha. The average production in the Dera district during the 2022/23 cropping season was 1.16 tons per hectare, with farmers using a 48.29 kg per hectare finger millet seed rate next to maize. The relatively low yield in Dera district can be attributed to a combination of environmental, agronomic, and management factors. A high seed rate of 48.29 kg per hectare might increase competition among plants for nutrients and resources, and when combined with issues like poor soil fertility, water stress, pest infestations, and inadequate management practices, it could result in lower-than-expected yields.

The combination of factors, rather than the seed rate alone, likely contributed to the suboptimal production of finger millet in Dera during the 2022/23 cropping season. The decision to use a 48.29 kg per hectare seed rate for finger millet in Dera district, which is higher than the recommended amount, likely stems from a mix of risk mitigation, historical practices, local environmental conditions, and possible gaps in knowledge. While the higher seed rate may seem like a way to improve crop establishment, it can lead to challenges like overcrowding, resource competition, and poor crop growth. However, farmers may view it as a necessary strategy to overcome specific local challenges such as poor soil fertility, water stress, pest problems, or seed quality issues, even if it doesn't necessarily align with the optimal seed rate recommendations.

Sekota district farmers allocated less land for finger millet than those in the Dera and Mecha districts farmers. The average amount of land allotted for finger millet from the 2022/23 cropping season was 0.43 hectares. The result showed that land allocated for finger millet was Highest in the Dera district (0.67 ha), followed by Mecha and Sekota districts. As per the survey results in Table 4.5, the farmers in Sekota district planted 18.49 kg of seed per hectare on average from 2022/23, and the average yield of finger millet per hectare was 0.68 tons. Farmers in the Sekota district use such a low seed rate despite achieving relatively good yields. Farmers in Sekota may have extensive local knowledge about the ideal seed rate for their specific area. Over time, they may have experimented and observed that 18.49 kg/ha is the optimal amount of seed for achieving good yields under local conditions. Traditional agricultural knowledge often adapts to the specific challenges faced by farmers in each district. The yield difference between districts can largely be attributed to differences in farming practices and environmental conditions.

In Mecha district, the farmers used a finger millet seed rate of 40.32 kilograms per hectare for planting in 2022/2023 and gained an average yield of 0.6 tons per hectare. Compared with that in the Sekota district, the finger millet seed rate was greater in the Mecha and Dera districts, where growers grow. The results of the descriptive statistics indicate that this causes seed waste and lowers yield. According to the result, the average yield per hectare in the study district is quite low mainly due to lack of improved varieties and agronomic packages.

Table 4.5. Area coverage, Yield, and Farming experience of respondents

Farmers resource base	Dera district		Sekota district		Mecha district	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std.
Farming experience	25.52	11.18	23.63	7.98	30.25	9.88
Livestock in TLU	3.14	0.8	2.37	0.74	6.4	1.99
Seed rate (kg/ha)	48.29	15.3	18.49	4.79	40.32	8.12
land cultivated in 2022/23 in hectares						
own farm	1.15	0.83	0.64	0.22	1.76	0.59
hired farm	0.06	0.15	0.22	0.23	0.19	0.23
Share farm	0.27	0.28	0.42	0.26	0.0	0.0
Total farm cultivated (ha)	1.48	0.8	1.26	0.17	1.96	0.46
Amount of land allocated in 2022/23(ha)						
Finger millet	0.672	0.31	0.43	0.15	0.48	0.12
Rice	0.077	0.23	0.0	0.0	0.0	0.0
Maize	0.473	0.3	0.0	0.0	0.89	0.21
Teff	0.289	0.19	0.249	0.19	0.21	0.2
Sorghum	0.0	0.0	0.306	0.17	0.0	0.0
Barley	0.006	0.04	0.008	0.03	0.09	0.14
Faba bean	0.0	0.0	0.019	0.05	0.0	0.0
Field pea	0.0	0.0	0.017	0.05	0.0	0.0
Wheat	0.003	0.02	0.184	0.19	1.03	4.37
Yield (tons)/ha in 2022/23						
Rice	1.32	0.911	0.0	0.0	0.0	0.0
Finger millet	1.169	0.458	0.689	0.09	0.603	0.226
Maize	1.699	0.887	0.0	0.0	1.955	0.57
Teff	0.363	0.351	0.502	0.329	0.192	0.166
Sorghum	0.0	0.0	0.78	0.163	0.0	0.0
Barley	0.014	0.092	0.052	0.201	0.188	0.324
Faba bean	0.0	0.0	0.131	0.34	0.0	0.0
Field pea	0.0	0.0	0.072	0.184	0.0	0.0
Wheat	0.019	0.191	0.594	0.455	0.593	0.579

(Source: survey data, 2023/24), Share farming is where two parties (the landowner and share farmer) carry on separate farming businesses on the same area of land without forming a partnership or company. Both parties share the benefits/risks of farming

4.2.2. Finger millet production and its importance

Table 4.6 shows the distribution of different crops grown in three districts (Dera, Sekota, and Mecha) along with the importance of finger millet in terms of its uses in these study areas. The table also highlights how finger millet is valued for different purposes in the three districts. The importance is divided into Animal Feed, Income Sources, Food Consumption, and Local Beverages. In the Mecha district, farmers planted finger millet (27.8%) and maize (27.8%), sharing equal coverage to other crops in 2022/2023. The majority of the farmers used finger millet for food consumption (40.9%), income sources (40.9%), and local beverages (18.8%). Mecha District emphasizes finger millet as an income source, with a notable role in food consumption. In Sekota district, farmers covered 27.7% finger millet, followed by 26.7% sorghum, in 2022/23 of their farmland. The majority of the farmers in the Sekota district utilized finger millet for food consumption (77.1%), and 28.3% used it for local beverages. Sekota District places the highest importance on finger millet for food consumption, with no other significant uses. In the Dera district, the sample household planted 32.1% finger millet, followed by 32.1% maize, and 29.2% of Teff during the 2022/23 cropping season. For finger millet's relevance, the farmers revealed that finger millet straw used as feed for animals (2.5%), income sources (25.8%), food consumption (34.9%), and local beverages (36.6%) were important. Dera district has a diverse mix of crops, with finger millet being valued primarily for food consumption and as a local beverage. This data reveals the varying significance of finger millet in these districts, depending on both its agricultural role and its cultural and economic value.

Table 4.6. Finger millet's relevance and the type of crop grown (n = 264)

Type of crops	Dera district		Sekota District		Mecha district	
	Freq.	%	Freq.	%	Freq.	%
Maize	110	32.1	0	0.0	63	27.8
Finger Millet	110	32.1	91	27.7	63	27.8
Faba bean	0	0.0	13	4.0	0	0.0
Teff	100	29.2	65	19.8	38	16
Sorghum	0	0.0	88	26.7	0	0.0
Rice	18	5.2	0	0.0	0	0.0
Barley	3	0.9	6	1.8	20	8.8
Field pea	0	0.0	10	3	0	0.0
Wheat	2	0.6	56	17	43	18.9
Total	343	100	329	100	227	100
Importance of F. millet						
Animal feed (Straw)	8	2.5	0	0.0	0	0.0
Income source	77	25.8	0	0	61	40.9
Food consumption	104	34.9	91	71.7	60	40.3
Local beverage	109	36.6	36	28.3	28	18.8
Total	298	100	127	100	149	100

(Source: Survey data 2023/24), *the same farmer repeatedly responded on the same selection criteria for preferring a variety.

4.2.3. Finger millet farmers' preferences and seed marketing

Table 4.7 shows the mean sales (tons) and crop preference ranking as a percentage of farmers' sown crops for three districts: Dera, Sekota, and Mecha. Respondents in Dera district sold 0.29 tons of finger millet seeds on average to the local market. But in Sekota district, farmers get money from the neighborhood market by selling an average of 0.018 (Std. =0.029) tons of finger millet seeds, and in Mecha district, too, the farmers sold 0.22 (Std. =0.15)tons of finger millet seeds to the local market on average. According to the respondents' preferences, in Mecha district finger millet was ranked first (36.5%), second (46.0%), and third (17.5%). Mecha district shows a preference for Maize (especially in terms of sales), but Finger Millet remains an important crop. Wheat and Barley also play a role. However, in Dera district, the farmers ranked finger millet as their preferred crop (70%), second (21.8%), third (7.3%), and fourth (0.9%) to determine its relative value. Dera district has a clear preference for Finger Millet, which is both the most grown and most sold crop. Maize and Teff are also important, but not as dominant as Finger Millet. In the Sekota district Finger millet was ranked first by 63.7% of the farmers and second by 20.9% of the farmers, according to the statistics. Sekota district favors Finger Millet as the most important crop, but the overall crop preference ranking is more spread out. Teff and Wheat are significant as well.

The number of ranks across the district is varied due to the crop diversity difference cultivated in the area by the respondents. The sales data indicates that in Dera and Mecha, Maize and Finger Millet are the primary crops, with a significant role in both food consumption and the local economy. In Sekota, Finger Millet dominates both in terms of ranking and importance, but other crops like Teff and Wheat also has their share of the market. In summary, the crop preferences and sales vary across districts, with Finger Millet being the most significant crop in Dera and Sekota, while Maize takes a leading role in Mecha.

Table 4.7. Amount of sales (tons) and crop preference (rank) as a percentage of farmers sown

Crop type	Dera district		Sekota district		Mecha district	
	Mean	Std.	Mean	Std.	Mean	Std.
Rice	1.568	0.426	0.00	0.00	0.00	0.00
Maize	6.597	0.511	0.00	0.00	11.82	0.247
Finger millet	2.968	0.267	0.180	0.029	2.28	0.153
Teff	1.098	0.130	0.030	0.010	0.87	0.099
Wheat	0.009	0.009	0.070	0.017	3.41	0.275
Sorghum	0.00	0.00	0.070	0.017	0.00	0.00
Faba bean	0.00	0.00	0.020	0.010	0.00	0.00
Barley	0.00	0.00	0.080	0.004	0.96	0.161
Field pea	0.00	0.00	0.010	0.008	0.00	0.00

Crops	Dera district				Sekota district						Mecha District			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	5th	6th	1st	2nd	3rd	4th
F. Millet	70.0	21.8	7.3	0.9	63.7	20.9	15.4	0.0	0.0	0.0	36.5	46	17.5	0.0
Rice	7.3	5.5	1.8	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize	6.4	67.3	20.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	47.6	33.3	19.0	0.0
Teff	16.4	6.4	60.9	5.5	11.0	37.4	23.1	3.3	0.0	0.0	39.7	15.9	36.5	7.9
Sorghum	0.0	0.0	0.0	0.0	25.3	29.7	45.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Barley	0.0	0.0	0.0	0.9	0.0	0.0	0.0	6.6	0.0	3.3	0.0	68.3	3.2	28.6
F. Bean	0.0	0.0	0.0	0.0	0.0	4.4	3.3	0.0	9.9	0.0	0.0	0.0	0.0	0.0
F. Pea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	3.3	6.6	0.0	0.0	0.0	0.0
Wheat	0.0	0.0	0.0	1.8	0.0	12.1	9.9	27.5	6.6	0.0	31.7	20.6	23.8	23.8

(Source: survey data, 2023/24), the number of ranks varied across the district due to the different respondents growing different numbers of crops and ranking them differently

4.3. Farmers' Knowledge of Finger Millet Varieties

Every respondent in every sampled district usually produces finger millet. During the 2023/24 cropping season, the sampled households (n = 110) in the Dera area used kiy (local) variety 7.3%, Nechi (local) variety (0.9%), Tikur (local) variety (79.1%), and both Kiy and Tikur (12.7%) local finger millet varieties (Table 4.8). Furthermore, among the respondents in this district, 15.5% used the improved variety of Necho in the previous season, and 14.5% used both the local (Tikur) and improved (Necho) varieties. Those farmers started to use improved finger millet varieties in 2012 (Figure 4.2).

However, 14.5% of the sample households grew other varieties of finger millet before the previous season (Figure 1). The Tikur (65.9%), Kiy (23.1%), and Nechi varieties (11%)

were the local finger millet varieties used by the studied households (n = 91) in the Sekota district for the 2023/24 cropping season. However, 17.6% of the 91 sample families grew alternative varieties of finger millet, while improved finger millet varieties were never used by the respondent farmers (Table 4.8). On the other hand, Mecha district farmers grow local finger millet Kiy (61.9%), Tikur (28.6%), and Nechi (9.5%) varieties, while out of the total sampled households, only 4.8% of respondents recently used the improved Mecha variety finger millet. Before the previous season, 92.1% of the sample households had grown different local varieties of finger millet.

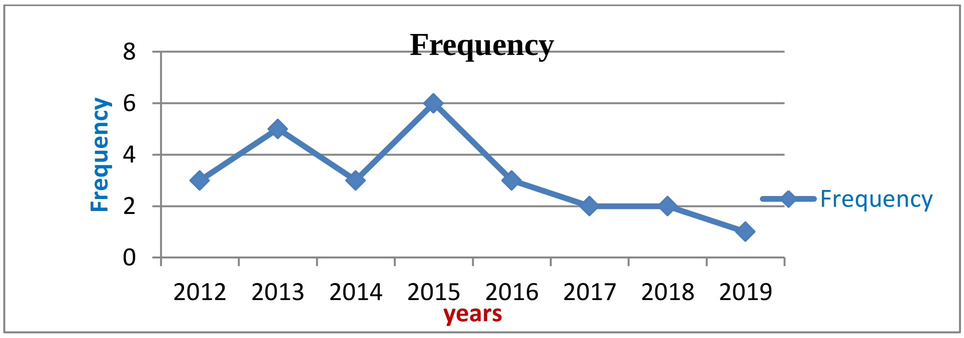

Figure 4.2. Utilization trends of improved finger millet varieties by respondents across years

Table 4.8. Types of local and improved varieties used by farmers across districts

Type of variety		Dera district		Sekota district		Mecha district	
		Freq.	%	Freq.	%	Freq.	%
Local varieties							
Black		87	79.1	60	65.9	18	28.6
Red		8	7.3	21	23.1	39	61.9
White		1	0.9	10	11	6	9.5
Improved varieties							
Mecha		0	0	0	0	3	4.8
Both local and improved		14	12.7	0	0	0	0
Total		110	100	91	100	63	100
Did you use different types of F.millet before last season (2023)?	Yes	16	14.5	16	17.6	58	92.1
	No	94	85.5	75	82.4	5	7.9
	Total	110	100	91	100	63	100

(Source: survey data, 2023/24)

The data from the survey on the selection criteria for different finger millet cultivars across the Dera, Sekota, and Mecha districts show notable differences in priorities and preferences for various cultivars (Table 4.9). The yield is a primary factor for selecting varieties in Dera district, with most farmers prioritizing it. This suggests that Dera farmers are more yield-oriented compared to Sekota and Mecha, where this factor is significantly more important. The most preferred cultivar in the Dera district is Tikur (61.6%), followed by Kiy (20.7%) and Necho (14.6%). In the Sekota district Tikur (52.5%) leads, with Kiy (27.8%) and Nechi (19.8%) also preferred. In Mecha district Tikur is again the top choice (53.2%), followed by Kiy (27.7%) and Nechi (19.1%). Sekota district shows a strong preference for seed color, with over 50% of respondents focusing on this trait. In Dera and Mecha, seed color is less of a priority, with farmers in Mecha showing the least concern (25.2%). Farmers in Mecha prioritize low fertility tolerance the most (46.2%), while Sekota and Dera give moderate attention to this trait. This may reflect differences in soil quality or farming practices across districts. In Sekota, marketability is highly valued (62.7%), which may indicate a stronger market demand for finger millet in that district. Dera and Mecha farmers focus less on this, with values of 14.0% and 24.4%, respectively. The preference for food quality is strongest in Dera (15.6%) and Sekota (62.3%), while Mecha does not consider this trait important (0.0%). This could suggest differences in consumption patterns or dietary preferences.

Drought tolerance is significant across all districts, especially in Sekota (48.5%) and Mecha (48.1%). This is likely driven by environmental factors such as water availability and the risk of droughts in these areas. Disease resistance is highly valued in Dera (18.1%) and Sekota (39.7%), but less so in Mecha (29.8%). It may reflect regional differences in pest and disease pressures. Sekota (41.2%) and Mecha (35.9%) farmers seem to value uniform maturity of crops, which is crucial for efficient harvesting. Dera farmers place less emphasis on this trait (18.3%). High germination rate is a key criterion, especially in Mecha (45.4%) and Sekota (45.1%), where reliable seedling establishment is important for crop success.

Pest tolerance is critical across all districts, with the highest preference in Mecha (46.9%) and Sekota (43.6%); likely due to pest challenges in these regions. Mecha district places the highest importance on loading tolerance (65.0%), while Sekota and Dera show lower percentages. This could reflect the physical handling and storage practices in Mecha. Mecha farmers show a preference for seed size (100%), while ear size is also important in Sekota (50.3%). Dera gives moderate importance to both. Brewing purpose is most important in Sekota (63.2%), suggesting that finger millet may be used more for brewing in that district. Dera and Mecha have a lower emphasis on this trait. Overall, the selection criteria highlight differences in priorities. While factors like yield, seed color, and food quality are more important in some districts, others, such as marketability, drought tolerance, and pest resistance, emerges as key considerations depending on local conditions. These differences suggest that farmers' preferences are shaped by environmental factors, economic opportunities, and local agricultural practices. Market preference (76.4%), pest tolerance (64.5%), injera quality (49.1%), and brewing quality (39.1%) are identified as the top four criteria in the Dera district to select local finger millet varieties. The primary determining factors for selecting various local finger millet varieties in the Mecha district were seed size, ear size, brewing purpose, pest tolerance, high germination rate, seed color, and marketability (Table 4.9). According to the descriptive statistics, the primary factors used by farmers to select (Nechi) local finger millet varieties were lodging tolerance (65%) and seed size (100%). On the other hand, the (Kiy) local finger millet variety was selected based on its high germination rate (45.4%), uniform maturity (47.8%), low fertility tolerance (46.2%), marketability (45.5%), disease tolerance (48.1%), and ability to brew (46.4%).

Table 4.9. Criteria of farmers to select different finger millet cultivars

Criteria	Dera district				Sekota district			Mecha district		
	N	W	K	T	W	K	T	W	K	T
Yield	14.6	3.0	20.7	61.6	19.8	27.8	52.5	19.1	27.7	53.2
Seed color	14.7	15.3	17.2	52.8	41.1	34.5	24.2	29.5	45.7	25.2
Low fertility tolerance	13.7	11.9	26.8	47.6	36.2	32.4	31.4	25.6	46.2	25.6
Marketability	14.0	6.0	17.3	62.7	40.1	35.5	24.4	29.8	45.5	24.4
Food quality	15.6	3.9	18.2	62.3	34.7	32.6	32.6	0.0	0.0	0.0
Drought tolerance	14.6	19.9	17.0	48.5	27.2	35.2	37.6	16.7	48.1	35.2
Disease resistance	18.1	24.1	18.1	39.7	35.9	30.0	34.2	29.8	45.8	24.4
Uniform maturity	18.3	15.3	25.2	41.2	30.0	34.1	35.9	29.2	47.8	23.0
High germination rate	14.8	6.2	34.0	45.1	31.7	32.9	35.3	30.3	45.4	24.4
Pest tolerance	14.0	10.5	32.0	43.6	32.2	30.8	37.0	28.1	46.9	25.0
Loading tolerance	26.4	13.9	25.0	34.7	34.1	36.0	29.9	65.0	35.0	0.0
Ear size	11.2	15.4	23.1	50.3	29.7	32.1	38.3	37.0	44.4	18.5
Seed size	22.2	15.2	22.2	40.4	26.2	34.9	38.9	100	0.0	0.0
Brewing purpose	8.3	11.8	16.7	63.2	0.0	0.0	0.0	30.4	46.4	23.2

(Source: survey data, 2023/24) N = Necho (improved), W = White, K = Kiy, T = Tikur, *the same farmer repeatedly responded on the same selection criteria for preferring a variety.

4.4. Seed Sources

Finger millet producer farmer's access seeds for the first time from different sources, such as from markets, neighbors, relatives, families, and friends, through purchase, exchange, loans, revolving funds, and gifts. In Dera district, 95.5% and 0.9% of the farmers access local seeds after walking less than 2 hours to the local government Keble center and more than 9 hours to neighbor local government Keble centers. Seventy-nine percent of the finger millet growers in Sekota district access seeds from the local government Keble center, and 20.9% of the other farmer's access seeds from neighbor local government Keble centers. In the Dera district, 63.6% of the farmers access the local finger millet seed through gifts, and Necho improved finger millet seed was obtained by the farmers through gifts from the Adet Agricultural Research Center, but in the Sekota district, 75.8% of the farmers also access local finger millet seed through a purchase (Table 4.10). For farmers in Dera District, the reasons for using the local seed source were due to the ability to choose the best seed in the area (43.4%), high level of trust (37.6%), and low cost (19%) of the variety. This result is in line with Dejen Bekis Fentie (2021) with more guaranteed to be sustainable, relatively less expensive, and easily accessible in farmer's villages. However, in Sekota district, the benefit of using this local seed source was due to the availability, and confidence to purchase the seed. Farmers who grow finger millet in the Mecha district acquired seeds from different sources including trade with other farmers (55.6%) followed by through purchases (39.7%), the market (36.5%), and neighbors (20.6%). This finding is consistent with Adane Gebreyohannes *et al*. (2021) research, which revealed that Ethiopian finger millet producers obtain seeds from a variety of sources, such as local markets, BoAs, and other farmers' stored seeds.

In the Dera, Mecha, and Sekota districts, 75.5%, 9.5%, and 52.7%, of farmers obtained finger millet seeds from their farms during the 2023 cropping season respectively, A total of 36.3% of farmers in the Sekota district, 46% in Mecha, and 22.7% in Dera use their Keble center to obtain seeds. According to the survey results, fewer than two hours are needed for 27%, 84.6%, and 93.7% of the farmers in Mecha, Sekota, and Dera districts respectively to obtain seeds. A total of 47.3% of the farmers in the Sekota district and 20% of the farmers in the Dera district obtained seeds through purchases (Table 4.10). According to Taju Mohammednur and Tesfaye Megersa (2021) seed source had a significant impact on seed quality, productivity, and early growth. A total of 22.7% and 1.8% of the sample farmers in the Dera district received finger millet seeds in their Keble centers and other Keble centers respectively. Similarly in the Sekota district, 11% of the farmers and 36.3% of the farmers receive their finger millet seeds from other Keble centers and their Keble centers respectively. The use of diverse seed sources, including self-saved seeds and local exchanges, indicates a dynamic seed system in the study area, although challenges related to seed quality and availability remain critical considerations. Overall, the findings underline the importance of improving access to high-quality seed sources and ensuring that farmers have reliable and timely access to finger millet seeds to enhance productivity and sustainability.

4.5. Seed System and Source of Finger Millet in the Study Areas

According to the research findings, the majority of farmers obtain their seeds from informal seed systems through gifts, trades, and purchases from friends, neighbors, and other farms. The outcome of Taju Mohammednur and Tesfaye Megersa's (2021), which examined the soybean seed system in southwest Ethiopia using the farmers' conserved seeds, is identical to this one. In farmer villages such as Bekis Fentie (2021), this unofficial seed system is the most likely to be affordable, accessible, and sustainable. According to

Rishipal Singh and Ramesh C. Agarwal (2018) and Tekeste Kifle (2023), farmers must help with the local production and distribution of high-quality seeds since the official seed industry is unable to meet the demand of local farmers. The results indicate that the farmers in the vicinity of the producing district were not using an improved variety of finger millet. The FGD members also noted that in certain study districts, informal seed systems dominated the finger millet seed system as a whole. Louwaars and De Boef (2012) reported that establishing a sustainable integrated seed system and implementing the combined approach of both formal and informal seed systems should be recognized as a key method to improve finger millet productivity. Efforts to support farmers in both seed production and distribution are essential for enhancing the sustainability of the seed systems and improving finger millet productivity.

Table 4.10. Farmer's local finger millet seed source for the first time

Variable		Dera district		Sekota district		Mecha district	
		Freq.	%	Freq.	%	Freq.	%
1. Seed source for the 1st time	Market	24	21.8	52	57.1	23	36.5
	Neighbors	3	2.7	10	11.0	13	20.6
	Relatives	11	10.0	15	16.5	7	11.1
	Families	72	65.5	10	11.0	12	19.0
	Friends	0	0.0	4	4.4	8	12.7
2. Systems of Seed acquiring	Purchase	11	10.0	69	75.8	25	39.7
	Exchange	28	25.5	10	11.0	35	55.6
	Loan	1	0.9	0	0.0	0	0.0
	Gift	70	63.6	12	13.2	3	4.8
3. Seed source in 2023	own farm	83	75.5	48	52.7	6	9.5
	Market	21	19.1	29	31.9	34	54.0
	Neighbors	2	1.8	7	7.7	10	15.9
	Relatives	2	1.8	0	0.0	3	4.8
	Families	1	0.9	0	0.0	5	7.9
	Friends	1	0.9	7	7.7	5	7.9
4. Seed supply	Own	38	34.5	48	52.7	3	4.8
	Purchase	22	20.0	43	47.3	39	61.9
	Exchange	4	3.6	0	0.0	18	28.6
	Loan	1	0.9	0	0.0	0	0.0
	Revolving fund	45	40.9	0	0.0	0	0.0
	Gift	0	0.0	0	0.0	3	4.8
	Total	110	100	91	100	63	100
5. Distance traveled to get seed	< 2 hrs	103	93.7	77	84.6	17	27.0
	3 - 5 hrs	1	0.9	11	12.1	33	52.4
	6 - 8 hrs	5	4.5	3	3.3	13	20.6
	>9 hrs	1	0.9	0	0.0	0	0.0
	Total	110	100	91	100	63	100
6. Where the Seed acquired from	Own	83	75.5	48	52.7	34	54
	Keble center	25	22.7	33	36.3	29	46.0
	Other keble center	2	1.8	10	11.0	0	0.0
	Total	110	100	91	100	63	100

(Source: survey data, 2023/24)

The data in Table 4.11 sheds light on farmers' purchasing habits and reasons for purchasing finger millet seeds in the Dera, Sekota, and Mecha districts. In Dera district a significant proportion of farmers (60.9%) do not purchase finger millet seeds, indicating that they may rely on their seed for planting. In Sekota district the percentage of farmers purchasing seeds (50.5%) is higher than in Dera but still substantial, with 49.5% not purchasing finger millet seeds. In Mecha district, all farmers (100%) in Mecha purchase finger millet seeds, reflecting perhaps a lack of locally saved seeds or an emphasis on buying seeds for better quality or variety. In Dera district, most farmers in Dera (24.5%) purchase finger millet seeds rarely (every 3 or more years), with fewer purchasing seeds annually (8.2%). This suggests that farmers in Dera may rely more on saved seeds or longer intervals between seed purchases. In the Sekota district, a majority of farmers (60.4%) purchase finger millet seeds every year, which indicates that farmers in Sekota may face challenges in saving seeds, or there is a regular need to replace seeds to ensure quality. A smaller percentage (31.9%) purchase seeds every other year, while 7.7% purchase seeds rarely. Mecha District, Similar to Sekota, a large portion of farmers in Mecha (38.1%) purchase seeds every year, with another 36.5% purchasing seeds every other year. The remaining 25.4% purchase seeds rarely, though the overall trend suggests a consistent need to buy seeds.

In Dera district, the most common reason for purchasing seeds in Dera is "Replace old seed" (23.6%), which suggests that farmers are replacing older, potentially less productive seeds to maintain crop yields. A smaller percentage (3.6%) purchase seeds to "Replace old varieties", which may indicate a desire to adopt new cultivars. Only a few farmers (12.7%) buy seeds for "Better seed quality", and only 0.9% buy seeds because they have "No own seed". In Sekota district, the predominant reason for purchasing seeds is to "Replace old varieties" (37.4%), suggesting that farmers may be looking for improved or more suitable varieties for their conditions. A smaller number (15.4%) purchase seeds to "Replace old seed" and none of the farmers in Sekota mentioned "Better seed quality" as a reason for purchasing finger millet seeds. A few (4.4%) purchase seeds because they "Have no own seed", which indicates that some farmers may be lacking their own saved seeds. In Mecha district the majority of farmers in Mecha (60.3%) purchase seeds to "Replace old varieties", highlighting a strong desire for improved cultivars or newer varieties. A significant number of farmers (25.4%) buy seeds to "Replace old seed". Only a few (14.3%) buy seeds due to "Better seed quality". Interestingly, all farmers in Mecha (100%) purchase seeds because they have "No own seed", suggesting that there is no significant practice of saving finger millet seeds in this district, making it necessary to purchase fresh seeds annually.

Farmers in Mecha district are entirely dependent on purchasing seeds, while in Dera and Sekota, seed saving or local production is more common, though a significant number still buy seeds to replace old or poor-quality seeds. Mecha and Sekota farmers tend to purchase seeds regularly (annually or every other year), while Dera farmers purchase less frequently, indicating more reliance on self-saved seeds. The main reasons for purchasing seeds vary across districts. Replacing old varieties is the dominant reason in Mecha and Sekota while replacing old seeds is more common in Dera. The need to buy seeds due to lack of own seed is especially notable in Mecha, where it is the only reason given by farmers. These findings suggest that farmers in each district face different challenges and have distinct practices related to seed sourcing, influenced by factors like seed quality, availability, and local agricultural conditions.

Table 4.11. Farmers' time and reason for purchasing finger millet seeds (n = 264)

Variable		Dera district		Sekota district		Mecha district	
		Freq.	%	Freq.	%	Freq.	%
Do you purchase finger millet seed?	Yes	43	39.1	46	50.5	63	100
	No	67	60.9	45	49.5	0	0
	Total	110	100	91	100	63	100
Time purchased	Every year	9	8.2	55	60.4	24	38.1
	Every other year	7	6.4	29	31.9	23	36.5
	Rarely(3 or more)	27	24.5	7	7.7	16	25.4
Reason for purchasing	Replace old varieties	4	3.6	34	37.4	38	60.3
	Replace old seed	26	23.6	14	15.4	16	25.4
	Better seed quality	14	12.7	0	0	9	14.3
	No own seed	1	0.9	4	4.4	63	100

(Source: survey data, 2023/24)

4.6. Finger Millet Agronomic Packages

For finger millet to be produced in various agroecologies and modern agricultural technologies is essential. There is limited availability of suggested agronomic packages, such as herbicide, fertilizer, storage, agronomy, pesticide, and improved varieties implementation in the Sekota district. The findings show that the majority of farmers in the Sekota district do not employ herbicide treatments or improved finger millet cultivars because they are unaware of agronomic packages. The results revealed that all the sampled finger millet growers were unaware of improved varieties due to a shortage of access to new improved varieties of finger millet. Improving access to improved varieties, fertilizers, and comprehensive agronomic guidelines, as well as enhancing farmer education on these technologies, would significantly contribute to increased yields and sustainable finger millet production.

Farmers rated the soil fertility of their farms as medium (37.4%) and low (62.6%). An overwhelming majority of the farmers (72.5%) till their land twice before planting, followed by 12.1% who till once and 12.1% who do not till at all. The practice of tilling twice before planting is likely the preferred method due to its perceived effectiveness in preparing the land for good crop growth. However, a portion of farmers' options for either one tilling or no tilling at all, are likely due to varying farm sizes, economic factors, or a preference for sustainable or traditional practices. The most common method for sowing finger millet in the study areas is the broadcast method. Owing to the variety of finger millet being farmed, the majority of farmers sow it in late May to mid-June (65.9%) and late June (14.3%) as shown in Figure 4.3. This is due to favorable weather conditions, especially rain, which is critical for the growth of the crop. This timing ensures that the crop receives sufficient moisture, and farmers can take advantage of optimal temperature and soil conditions for successful germination and early growth. The smaller percentage of farmers sowing in late June may reflect varying local conditions or the need to adjust for factors like late rains or other seasonal conditions.

Seventy-eight percent of them believe that their soil fertility is low but they have not applied fertilizer for finger millet. The reasons behind the limitation of fertilizer use 62.6% of sampled households said due to the higher cost of fertilizer and restricted access to fertilizer (15.5%). For the production of finger millet locally, from the sampled farmers (264) only 11% of farmers utilize urea and NPS and cooperatives provide NPS and Urea to these farmers (22%). Key informants revealed the other factor was the absence of well-documented finger millet packages, which resulted in restricted use of fertilizer for the crop.

The majority of the farmers (95.6%) weeding their finger millet crops twice, whereas 4.4% weed only once. Among them, 95.6%, 92.3%, and 7.7% of the growers begin weeding at the knee, vegetative, and blooming stages, respectively (Table 4.12). The practices in Sekota district show that weeding is essential for successful finger millet farming, and farmers are using a range of strategies based on the growth stage of the crop and the intensity of weed pressure. Two rounds of weeding, with the majority of farmers starting at the knee and vegetative stages, are common to ensure that weeds do not compete with the crop during critical growth phases. The variations in the timing of the first weeding (from three weeks to 35 days) reflect differences in local conditions, experiences, and weed pressures, but the goal is generally the same: to keep the millet fields clean and maximize yields.

Table 4.12. Weeding time, frequency, and stage of different finger millet varieties

Weeding of finger millet		Frequency	Percent
1st time for the weeding	3 weeks after sowing	21	8.0
	4 weeks after sowing	39	14.8
	35 days after sowing	70	26.5
	mid-July	91	34.5
	first July	25	9.5
	mid-August	18	6.8
	Total	264	100
Frequency of weeding	1 time	43	16.3
	2 times	215	81.4
	3 times	6	2.3
	Total	264	100
Stage of weeding	At knee stage	236	48.9
	At vegetative stage	225	46.6
	At flowering stage	22	4.6
	Total	483	100

(Source: own survey data 2023/24)

The decision of whether to plow once, twice, or more is highly contextual and dependent on the individual farmer's circumstances. The variation in the number of plowing sessions in each district is influenced by soil conditions, weed and pest management, traditional practices, labor availability, economic factors, and weather conditions. One hundred percent of finger millet growers have used the broadcast method according to the survey results. The finger millet varieties sown by farmers (n = 110) in the Dera district varied in terms of timing (Figure 4.3). Mid-July (71.8%), first July (13.6%), mid-August (13.6%), and four weeks after sowing (0.9%) are the times when farmers begin their first weeding (Table 4.12). Thirty-five percent of the farmers had only one weeding experience, whereas 64.5% had two. The crop stages included the knee (84.5%), vegetative (78.2%), and flowering (0.9%) stages. When growing finger millet, 93.6% of the farmers applied herbicide to keep weeds at a minimum.

The results suggest that weeding is a critical part of finger millet farming, typically carried out around 4-5 weeks after sowing, with most farmers opting for two weeding during the crop's growth cycle. The primary weeding occurs at the knee or vegetative stage, with minimal weeding during flowering. These practices reflect the importance of maintaining weed control during key growth periods to ensure optimal crop development.

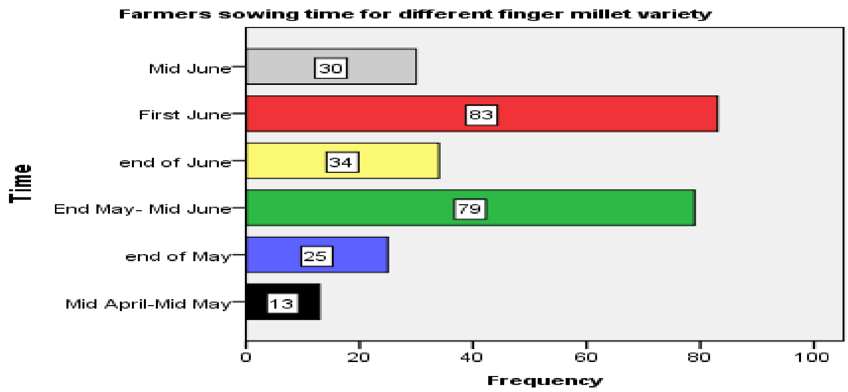

Figure 4.3. Different finger millet varieties sowing time used by the farmers

4.6.1. Respondents agricultural package information source

Different sources provide information about agronomic packages to those farmers (Table 4.13). The data in Mecha district indicates that for all three categories (improved varieties, fertilizers, and agronomic practices); three households reported using each information source, each contributing 33.3% to the total. Table 4.13 shows respondents' perceptions of soil fertility in three districts: Dera, Sekota, and Mecha. In Dera, 20.9% of respondents rated the soil as good, 26.4% as medium, and 52.7% as low. In Sekota, none of the respondents rated the soil as good, 37.4% rated it as medium, and the majority, 62.6%, rated it as low. According to Table 4.13 in Mecha, 14.3% considered the soil good, 49.2% medium, and 36.5% low. Overall, the majority of respondents in all districts perceived their soil fertility as low, indicating challenges in soil quality across the district. In cases where the land's soil fertility is low, 79.1% of the farmers apply fertilizer. The 20.9%, 60%, and 0.9% of finger millet growers use animal manure, urea, and NPS, NPS, and compost, respectively. The source of fertilizer for finger millet growers was from cooperatives (60%) the market (contrabandist) (20.9%) and some of the other prepared compost on their own (0.9%). Despite the low fertility of the land, farmers do not use fertilizer because of its higher cost (15.5%) and limited availability (1.8%). In the Dera district farmers receive information on improved varieties from the agricultural office

(5.5%), other farmers (6.4%), traders (0.9%), and relatives/friends (1.8%). Additionally, 4.5% of the farmers obtained information from both the agricultural office and the traders. The farmers received information about fertilizer, pesticides, and agronomy, 14.5%, 1.8%, and 19.1%, from the agricultural office respectively, a total of 10.9% and 11.8% of the farmers also acquired information on pesticides and herbicides from local traders, respectively. However, 7.3% of the farmers also obtained information on pesticides from traders, the agricultural office, and farmer shops. All the other farmers, except those who received information from other farmers, did not receive storage information (Table 4.13). These findings highlight the challenges in accessing and utilizing agronomic packages, particularly in areas with limited information flow and low soil fertility. The reliance on informal sources of information, such as neighboring farmers and traders, suggests that efforts to improve agricultural productivity should focus on enhancing the dissemination of agronomic knowledge, particularly through formal channels like agricultural offices and cooperatives. Additionally, improving the accessibility and affordability of fertilizers and other inputs would help address some of the barriers to effective finger millet production in those districts.

Table 4.13. Agricultural information sources and soil fertility perception of respondents

Information source	Improved varieties		Fertilizers		Pesticide		Agronomy		Storage		Herbicide	
	n	%	N	%	N	%	N	%	N	%	N	%
Have information yes	25	9.4	24	9.1	23	8.7	24	9.1	4	1.5	16	6.1
BoA	6	2.2	22	8.3	10	3.8	24	9.1	0	0	6	2.3
Relatives	8	3.1	2	0.8	0	0	0	0	0	0	0	0
Traders	5	1.9	0	0	13	4.9	0	0	0	0	10	3.8
Neighbors	6	2.2	0	0	0	0	0	0	4	1.5	0	0

Respondent's perception of soil fertility of their land

Fertility rate	Dera district		Sekota district		Mecha district	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Good	23	20.9	0	0	9	14.3
Medium	29	26.4	34	37.4	31	49.2
Low	58	52.7	57	62.6	23	36.5
Total	110	100	91	100	63	100

4.7. Contractual seed production (CSP)

The results in the Dera district show that, 82.7% produced seeds on a contract basis for maize during different cropping seasons through Amhara Seed Enterprise (ASE) and the Guna Seed Multiplication and Marketing Cooperative Union (GSMMCU). In the Mecha district, farmers participated in community seed production of maize crops (9.5%). According to the results, 20% of the farmers preferred community seed production to obtain high yields, good compensation, and access to high-quality seeds. However, because neither governmental nor non-governmental organizations promoted the production of finger millet there is no community seed production. In the Sekot district, no CSP is working on any crop because of a lack of awareness about community seed production, and no demand for any kind of crop. When compared with 20% of sampled farmers from the Mecha district and 55.6% of sampled farmers from the Dera district the sample farmers preferred finger millet community seed production over maize. This occurred because farmers in Mecha district participated in the maize community seed production during the 2020 and 2022 cropping seasons, and farmers in Dera district participated in the maize. Ethiopia has a few official commercial seed programs that are in operation(Abebe Atilaw and Lijalem Korbu, 2011). Expanding community-based seed systems for finger millet could significantly improve seed quality, increase production efficiency, and enhance the availability of high-quality seeds for farmers in the study area.

4.8. Seed Management and Protection

4.8.1. Seed sorting

Table 4.14 provides an overview of farmers' seed sorting practices and the timing of sorting in three districts: Dera, Sekota, and Mecha. The data highlights who is responsible for seed sorting and when the sorting takes place, revealing notable differences across the districts. Seed sorting is an important task for good-quality seed production. A total of 3.6% sample households from Dera district do not separate grain from seed; this is in contrast to 79.1% of female farmers, 16.4% of male farmers, and 0.9% of children. These farmers sort finger millet seeds before planting (88.2%), just after threshing (7.3%), and while harvesting (0.9%). Sorting grain from seeds was a major responsibility of (61.9%) male and female farmers in the Mecha district. According to the results, the farmers sorted the finger millet on the farm during harvesting 68.3%) and at physiological maturity before harvesting (31.7%). In the Mecha district, 60.4% of farmers said that seed sorting from grain was the responsibility of both male and female farmers and 39.6% said that female farmers solely. A total of 36.3% of those farmers in Sekota district completed this task during harvest, 56% did so shortly after threshing, and 7.7% did so right before planting. Overall, the seed sorting practices and timing show significant regional variation. In Dera, seed sorting is predominantly a female-led activity done right before planting, while in Sekota and Mecha, sorting is more of a collaborative effort between men and women, with sorting taking place at different stages of the harvest process. These variations in seed sorting practices underscore the importance of context-specific seed management approaches to enhance seed quality and, ultimately, agricultural productivity.

Table 4.14. Farmers' seed sorting practices and time of sorting from grain

Seed sorting		Dera district		Sekota district		Mecha district	
		Freq.	%	Freq.	%	Freq.	%
Who responsible for seed sorting	Female farmers only	87	79.1	36	39.6	3	4.8
	Male farmer only	0	0	0	0	21	33.3
	Both male and female farmers	18	16.4	55	60.4	39	61.9
	Children	1	0.9	0	0	0	0
	Does not sort	4	3.6	0	0	0	0
	Total	110	100	91	100	63	100
Time of sorting	During harvesting	1	0.9	33	36.3	20	68.3
	Before harvesting	0	0	0	0	43	31.7
	Just after threshing	8	7.3	51	56	0	0
	Just before planting	97	88.2	7	7.7	0	0
	Does not sort	4	3.6	0	0	0	0
	Total	110	100	91	100	63	100

(Source: survey data, 2023/24)

4.8.2. Seed cleaning

Table 4.15 provides insights into farmers' seed cleaning methods and the reasons behind these practices across three districts: Dera, Sekota, and Mecha. Seed cleaning is a postharvest activity during seed production and is used to improve the physical quality of seeds. Sampled farmers from the Dera, Sekota, and Mecha districts, approximately 100%, 70.3%, and 60.3%, respectively, used winnowing as their method of seed cleaning. In Dera district, all farmers (100%) use winnowing as their primary method of seed cleaning, with no reported use of sieving or a combination of methods. However, sieving was the other cleaning strategy used by the farmers in Sekota (29.7%) and Mecha (12.7%). In Sekota district, winnowing is the predominant method (70.3%), but a significant portion (29.7%) also uses sieving. In Mecha district, winnowing is still the most common method (60.3%), but there is a notable portion (27%) using both winnowing and sieving for cleaning seeds. This variation suggests that while winnowing is universally used, farmers in Sekota and Mecha districts are more likely to adopt additional methods like sieving to ensure cleaner seeds. The survey describes the reasons farmers in three districts (Sekota, Dera, and Mecha) clean their seeds. Removing inert matter is the most common reason across all districts, with Sekota having the highest percentage (82.4%) of farmers citing it. Inert matter refers to anything that is not a viable seed, such as dirt, stones, and chaff. While removing small/broken seeds are important in Dera and Mecha, but not mentioned in

Sekota. Additionally removing weeds/other crops is less common overall, with Sekota and Mecha reporting this more frequently than Dera. This information is valuable for understanding the agricultural practices in these areas and could be used to improve seed-cleaning techniques and ultimately increase crop yields. The respondents stated that their reasons for cleaning the seeds were to remove inert.

Table 4.15. Proportion of farmer's seed cleaning method and reason for seed cleaning

Seed cleaning		Dera district		Sekota district		Mecha district	
		Freq.	%	Freq.	%	Freq.	%
Methods of seed cleaning	Winnowing	110	100	64	70.3	38	60.3
	Sieving	0	0	27	29.7	8	12.7
	Both	0	0	0	0	17	27
	Total	110	100	91	100	63	100
Reasons for seed cleaning	Reason for seed cleaning						
	Remove inert matter	54	49.1	75	82.4	48	76.2
	Remove weeds/other crops	6	5.5	16	17.6	10	15.9
	Remove small/broken seed	50	45.4	0	0	5	7.9
	Total	110	100	91	100	63	100

(Source: survey data, 2023/24)

4.8.3. Seed replacement

Table 4.16 provides an analysis of seed replacement practices, reasons for seed replacement, and the sources of seeds used by farmers in the Dera, Sekota, and Mecha districts. In Dera district, 30% of farmers replace finger millet seeds, while 70% do not. Sekota District: 80.2% replace seeds, with 19.8% not replacing them. Mecha district: 59.3% of farmers replace seeds, while 30.7% do not replace seeds in other categories. In Sekota, seed replacement is more common, suggesting a greater reliance on improving or renewing seed stock compared to Dera. Dera and Mecha might face challenges related to using old seeds, potentially affecting yields or introducing less resistance to pests or diseases.

Dera district: Farmers replace a variety of seeds, with a notable shift from red millet to black (53.7%) and some instances of replacing white with black (2.4%). Sekota District: More common shifts include black replacing black (41%), and white replacing red (10%).

Mecha district: Farmers replace white with red (41.8%) and red with black (48.4%). Dera is experiencing a diversity of variety replacements, which could be driven by a desire for better yield or market preferences. In Mecha, the replacement of white with red and red with black suggests a focus on improving grain quality, possibly linked to market demands or local preferences. For example, growers switch from black to red because the latter variety produces “injera” of a higher caliber than the former. Dera district: 61.7% replace seeds because they don't have quality seeds. 19.1% replace seeds due to the old age of the seed stock. Sekota District: 38.4% replace seeds due to a lack of good-quality seeds and 34.2% replace seeds of old variety. Mecha District: 25% replace seeds due to lack of quality seeds and 28.3% replace seeds to replace old varieties. In addition to this 13.3% replace seeds for the high quality of Injera. In Dera district, the farmer who replaced red with black indicated that the red finger millet variety had a greater injera quality than the black finger millet variety. Dera faces a significant challenge in accessing quality seeds, which may lead to poor yields if farmers are continually using old or non-optimal varieties. In Sekota and Mecha, the emphasis on replacing seeds for quality and variety improvements suggests greater opportunities for agricultural enhancement, especially if farmers can access better seed varieties.

Dera district: Only a small percentage (4.5%) of farmers’ source seeds from the market, with most relying on other farmers (16.4%). Sekota District: A significant portion of seeds (41%) comes from other farmers, while the market plays a minor role (1.8%). Mecha District: Again, the majority of seeds come from other farmers (7.3%), with the market providing a very small portion (0.9%). The reliance on other farmers as a primary seed source suggests a strong community-based system for seed exchange. However, the small market share indicates that formal seed markets may not be well-developed in these regions. Improving the seed market infrastructure could provide farmers with better access to high-quality seeds, thereby improving overall crop performance.

The data highlights significant differences in seed replacement practices, reasons for replacement, and sources. The result indicates the importance of seed sorting and replacement for maintaining crop quality and productivity. While, Dera faces challenges in seed quality and availability, Sekota and Mecha show more active engagement in replacing seeds for variety improvement and higher yields. Strengthening seed access, improving the quality of seeds, and developing local seed markets are key areas for policy intervention to enhance agricultural productivity in these districts.

Table 4.16. Farmer's seed replacement and the seed source for replacement

Seed replacement		Dera district		Sekota district		Mecha district	
		Freq.	%	Freq.	%	Freq.	%
Do you replace Seed of finger millet?	No	77	70	18	19.8	64	100
	Yes	33	30	73	80.2	38	59.3
Variety was replaced by the farmers'	black by Necho	7	17.1	0	0	0	0
	black by black	4	9.8	41	41	0	0
	white by red	1	2.4	10	10	23	41.8
	white by white	0	0	12	12	0	0
	white by black	1	2.4	21	21	10	15.6
	red by red	6	14.6	0	0	0	0
	red by black	22	53.7	16	16	31	48.4
	Total	41	100	100	100	0	0
Why do farmers replace seeds?	Replace old seed	9	19.1	20	27.4	9	15
	High quality of Injera	1	2.1	0	0	8	13.3
	High market demand	0	0	0	0	4	6.7
	Replace old variety	7	14.9	25	34.2	17	28.3
	Brewing purpose	1	2.1	0	0	0	0
	Low yield	0	0	0	0	7	11.7
	No own quality seed	29	61.7	28	38.4	15	25
	Total	47	100	73	100	60	100

Seed source	Variety							
	Nacho		Red		Black		White	
	N	%	Freq.	%	Freq.	%	Freq.	%
Market	2	1.8	1	0.9	1	0.9	0	0
Other farmers	5	4.5	18	16.4	8	7.3	2	1.8

(Source: survey data, 2023/24)

4.9. Respondents' Good Seed Traits

Table 4.17 lists the characteristics of good finger millet seeds, along with the frequency and percentage of responses for each characteristic, as well as their ranking based on their importance. The most crucial qualities of high-quality finger millet seeds are viewed differently by farmers in different districts. The five most important characteristics of good finger millet seeds, according to the survey data, are high yield, disease resistance, drought resistance, low fertility tolerance, and marketability. High yield ranked first with 17.2% of responses, followed by disease resistance at 15.3%. Drought resistance and low fertility tolerance both received 8.7%, ranking third and fourth, while marketability was fifth with

8.0%. These factors were identified as the key qualities that contribute to the desirability of finger millet seeds.

In the Dera district, farmers identified the five most important quality parameters of high-quality seeds were lodging tolerance (12.7%), tillering capacity (9.1%), marketability (11.6%), disease resistance (16.5%), and high yield (16.5%); however, in Sekota district, the farmers identified disease resistance (12.9%), insect resistance (11.5%), drought tolerance (20.2%), fertility tolerance (20.2%), and seed color (9.3%) above all other qualities. These characteristics are ranked based on their importance as indicated by the frequency and percentage of responses from the survey. The most important factors seem to be high yield, disease resistance, and drought resistance, followed by low fertility tolerance and marketability. This information is valuable to understanding the specific needs and priorities of farmers in the region, and targeted interventions can be developed to improve seed quality and enhance agricultural productivity.

Table 4.17. The five most important characteristics of good finger millet seeds

Characteristics	Responses		Rank
	Frequency	Percent	
Large seed size	77	7.1	6
Early maturing	4	0.4	16
Straw palatability	15	1.4	13
Spike length	13	1.2	15
High tillering capacity	50	4.6	10
High straw yield	61	5.6	9
Injera quality	40	3.6	12
"Wuha mansat”	14	1.3	14
Marketability	88	8.0	5
Disease resistance	168	15.3	2
Insect resistance	64	5.8	8
Drought resistance	96	8.7	3
High yielding	189	17.2	1
Brewing quality	15	1.4	13
Low fertility tolerance	95	8.7	4
Seed color	67	6.1	7
High germination percentage	42	3.8	11
Total	1098	100	

(Source: survey data, 2023/24)

4.10. Seed Storage and Protection

The data presented in Table 4.18 shows the storage methods and protection measures for grain seeds across three districts: Dera, Sekota, and Mecha. The frequencies and percentages are provided for each type of storage method and protection measure. Dera district: The majority of farmers (97.3%) store grain in dibignit (gotera) in the house, a traditional storage method, while a small percentage (1.8%) use sacks in the house. A very small number (0.9%) use underground pits. Sekota district: All farmers (100%) store grain in sacks in the house. This is the sole method used in Sekota.Mecha district: A significant portion of farmers (49.2%) store grain in sacks in the house, while another 41.3% use dibignit (gotera) in the house.

Dera district: Most farmers (90%) store seeds in dibignit (gotera) in the house, while 9.1% use sacks in the house. A very small number (0.9%) use underground pits in the house. Mecha district: The majority (54%) use sacks in the house to store seeds, with 31.8% using dibignit (gotera) in the house. A small percentage (9.5%) store seeds in dibignit (gotera) outside the house. In all three districts (Dera, Sekota, and Mecha), no protection measures are reported to be used for seeds, grain, and spikes. Concerning safeguarding the finger millet spike, seed, and grain against storage pests, all the farmers did nothing. The lack of protection measures suggests that farmers may be unaware of or unable to afford more effective protection methods, such as pest control or environmental control measures (e.g., moisture reduction). This could impact food security and farming sustainability in these districts. The lack of protection may also contribute to lower seed quality, thereby reducing yields in subsequent harvests, and impacting food supply and farmer income. There may be a need for interventions aimed at improving storage practices and protection measures. Providing access to better storage facilities, education on protection methods, or subsidies for modern storage solutions could help reduce losses.

Sekota district: All farmers (100%) store seeds in sacks in the house, similar to their grain storage method. This is a result of the district being a dry land area and farmers storing finger millet seed in sacks to keep it safe. In those three study districts, the farmers have not taken any precautions against storage pests for spikes, seeds, or grains because finger millet seeds can be stored for a long period. According to Dida *et al*., 2007 and Anuradha *et al*., 2010 finger millet has excellent storage qualities.

Dibignit (gotera) appears to be the most popular storage method for both grain and seeds in Dera, which suggests a strong reliance on traditional storage techniques. In Sekota, sacks are the preferred method for grain and seeds, highlighting a more modern and perhaps more standardized approach to storage. Mecha district shows a blend of traditional and modern methods with a significant portion using sacks, but also a reliance on dibignit for seeds. This could indicate differing levels of resource availability, access to modern storage solutions, or local agricultural practices.

Table 4.18. Farmers' storage methods and protection measures for grain seeds

Storage	Dera district		Sekota district		Mecha district	
	Freq.	%	Freq.	%	Freq.	%
Storage method for grain						
Sacks in the house	2	1.8	91	100	31	49.2
Dibignit(gotera) in the house	107	97.3	0	0	26	41.3
Underground pit in the house	1	0.9	0	0	0	0
Sacks and dibignit(gotera) in the house	0	0	0	0	6	9.5
Total	110	100	91	100	63	100
Storage method for seed						
Sacks in the house	10	9.1	91	100	34	54
Dibignit(gotera) in the house	90	90	-	-	20	31.8
Underground pit in the house	1	0.9	-	-	0	0
Dibignit(gotera)outside the house	0	0	0	0	6	9.5
Total	110	100	91	100	63	100
Protection measures for seed, grain, and spike						
No measure taken	110	100	91	100	63	100
Total	110	100	91	100	63	100

(Source: survey data, 2023/24)

4.11. Seed Diversity, Management, and Varietal loss

In the Dera district farmers stopped sowing the finger millet varieties Necho (0.9%), Mecha (0.9%), Tesema (0.9%), Nechi (0.9%), and Tikur (0.9%) between the years 2009 and 2013. The reasons for this were deliberate loss (0.9%), low yield (1.8%), lodging (0.9%), and low fertility tolerance (1.8%). However, from the year 2019 to 2023, farmers stopped growing Nacho (0.9%), white (6.4%), and black varieties because of diseases (2.7%), low yields (5.4%), poor injera quality (3.6%), low marketability (2.7%), low straw yield (2.7%), and poor "Injera" and brewing quality (3.6%). According to Table 4.19, Farmer abandonment of the Red (77%) and White (66%) varieties in the Sekota district occurred during the year 2009 to 2013 cropping season because of accidental loss (35.2%)

and low-yielding (95.1%) varieties. However, farmers ceased cultivating native white (84.6%), red (82.4%), and black (15.4%) varieties between 2019 and 2023 because of deliberate loss (17.6%), accidental loss (17.6%), low yield (100%), and scarcity of farmland (100%) as shown by Table 4.20. According to the FGD participants, farmers prioritized other crops due to the above reasons over finger millet, leading to neglect and a decline in cultivation. This information provides valuable insights into the need for interventions that address these challenges, such as improving seed quality, enhancing cultivation practices, promoting the value of finger millet to farmers, and selecting varieties that are more resilient to diseases and better suited to market demands.

Table 4.19. Finger millet varieties stopped growing by farmers from 2009 to 2013

Years	Variety	Dera district		Sekota district		Mecha district	
		Freq.	%	Freq.	%	Freq.	%
Varieties Stopped from production from 2009 to 2013	Necho	2	50	0	0	0	0
	Mecha	1	25	0	0	0	0
	Black	0	0	0	0	4	30.8
	White	1	25	65	45.8	3	23.1
	Red	0	0	77	54.2	6	46.2
	Total	4	100	142	100	13	100
The reason to stop producing from the years 2009 to 2013	Low fertility tolerance	1	20	0	0	6	46.2
	Lack of variety	1	20	0	0	0	0
	Low yield	2	40	87	41.1	0	0
	Lodging	1	20	0	0	0	0
	Accidental loss	0	0	32	15.2	7	53.8
	Land size limitation	0	0	91	43.3	0	0
	Total	5	100	210	100	13	100

(Source: survey data, 2023/24)

Table 4.20. The finger millet variety stops growing by farmers from 2019 to 2013

Variety	Dera district		Sekota district		Mecha district	
	Freq.	%	Freq.	%	Freq.	%
Variety stop grew in 2019-2023						
Necho	1	11.1	0	0	0	0
White	7	77.8	77	46.4	5	50
Black	1	11.1	14	8.4	5	50
Red	0	0	75	45.2	0	0
Total	9	100	166	100	10	100
Reason to stop grew 2019-2023						
Disease	3	13	0	0	0	0
Lack the variety	1	4.3	0	0	0	0
Low seed yield	5	21.7	91	42.5	14	66.7
Low injera quality	4	17.4	0	0	0	0
Low market demand	3	13	0	0	0	0
Low straw yield	3	13	0	0	0	0
Low brewing and injera quality	4	17.4	0	0	0	0
Land size limitation	0	0	91	42.5	0	0
Accidental loss	0	0	16	7.5	5	23.8
Deliberate loss	0	0	16	7.5	2	9.5
Total	23	100	214	100	21	100

(Source: survey data, 2023/24)

4.12. Farmer Breeding

4.12.1. Seed selection

Table 4.21 presents the results of a survey regarding farmers' practices of varietal/seed selection, including whether they engage in this practice, who is responsible for it, and at which stages of the growing process selection occurs. Farmers are engaging in a variety of conventional breeding practices, such as seed selection. The majority of farmers (83%) engage in varietal or seed selection, which suggests that a significant portion of the farming community is actively involved in ensuring the quality and suitability of seeds for future planting. This could be an indication of a desire to improve yields, select for better traits, or adapt to local environmental conditions. The 17% who do not practice seed selection could be due to a lack of awareness, resources, or preference for purchasing commercial seeds rather than saving and selecting their own. This group may face challenges in seed quality or may not perceive the need for such practices.

Timing of Seed Selection: Pre-harvesting selection (34.8%) is the most common time for seed selection, which indicates that farmers are proactive in identifying suitable plants for seed saving before harvesting. This could allow them to choose the best plants that have had time to fully mature and express desirable traits. Harvesting (28.4%) is the second most common time, which suggests that farmers may make final decisions about seed selection when they are harvesting the crop, possibly when they can evaluate the plants' overall performance. At threshing (17.4%) indicates that some farmers choose seeds during the threshing process, likely after the plants have been fully harvested and processed. This could be due to the desire to pick the best seeds from the harvested grain. Storage (1.1%) represents the least common time for selection, which implies that very few farmers wait until after storage to select their seeds. This could indicate that by the time the seed is stored, farmers are satisfied with their selection or find it impractical to re-select during storage.

The majority of farmers practicing seed selection could contribute to the overall improvement in crop yield and quality. By selecting seeds from plants that show desirable traits (e.g., resistance to pests, higher yields, or better drought tolerance), farmers may increase the productivity and resilience of their crops. The focus on selecting spikes and plants suggests that farmers are aiming for the best genetic material. This practice can help ensure better-quality seed for future planting seasons, potentially improving crop success in subsequent years. The practice of seed selection is essential for seed security, as it allows farmers to save seeds from year to year and reduce their dependency on external seed sources. This is particularly important in areas where access to high-quality seeds may be limited or expensive. The fact that farmers are involved in selecting seeds well before harvest (pre-harvesting and harvesting) demonstrates an active interest in preserving high-quality seeds for future use.

The Seventeen percent of farmers who do not engage in seed selection may be at a disadvantage in terms of seed quality, as they may rely on external sources for seeds, which could be costly or less adapted to local conditions. This group may also face challenges in maintaining genetic diversity or selecting traits that are specifically beneficial to their local environment. There is a clear opportunity for agricultural extension services to support farmers, particularly those who do not practice seed selection. Providing training on best practices for seed selection could enhance the overall productivity of the farming community. Farmers who select seeds at later stages like at threshing or storage could benefit from education on the advantages of early-stage selection, ensuring better seed quality and reducing the risk of storing poor-quality seeds.

Table 4.21. Farmers' practices of varietal/seed selection and stages of selection

Selection practice		Frequency	Percent
Do farmers practice varietal/seed selection?	Yes	219	83
	No	45	17
	Total	264	100
Time of selection	pre harvesting	92	34.8
	at harvesting	75	28.4
	at threshing	46	17.4
	at storage	3	1.1

(Source: survey data, 2023/24)

4.13. Seed Security

Seed security is a crucial aspect of agricultural sustainability and food security, encompassing the availability, access, and quality of seeds necessary for farmers to cultivate crops effectively. Understanding seed security involves differentiating between acute and chronic seed insecurity, which can significantly impact agricultural productivity and livelihoods. In the Dera district, 43.6% of the farmers had secured seeds for the 2024/25 cropping season; the remaining farmers had not secured because of drought (0.9%), consumption (30.9%), and insufficient seed production (14.5%). These farmers were not secured frequently (31.8%), occasionally (11.8%), and every other year (12.7%). Seed help (9.1%), credit services for seed purchases (7.3%), variety changes (20.9%), increasing seed output (3.6%), and separating seeds from grains (12.7%) were among the suggestions made by farmers to reduce seed insecurity.

Forty-four percent of the farmers in the Sekota district had access to seeds. From the remaining producers 46.2% of farmers every year 3.3% every other year and 6.6% infrequently seed unsecured this result suggests that the causes of seed insecurity were drought (40.7%), consumption (7.7%), and inadequate seed production (7.7%). Farmers recommend changing varieties (3.3%), increasing seed yield (16.5%), providing seed aid (8.8%), and practicing good agronomic and pest management (27.5%) as ways to reduce the degree of seed insecurity (Table 4.22).

In the Mecha district, most of the finger millet growers (44%) were unsecured every year (38.1%) followed by every other year (31.7%). The survey results indicated that consumption (34.9%), insufficient seed production (15.9%), diseases (9.5%), selling all out (6.3%), and drought (3.2%) were the reasons for farmer seed insecurity (Table 4.22). To solve this problem, the respondents suggested that proper agronomic and pest management (20.6%), changing varieties (20.6%), properly harvesting (12.7%), separating seeds from grain (7.9%), providing seed aid (4.8%), and increasing seed yield (3.2%) should be solutions to reduce seed insecurity.

According to Practitioners(2015), seeds must meet acceptable standards in terms of the quality of the variety. Quality encompasses both physical attributes (like germination rates) and genetic characteristics (such as plant type and growth duration).

Table 4.22. Farmers' suggestions to reduce seed insecurity

Seed security		Dera district		Sekota district		Mecha district	
		Freq.	%	Freq.	%	Freq.	%
Are you seed-secured?	Yes	48	43.6	40	44	19	30.2
	No	62	56.4	51	56	44	69.8
	Total	110	100	91	100	63	100
Unsecured time	Every year	35	31.8	42	46.2	24	38.1
	Every other year	14	12.7	3	3.3	20	31.7
	Rarely(>3years)	13	11.8	6	6.6	0	0
Reason for seed insecurity	Drought	1	0.9	37	40.7	2	3.2
	Consumption	18	16.4	7	7.7	22	34.9
	Insufficient seed production	32	29	7	7.7	10	15.9
	Selling all-out	9	8.2	0	0	4	6.3
	PH problem	1	0.9	0	0	0	0
	Disease	0	0	0	0	6	9.5
Suggestion to reduce seed insecurity	Proper agronomic and pest management	15	13.7	25	27.5	13	20.6
	Seed aid	6	5.5	8	8.8	3	4.8
	Change varieties	15	13.6	3	3.3	13	20.6
	Increasing seed yield	4	3.6	15	16.5	2	3.2
	Separation of seed from grain	22	20	0	0	5	7.9
	Properly harvest	0	0	0	0	8	12.7

(Source: own survey data 2023/24)

4.14. Seed Quality Attribute

4.14.1. Seed analytical purity

The most important characteristics of seed quality are, according to ISTA 2014, moisture content, TSW, other crop seeds, and seed purity. Each of these characteristics has a specific laboratory standard for a particular crop. Table 4.23 presents the results of testing several physical quality features for seed samples acquired from formal and informal seed sources. There is a highly significant difference in seed purity. Formal seed sources are significantly purer than informal sources ($P < 0.05$). Formal seed sources have significantly fewer other crop seeds and weed seeds than informal sources ($P < 0.05$). There is a significant difference in inert matter. Formal seed sources have significantly less inert matter than informal sources ($P < 0.05$). Yekoye Abebaw Yitayew (2023) on assessment of bread wheat seed quality obtained similar results, indicating notable variations in several seed quality criteria between formal and informal seed sources. Moreover, field pea variety seed samples from the two groups at Enarji Enawuga and Yilmana Densa district showed a statistically significant difference in physical purity characteristics (apart from other crop seeds), according to Yenus Ali (2023). For seed samples obtained from formal and informal seed sources, respectively, the mean percentages of pure seed were 99.98% and 63.55%. According to Mayer G.Mula (2014), a farmer's output can rise by roughly 20–30% when using high-quality seeds that are physically and genetically pure. Comparing the mean percentages of inert matter and other crop seeds from official and informal seed sources, the informal seed sample showed greater percentages. Farmers' carelessness during pre- and post-harvest activities is the reason why the seed sample from the unofficial source contained a mixture of finger millet seeds. Formal seed sources demonstrate higher Seed Purity, lower Other Crop Seeds, lower Weed Seeds, and lower Inert matter compared to informal sources. All these differences are statistically significant ($P < 0.05$). This data indicates that formal seed sources tend to have superior seed quality in terms of purity, crop integrity, and seed weight.

4.14.2. Moisture content (%)

According to ISTA 2014, a seed's water content, or seed moisture content, is often represented as a percentage of the seed's overall weight. It has a significant impact on the durability, storage life, and quality of seeds. There is no significant difference in moisture content between formal and informal seed sources ($P > 0.05$). On average, 12.23% of MC was recorded from formal seed sources and 12.4% from informal seed sources, but those MC from the two seed sources were statistically non-significant (Table 4.23).

4.14.3. Thousand seed weight (TSW)

Table 4.23 presents the results of a comparison of seed quality attributes between formal and informal seed sources, including Thousand Seed Weight (TSW). The data includes the mean, standard deviation, and t-test results, highlighting significant differences in several key attributes. Seed vigor and genetic potential are measured by TSW. Regarding the density, size, and overall quality of the seeds, it provides significant information. Formal sources have significantly higher thousand seed weights compared to informal sources (P <0.05). When the seed sample was taken from formal and informal seed sources, the mean percentage of TSW was 3.21g and 1.93g, respectively. Formal seed sources demonstrate higher Thousand Seed Weight (TSW) compared to informal sources. This data indicates that formal seed sources tend to have superior seed quality in terms of seed weight.

Table 4.23. Comparison of analytical quality attributes between formal and informal source

Variable	Formal (n=3)		Informal (n=5)		t-test result	
	Mean	Std. Dev.	Mean	Std. Dev.	t (df=7)	P value
Seed purity (%)	99.98	0.0015	63.55	6.76	-9.040	0.000
Other crop seed (%)	0.0006	0.0011	3.166	7.06	7.520	0.000
Weed seed (%)	0.0003	0.0005	0.0222	0.016	2.277	0.000
Inert matters (%)	0.0003	0.0005	4.7	0.803	9.814	0.000
TSW (g)	3.21	0.2621	1.93	0.206	-7.769	0.000
MC (%)	12.23	0.665	12.40	10.53	0.242	0.793

(Source: own Laboratory data 2023/24), n= numbers of sample, MC= Moisture content, TSW =Thousand seed weight

4.14.4. Germination percentage

To compare the quality of various lots and calculate the field planting value, germination tests are employed to ascertain a seed lot's capability for germination (ISTA, 1993). In healthy soil with ideal moisture, temperature, and light levels, a normal seedling has the potential to continue growing into a good plant. In Table 4.24, the average values of fresh seed, hard seed, abnormal seed, dead seed, and normal seedlings are displayed. As per the results, there was a significant difference in the percentage of normal seedlings between formal and informal seed sources, with formal seed sources having a higher percentage of normal seedlings (P < 0.05). The average proportion of normal seedling germination (germination percentage) for seeds acquired from formal and informal seed sources was

97.3% and 84.6%, respectively. There is a significant difference in the percentage of fresh seeds, with informal sources having a higher percentage of fresh seeds than formal sources ($P < 0.05$). There is a marginally significant difference in abnormal seedling percentages, with informal sources having a higher percentage of abnormal seedlings. Higher mean percentages (4.8%) and lower mean percentages (2.3%) were found for abnormal seedlings from informal and formal seed sources, respectively. However, there was no significant difference for hard seed or dead seed between formal and informal seed sources.

Table 4.24. Comparison of standard germination between formal and informal source

Variable	Formal (n=3)		Informal (n=5)		t-test result	
	Mean	Std. Dev.	Mean	Std. Dev.	t (df=7)	P value
Normal seedling (%)	97.3	2.0	84.6	4.8	-4.232	0.002
Abnormal seedling (%)	2.3	1.5	4.8	1.3	2.443	0.050
Dead seedling (%)	0.3	0.5	2.4	2.7	1.268	0.231
Fresh seed (%)	0.0	0.0	1.2	1.3	1.543	0.025
Hard seed (%)	0.0	0.0	7.0	2.9	4.027	0.06

(Source: own Laboratory data 2023/24), n= number of samples

4.14.5. Seed vigor

Table 4.25 compares seed vigor attributes between formal (n=3) and informal (n=5) seed sources, including various seedling characteristics such as Seedling Shoot Length, Seedling Root Length, Seedling Dry Weight, Rate of Germination, and Seed Vigor Index (SVI-1 and SVI-2). The results are statistically analyzed using a t-test to assess differences between the two sources. To assess the vigor of the seed sample obtained from both official and informal seed sources, physiological parameters such as germination rate, length of the seedling shoot, seedling root length, dry weight of the seedling, and seedling vigor index 1 (SVI 1) and 2 (SVI 2) were measured. There was a significant difference ($p = 0.035$) in the dry weight of the seedlings between the two groups. Only Seedling Dry Weight ($P = 0.035$) shows a significant difference, with formal seed sources having higher seedling dry weight than informal ones. Compared to the informal seed source, which reported 0.01 g of seedling dry weight, the formal seed source recorded a higher mean seedling dry weight of 0.02 g. To assess the growth potential, two metrics are used to assess seedlings formed from seeds: seedling length and dry weight. The general quality and vigor of the seedlings can be understood with the aid of these metrics. This result is consistent with Yekoye Abebaw Yitayew *et al.*, 2023 study on bread wheat, which found that a highly significant difference was seen in the dry weight of the seedlings from seed samples obtained from formal and informal seed sources. Other seed vigor indicators, such as seedling shoot length, seedling root length, seedling vigor index 1, seedling vigor index 2, and rate of germination, did not show a statistically significant difference between the two groups. There were no significant differences in other attributes such as Seedling Shoot Length, Seedling Root Length, Rate of Germination, and Seed Vigor Indices (SVI-1 and SVI-2), indicating that the vigor of seeds from formal and informal sources is similar in these aspects. As can be seen in Table 25, the informal seed source had a seedling shoot length of 1.2 cm and a germination rate of 7.6%, whereas the formal seed source had a mean value of 7.5 cm and an 8.8% germination rate. According to Kaydan and Yagmur (2008), a crucial factor in plant growth research is the length of the seedling shoot, which indicates the health and vitality of the seedlings. However, the official and informal seed sources had vigor indices of 12282.6 and 7585.1, respectively. The formal seed source also had a higher SVI 2 (2.1) than the informal seed source (1.3), but the difference was not statistically significant. Hence, the lack of statistically significant differences in most vigor indicators suggests a need for more in-depth research to understand the nuances of seed vigor beyond TSW.

Table 4.25. Comparison of seed vigor attributes from formal and informal seed source

	Form (n=3)		Inform (n=5)		t-test result	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	t (df=7)	P value
Seedling shoot length (cm)	1.2	8.9	7.5	4.2	-1.85	0.178
Seedling root length (cm)	16.53	3.9	13.9	6.8	-0.59	0.514
Seedling dry weight (g)	0.02	0.01	0.01	0.003	-1.19	0.035
Rate of germination (%)	7.6	0.57	8.8	3.03	0.62	0.169
SVI- 1	12282.6	893.5	7585.1	4089.8	-1.904	0.183
SVI- 2	2.1	1.1	1.3	0.3	-1.555	0.183

(Source: own Laboratory data 2023/24), SVI 1= seed vigor index 1, SVI 2= seed vigor index 2.

4.15. Informal Seed Quality Analysis

4.15.1. Physical purity

Table 4.26 presents the mean values for various physical quality metrics of seed samples from informal sources, including parameters such as TSW (Thousand Seed Weight), Pure Seed Percentage, Other Crop Seed Percentage, Inert Matter Percentage, Weed Seed Percen tage, and Moisture Content (MC). Each parameter reflects different aspects of seed quality, with results for each treatment (S1 to S24) compared. When seeds are considered physically pure, it means that they are free of contaminants like weed seeds, other crop seeds, and inert stuff. For maximum crop output and to reduce plant competition, this component of seed quality is essential. Determining the percentages of pure seed, other crop seeds, weed seeds, and inert particles in a seed lot is known as physical purity testing. When comparing various samples obtained from unofficial seed sources for various seed quality parameters, the mean separation revealed a substantial difference. Concerning TSW, a significant difference ($p<0.001$) was found between the seed samples of S1 (a white finger millet variety stored in sacks in the house) from Sekota district, S11 (a red finger millet variety stored in sacks in the house) from Dera district, and S17 (a red finger millet variety stored at sacks in the house) from Mecha district. This finding shows that there was a substantial mean difference in the informal seed sources in the districts of Dera, Mecha, and Sekota. Greater TSW mean values were found in seed samples S1, S11, and S21 (2.18g), while lower mean values were found in seed samples S10 (white finger millet variety kept in sacks in the house) from Dera district and S20 (red finger millet variety stored in gotera in the house) from Mecha district (1.6g).

Regarding pure seed (%), weed seed (%), inert matter (%), other crop seed (%), and moisture content (%), statistically significant differences were also found between some seed samples that were obtained from three distinct districts. As shown by Table 26, the pure seed sample's mean percentage was 62.59%; S1 had the highest mean percentage at 74%, and S21 had the lowest at 22.29%. S1 and S11 stand out with high values of pure seeds (74% and 70%, respectively) and low inert matter (5.10% for both), making those desirable sources of seed for quality. Sample 21 has the lowest percentage of pure seed (22.29%) and high levels of other crop seeds and inert matter, indicating poorer quality. The variability among seed sources is high in certain parameters, such as inert matter and weed seeds, suggesting differences in how the seeds were handled or stored. This analysis provides useful insights into the physical quality of seeds from informal sources and can help guide decisions regarding seed selection for agricultural use. This finding suggests that the farmer who provided the seed samples had a low percentage of clean seed for planting, which had an impact on crop productivity. Sample 20 (5.4%) and S3 and S12 (39.1%) exhibited higher mean percentages of inert matter and other crop seeds. A considerable mean difference was found between S1 and the other seed samples of the white finger millet variety that were kept in the sacks at the home and were gathered from the Sekota district. A range of seed samples obtained from unofficial sources had an average moisture level of 13.1%.

The physical quality of finger millet seeds obtained from informal sources is influenced by a combination of production and postharvest factors. Production factors such as the genetics of the parent plant, crop management practices, and soil conditions play a major role in determining the initial seed quality. Postharvest factors such as timing of harvest, drying methods, storage conditions, and cleaning practices further affect seed quality. Seeds obtained from well-managed, properly harvested, and well-stored sources tend to exhibit better physical purity, higher TSW, and fewer contaminants, making them more viable for planting. Conversely, poor seed handling and storage practices can lead to lower seed quality, as seen in seed samples with higher levels of inert matter, other crop seeds, and weed seeds, ultimately leading to poorer crop productivity. Therefore, improving both production and postharvest practices is crucial to enhance seed quality in informal seed systems.

Table 4.26. Mean value of the sample's various physical quality parameters from an informal source

Treatments	Parameter					
	TSW(g)	Pure seed (%)	Other crop seed (%)	Inert matter (%)	Weed seed (%)	MC (%)
S1	2.18^{a}	74^{e}	21.20^{h}	5.10^{a}	0.20^{a}	11.60^{c}
S2	1.79^{f}	71.59^{a}	25.30^{g}	3.10^{e}	0.008^{b}	12.20^{b}
S3	1.97^{c}	57.69^{c}	39.1^{a}	3.20^{de}	0.001^{b}	11.60^{c}
S4	1.91^{e}	38.74^{d}	38.0^{a}	3.56^{cde}	0.001^{b}	11.20^{d}
S5	1.72^{g}	69^{e}	27.81^{ef}	3.80^{bcd}	0.001^{b}	12.40^{b}
S6	1.93d^{e}	67^{e}	29.30^{de}	4.10^{bc}	0.001^{b}	11.53^{c}
S7	2.1^{b}	64^{e}	31.51^{bc}	4.30^{b}	0.001^{b}	11.20^{d}
S8	1.82^{f}	66^{e}	30.13^{cd}	3.40^{de}	0.001^{b}	13.70^{a}
S9	1.97^{cd}	62^{e}	32.7^{b}	5.36^{a}	0.001^{b}	13.70^{a}
S10	1.61^{h}	73^{e}	21.20^{h}	5.26^{a}	0.001^{b}	13.70^{a}
S11	2.18^{a}	70^{e}	25.30^{g}	5.10^{a}	0.001^{b}	13.63^{a}
S12	1.79^{f}	58^{e}	39.1^{a}	3.10^{e}	0.001^{b}	13.83^{a}
S13	1.98^{c}	58.48^{bc}	38.0^{a}	3.20^{de}	0.001^{b}	13.70^{a}
S14	1.91^{e}	69.48^{ab}	26.91^{gf}	3.60^{cde}	0.001^{b}	13.66^{a}
S15	1.73^{g}	66.89^{abc}	29.30^{de}	3.80^{bcd}	0.001^{b}	13.70^{a}
S16	1.99^{c}	64^{e}	31.51^{bc}	4.10^{bc}	0.001^{b}	13.70^{a}
S17	2.1^{b}	66^{e}	30.15^{cd}	4.30^{b}	0.001^{b}	13.66^{a}
S18	1.82^{f}	64^{e}	32.7^{b}	3.40^{de}	0.001^{b}	13.70^{a}
S19	1.97^{cd}	56^{e}	38.0^{a}	5.30^{a}	0.001^{b}	13.70^{a}
S20	1.61^{h}	68^{e}	26.91^{fg}	5.40^{a}	0.001^{b}	13.70^{a}
S21	2.18^{a}	22.29^{e}	29.30^{de}	5.10^{a}	0.001^{b}	13.70^{a}
S22	1.79^{f}	65e	31.51^{bc}	3.10^{e}	0.001^{b}	13.70^{a}
S23	1.98^{c}	67^{e}	31.51^{bc}	3.20^{de}	0.001^{b}	13.70^{a}
S24	1.91^{e}	64^{e}	31.51^{bc}	3.60^{cde}	0.001^{b}	13.70^{a}
Mean	1.91	62.59	30.74	4.06	0.009	13.10
LSD (5%)	**	**	**	**	*	*
CV (%)	1.28	0.2	3.62	10.36	2.13	1.27

(Source: own Laboratory data 2023/24), Means with the same letter are not significantly different, S1=white variety stored in sacks in the house from sekota district (hamusit Keble), S2=red variety stored in sacks in in the house from sekota district (hamusit Keble), S3=black variety stored in sacks in the house from sekota district (hamusit Keble), S4=white variety stored in the house from sekota district (wal Keble), S5=red variety stored in the house in sekota district (wal Keble), S6=black variety stored in the house in sekota district (wal Keble), S7=white variety stored in the house in Dera district (geregera Keble), S8=red variety stored in the house in Dera district (geregera Keble), S9=black variety stored in the house in Dera district (geregera Keble), S10=white variety stored in the house in Dera district (wenchite Keble), S11=red variety stored in the house in Dera district (wenchite Keble), S12= black finger millet seed stored in the house in Dera district (wenchite Keble), S13=white variety stored in sacks in the house in Mecha district (enamert Keble), S14=red variety stored in sacks in the house in Mecha district (enamert Keble), S15=black variety stored in the house in Mecha district (enamert Keble), S16= white variety stored in sacks in the house in Mecha district (enguti Keble), S17=red variety stored in the house in Mecha district (enguti Keble), S18=black variety stored in sacks in the house in Mecha district (enguti Keble), S19=black variety stored in gotera in the house in Dera district (wenchite Keble), S20=red variety stored in gotera in the house in Dera district (geregera Keble), S21=red variety stored in gotera in the house in Mecha district (enguti Keble), S22=red variety stored in gotera outside the house in Mecha district (enguti Keble), S23= red variety stored in underground pit in Mecha district (enguti Keble), S24=white variety stored in underground pit in Mecha district (enamert Keble), S25=Mecha variety from adet agricultural research center, S26=Necho variety from adet agricultural research center, S27=adet 05 variety from adet agricultural research center.

4.15.2. Physiological seed quality

Table 4.27 presents the average germination values for seed samples collected from informal seed sources (S1 to S24). Observed differences in fresh seed, dead seed, hard seed, abnormal seedling, and normal seedling between varieties and districts were shown by the mean separation. The normal seedling percentages range from 71.00% (S5 and S14) to 95.33% (S24), with S23 and S24 showing the highest percentages (95.00% and 95.33%, respectively). These values are significantly higher than others, as indicated by the "*" in the LSD (5%) column, which shows significant differences at the 5% level. The mean percentage of normal seedlings in the seed samples obtained from informal sources was 84.3% on average. The kinds of white finger millet stored in underground pits, or S24 had a higher mean percentage of normal seedlings than the S5 and S14 seed samples from Mecha and Sekota districts, respectively, and the red finger millet variety stored from sacks in the house, or S14 had a lower mean normal seedling percentage of 71%. To successfully develop and yield crops, normal seedlings are necessary. Conversely, the mean percentage of aberrant seedlings from informal seed sources averaged 4.97%, with the highest mean percentage of abnormal seedlings coming from a seed sample taken from the Mecha district, S15 (a black finger millet variety stored in bags inside the house). The abnormal seedling percentages vary from 0.00% (in S23 and S24) to 11.33% (S15), with a general trend showing lower abnormal seedling percentages in many treatments. The percentage of fresh seeds generally ranges from 0.00% to 3.33%, with a few treatments such as S1 showing relatively higher percentages. The LSD shows significant differences (**), meaning some treatments have notably more fresh seeds than others. The mean percentage for fresh seed was 1.18% on average, while the S1 (white finger millet type, kept in sacks in the home) seed sample, which was obtained from the Sekota district, had a higher mean percentage of 3.33%. 2.97% and 6.58%, respectively, were the mean values for fresh, hard, and dead seeds. Of seed samples S15 and S5, respectively, there were more dead seeds (10%) and hard seeds (15%). Dead seedling percentages range from 0.00% (in S3, S12, S20, S23, S24) to 10.00% (in S6 and S15). Hard seed percentages also show variation, ranging from 0.00% (in S23, S24) to 15.00% (in S5 and S14).

Table 4.27. Average germination values for seed samples from informal seed sources

Treatments	Parameter				
	Normal seedling (%)	Abnormal seedling (%)	Fresh seed (%)	Dead seedling (%)	Hard seed (%)
S1	77.00^{f}	6.00^{bcd}	3.33^{a}	7.00^{b}	7.00^{cde}
S2	85.00^{de}	4.00^{bcdef}	1.00^{cd}	2.00^{de}	8.00^{bcd}
S3	92.00^{ab}	1.00^{ef}	1.00^{cd}	0.00^{f}	6.00^{de}
S4	90.00^{bc}	4.00^{bcdef}	1.00^{cd}	2.00^{de}	3.00^{ef}
S5	71.00^{g}	7.00^{abc}	2.00^{bc}	5.00^{c}	15.00^{a}
S6	74.00^{df}	11.00^{a}	2.00^{bc}	10.00^{a}	6.00^{de}
S7	82.00^{e}	7.00^{abc}	0.00^{d}	2.00de	4.00^{def}
S8	82.00^{e}	2.00^{def}	1.00^{cd}	3.00^{d}	12.00^{ab}
S9	85.00^{de}	4.00^{bcdef}	1.00^{cd}	2.00^{de}	8.00^{bcd}
S10	77.00^{f}	6.00^{bcd}	3.00^{ab}	7.00^{b}	7.00^{cde}
S11	85.00^{de}	4.00^{bcdef}	1.00^{cd}	2.00^{de}	8.00^{bcd}
S12	92.00^{ab}	1.00^{ef}	1.00^{cd}	0.00^{f}	3.00^{ef}
S13	90.00^{bc}	4.00^{bcdef}	1.00^{cd}	2.00^{de}	3.00^{ef}
S14	71.00^{g}	7.00^{abc}	2.00^{bc}	5.00^{c}	15.00^{a}
S15	74.00^{fg}	11.33^{a}	2.00^{bc}	10.00^{a}	3.00^{ef}
S16	85.00^{de}	6.00^{bcd}	0.00^{d}	1.00^{ef}	8.00^{bcd}
S17	85.00^{de}	6.00^{bcd}	0.00^{d}	1.00^{ef}	8.00^{bcd}
S18	83.00^{de}	8.00^{ab}	0.00^{d}	2.00^{de}	7.00^{cde}
S19	87.00^{cd}	5.00^{bcde}	0.00^{d}	2.00^{de}	6.00^{de}
S20	91.00^{abc}	5.00^{bcde}	1.00^{cd}	0.00^{f}	3.00^{ef}
S21	84.00^{de}	3.00^{cdef}	2.00^{bc}	0.00^{f}	11.00^{abc}
S22	90.00^{bc}	2.00^{def}	1.00^{cd}	1.00^{ef}	6.00^{de}
S23	95.00^{a}	5.00^{bcde}	0.00^{d}	0.00^{f}	0.00^{f}
S24	95.33^{a}	0.00^{f}	2.00^{bc}	1.00^{ef}	1.00^{f}
Mean	84.3	4.97	1.18	2.97	6.58
LSD (5%)	*	*	*	*	*
CV (%)	4.12	5.48	0.67	2.32	3.75

(Source: own Laboratory data 2023/24), Means with the same letter in a column are not significantly different at p ≥0.05.

4.15.3. Vigor test and speed of germination

The ability of seeds to sprout, and grow swiftly, and consistently in less-than-ideal circumstances is known as seed vigor. In challenging settings, in particular, high-vigor seeds tend to perform better in terms of emergence speed and seedling establishment. Table 4.28 presents a comparison of physiological seed quality parameters across different informal seed sources, revealing significant variability in seed performance. Germination rate (GR) varies considerably, with treatments S2(stored in sacks in the home and collected from Sekota district) and S21 (stored in gotera in the home and collected from Mecha district) exhibiting the highest rates (14%), while others like S1, S7, and S24 show much lower rates (6%). Shoot length (SL) and root length (RL) also display noticeable variability, with several treatments demonstrating high shoot growth but low root development. The shoot length is significantly different among treatments, with the highest values of 4.32 cm (S24) and the lowest of 1.05 cm (S16), showing significant differences at the 5% level (indicated by *) in the LSD. The mean seedling shoot length was 2.6 cm on average, with S24 recording the longest seedling shoot (4.31 cm) and S16 recording the shortest (1.0 cm). Notably, S13 had the highest seedling dry matter (SDM) at 0.026 g, while others, like S9, performed poorly in this aspect. Overall, while some seed sources, such as S2, S8, and S12, show higher seedling quality across several parameters, other sources, like S9 and S17, exhibit weaker seedling characteristics. These results emphasize the importance of selecting high-quality seed sources for better seedling vigor and growth potential.

Seedling vigor index (SVI) 1 remains consistent across treatments, but SVI 2 shows significant variation, with values ranging from 0.4 in S5 to 21.98 in S12, indicating differences in seedling development potential. Higher SVI values suggest more resilience and adaptation, which are crucial for successful crop development under difficult conditions, according to Teixeira *et al*., 2021 findings on the application of vigor indices on rice seed germination. The multidimensional seedling vigor index provides information on the general health and potential of seedlings in agricultural settings by combining germination rates with shoot and root growth. Larger seeds frequently give higher vigor indices due to increased nutrient reserves and growth potential. Research on seedling vigor index (Javaid *et al*., 2022) and Pradeep (2018) demonstrates that SVI is influenced by seed size.

Table 4.28. Mean comparison of physiological quality between informal seed sources

Treatments	Parameter					
	GR (%)	SVI 1	SVI 2	SL (cm)	RL (cm)	SDM(g)
S1	6.66^{bc}	257.176^{a}	17.32^{f}	4.23^{a}	0.75^{b}	0.022^{abcd}
S2	14.00^{a}	257.18^{a}	14.28^{l}	1.15^{c}	0.075^{b}	0.016^{abcdef}
S3	8.00^{abc}	257183^{a}	13.15^{h}	4.11^{a}	0.075^{b}	0.014^{bcdef}
S4	7.00^{bc}	257.18^{a}	4.62^{n}	1.13^{c}	0.14^{a}	0.015^{abcdef}
S5	11.00^{abc}	257.18^{a}	0.4^{o}	4.29^{a}	0.74^{b}	0.0138^{cdef}
S6	8.00^{abc}	257.146^{a}	17.61^{e}	4.24^{a}	0.075^{b}	0.023^{abcd}
S7	6.00^{c}	257.21^{a}	20.41^{d}	4.31^{a}	0.74^{b}	0.024^{abc}
S8	13.00^{ab}	257.18^{a}	20.81^{a}	1.32^{c}	0.14^{a}	0.025^{ab}
S9	9.00^{abc}	257.18^{a}	1.0^{o}	1.29^{c}	0.075^{b}	0.0079^{f}
S10	7.00^{bc}	257.18^{a}	0.8^{o}	1.26^{c}	0.075^{b}	0.011^{ef}
S11	13.00^{ab}	257.18^{a}	19.72^{k}	1.96^{b}	0.075^{b}	0.023^{abcd}
S12	8.00^{abc}	257.18^{a}	21.98^{b}	4.15^{a}	0.075^{b}	0.023^{abcd}
S13	6.00^{c}	257.18^{a}	2.3^{o}	1.35^{c}	0.075^{b}	0.026^{a}
S14	10.00^{abc}	257.18^{a}	14.27^{g}	4.15^{a}	0.075^{b}	0.020^{abcde}
S15	7.00^{bc}	257.18^{a}	12.13^{i}	4.08^{a}	0.075^{b}	0.016^{abcdef}
S16	7.00^{bc}	257.18^{a}	11.39^{m}	1.05^{c}	0.075^{b}	0.0134^{def}
S17	12.00^{ab}	257.18^{a}	0.5^{o}	4.13^{a}	0.075^{b}	0.0057^{f}
S18	7.00^{bc}	257.18^{a}	1.7^{o}	1.22^{c}	0.075^{b}	0.020^{abcde}
S19	9.00^{abc}	257.18^{a}	14.44^{g}	4.15^{a}	0.74^{b}	0.016^{abcdef}
S20	12.00^{abc}	257.18^{a}	1.91^{k}	1.28^{c}	0.74^{b}	0.021^{abcde}
S21	14.00^{a}	257.173^{a}	1.76^{k}	1.25^{c}	0.075^{b}	0.022^{abcde}
S22	12.00^{abc}	257.18^{a}	$14.31.0^{l}$	1.15^{c}	0.075^{b}	0.015^{abcdef}
S23	10.00^{abc}	257.18^{a}	2.26^{j}	1.35^{c}	0.075^{b}	0.023^{abcd}
S24	6.00^{c}	257.18^{a}	20.92^{c}	4.32^{a}	0.75^{b}	0.021^{abcde}
Mean	9.28	257.17	10.42	2.6	0.081	1.17
LSD (5%)	*	**ns**	*	**	*	*
CV (%)	36.8	0.073	0.5	8.94	4.6	13.6

(Source: own Laboratory data 2023/24), Means with the same letter in a column are not significantly different at p ≥0.05. Where; GR = Germination Rate, SVI 1 = Seedling vigor Index 1, SVI 2 = Seedling vigor Index, SL = Shoot Length, RL = Root Length, SDM = Seedling Dry Matter.

Chapter 5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Finger millet is an important crop in Ethiopia, as a staple food crop. The crop has high nutritional value and is adaptable to diverse agroecologies, which makes it an essential food security crop for smallholder farmers. However, the study highlights the challenges faced by the finger millet seed system and quality analysis in the Amhara Region of Mecha, Dera, and Sekota districts. Smallholder farmers primarily rely on informal seed sources like their own saved seeds or exchanges with other farmers. Seeds from formal sources consistently outperformed those from informal sources in terms of physical purity, physiological quality, and seed vigor. The formal seed system, designed to provide improved varieties and high-quality seeds, is largely underutilized by farmers. This underutilization is different in different study districts likely due to factors such as limited and absence of access to formal seed sources, inadequate extension services, a lack of awareness about the benefits of improved varieties, access to land, and shrinking farm size, the ability to meet diverse seed demands, instead of promoting only a few crops, and poor seed quality of local varieties. Besides that, seeds from formal sources generally exhibited better quality in terms of physical purity, physiological quality, and seed vigor. However, the quality of the finger millet seeds used by the farmers from informal seed sources was low in all the quality aspects investigated; and then found significant differences in physical and physiological seed quality parameters between seeds from formal and informal sources. Additionally, the seed selection, processing, and storage methods used by farmers in the production of seeds across all districts compromised the seed quality.

5.2. Recommendations

Finger millet farmers in the Sekota, Dera, and Mecha district should be encouraged to source high-quality seeds by strengthening the formal seed system value chain to ensure better quality and making certified seeds more accessible. Since most farmers currently obtain seeds from informal sources and many have education levels below the primary level, raising awareness about the importance of using quality seeds is crucial. Providing farmers with improved seed production technologies, training on seed selection, and proper post-harvest handling techniques will further enhance seed quality. Additionally, exploring the feasibility of implementing a seed certification program can ensure the genetic purity and quality of seeds distributed. An integrated seed system combining formal, informal, and community-based approaches is essential for creating a more robust and resilient seed supply, addressing challenges in seed accessibility and quality.

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7. APPENDIX

Appendix 1. List of appendix table

Appendix Table 1. Percentage of farmers on attributes and attributes levels in 2023 in the Mecha

Attribute name	White			Red			Black		
	H	M	L	H	M	L	H	M	L
Productivity	30.2	14.3	3.2	4.4	46	3.2	0	0	3.2
Straw favorability	23.8	20.6	3.2	4.8	28.6	21	0	3.2	0
Straw amount	19	25.4	3.2	11.1	20.6	22	0	3.2	0
Tiller no	23.8	23.8	0	12.7	36.5	4.8	0	0	3.2
Seed price	39.7	7.9	0	7.9	38.1	7.9	0	3.2	0
Grain price	27	20.6	0	7.9	38.1	7.9	0	0	3.2
Drought tolerance	14.3	33.3	0	14.3	30.2	9.5	0	3.2	0
Brewing purpose	12.7	34.9	0	34.9	19	0	0	3.2	0
Food quality	42.9	4.8	0	49.2	4.8	0	3.2	0	0
Maturity time (Month)	3-4	4-5	5-6	3-4	4-5	5-6	3-4	4-5	5-6
	6.3	17.5	23.8	0	23.8	30.2	0	0	3.2
Length of finger	T	M	S	T	M	S	T	M	S
	28.6	19	0	19	14.3	21	0	0	3.2
Disease resistance	NA	A			NA	A		NA	A
	4.8	42.9			20.6	33.3		0	3.2

(Source: survey data, 2023/24) H = high, M = medium, L = low, T = tall, S = short, A = appeared, NA = not applied)

Appendix Table 1. Percentages of farmers on attributes and attribute levels in 2023 in the Sekota

Attribute name	Red			White			Black		
	H	M	L	H	M	L	H	M	L
Productivity	44	56	0	20.9	22	57.1	42.9	26.4	30.8
Straw favorability	4.4	92.3	3.3	0	59.3	0	0	0	0
Straw amount	0	40.7	0	0	20.9	57.1	0	25.3	4.4
Tiller no	8.8	91.2	0	0	91.2	8.8	19.8	80.2	0
Seed price	40.7	59.3	0	23.1	59.3	17.6	65.9	34.1	0
Grain price	11	59.3	29.7	17.6	52.7	29.7	13.2	74.7	12.1
Drought tolerance	62.6	29.7	7.7	28.6	50.5	20.9	80.2	19.8	0
Brewing purpose	44	56	0	31.9	61.5	6.6	44	49.5	6.6
Food quality	38.5	45.1	16.5	54.9	45.1	0	56	44	0
Maturity time (Month)	3-4	4-5	5-6	3-4	4-5	5-6	3-4	4-5	5-6
	0	0	100	100	0	0	0	0	100
Length of finger	T	M	S	T	M	S	T	M	S
	0	0	0	0	100	0	23.1	76.9	0
Disease resistance	A	NA	A	NA	A	NA			
	16.5	83.5	23.1	76.9	26.4	73.6			

(Source: survey data, 2023/24), H=high, M=Medium, L=Low, T=Tall, S=Short, A=appeared, NA=Not Appeared

Appendix Table 2. Percentages of farmers on attributes and attribute levels in 2023 in the Dera

Attribute name	Necho			White			Red			Black		
	H	M	L	H	M	L	H	M	L	H	M	L
Productivity	10.9	10.9	0.9	0.9	29.1	6.4	5.5	21.8	0	59.1	38.2	0.9
Straw favorability	14.5	8.2	0	5.5	32.7	0	16.4	10.9	0	64.5	31.8	0.9
Straw amount	0.9	21.8	0	0.9	32.7	4.5	5.5	19.1	0	80.9	16.4	0
Tiller no	10	10.9	1.8	0.9	34.5	1.8	0.9	26.4	0	48.2	48.2	0.9
Seed price	20	2.7	0	2.7	23.6	10.9	4.5	22.7	0	44.5	51.8	0
Grain price	5.5	17.3	0	0.9	20.9	16.4	1.8	25.5	0	47.3	47.3	1.8
Drought tolerance	20.9	1.8	0	14.5	22.7	0	15.5	7.3	2.7	20	76.4	0
Brewing purpose	1.8	1.8	19.1	0	23.6	13.6	6.4	17.3	1.8	83.6	12.7	0
Food quality	10	12.7	0	7.3	30	0	10.9	14.5	0	82.7	13.6	0
Maturity time	3-4	4-5	5-6	3-4	4-5	5-6	3-4	4-5	5-6	3-4	4-5	5-6
(Month)	21.8	0.9	0	36.4	0.9	0	0	10	15.5	2.7	80.9	12.7
Length of finger	T	M	S	T	M	S	T	M	S	T	M	S
	0	21.8	0.9	1.8	33.6	1.8	2.7	21.8	0.9	80	17	0
Disease resistance	A	NA		A	NA		A	NA		A	NA	
	4.5	17.3		8.2	31.8		7.3	20		77.3	20.9	

(Source: survey data, 2023/24) H=high, M=Medium, L=Low, T=Tall, S=Short, A=appeared, NA=Not Appeared

Appendix 4. List of Questioner

FINGER MILLET SEED SYSTEM HOUSEHOLDS' SURVEY

FORMAL SURVEY OF FARM HOUSEHOLDS

IN MECHA, SEKOTA, AND DERA DISTRICTS, AMHARA

REGION, ETHIOPIA

This questionnaire aims to collect data on the seed system, sources, and farmers' perceptions of seed quality and management practices for finger millet in the Dera, Sekota, and Mecha districts of the Amhara Region, Ethiopia. This section will analytically discuss the formal and informal seed system finger millet which will give an input for the development of research study.

Part I. Household information የቤተሰብ መረጃ

0. Serial number ተራ ቁጥር ___________, Date ቀን__________________

1.1. Zone ዞን ______________, Woreda ወረዳ_________________, Peasant Association ቀበሌ _______________

1.2. Name of farmer የገበሬ ስም___________________,

1.3. Sex ጾታ__________,

1.4. Age ዕድሜ_________

1.5. Members of Families: የቤተሰብ አባላት ብዛት Male ወንድ______, Female ሴት______

1.6. Households type, circle your choice 1. Male-headed ወንድ አባወራ

2. Female headed ሴት አባወራ

1.7. Household size የቤተሰብ ብዛት

1. Males >15 years ወንድ ከአስራ አምስት አመት በላይ ____

2. Females >15 years ሴት ከአስራ አምስት አመት በላይ ____

3. Males <15 years ወንድ ከአስራ አምስት አመት በታች ___

4. Females <15 years ሴት ከአስራ አምስት አመት በታች __

1.8. Education status: የትምህርት ሁኔታ circle your choice

1. Illiterate ያልተማረ 2. Read and write ማንበብና መጻፍ 3. Adult education ጎልማሳ ትምህርት የተማረ 4. None completed primary አንደኛ ደረጃ ያላጠናቀቀ 5. Completed primary/አንደኛ ደረጃ ያጠናቀቀ 6. None completed secondary/ሁለተኛ ደረጃ ያላጠናቀቀ 7. Completed secondary ሁለተኛ ደረጃ ያጠናቀቀ 8. Above secondary ከሁለተኛ ደረጃ በላይ

Part II. Household Resource Base የቤተሰብ የሀብት መሰረት

2.1. How many animals/cattle do you have? ምን ያህል እንስሳት አለህ/አለሽ?

1. Ox/በሬ___________ 2. Cow/ላም________3. Calf/ጥጃ_________4.Sheep/በግ__________5. Goat/ፍየል_______6. Donkey/አህያ______ 7. Horse/ፈረስ_______ 8. Mule/በቅሎ_______ 9. Others ______________

2.2. Of the land you cultivated in 2022/23, how much timad /hectare was the total size? በ 2014/15 ያረስከው መሬት በጥማድ/ኄክታር ስንት ነው?

Own farm የግል ይዞታ____________ጥማድ/ኄክታር,

Hired farm የኪራይ_____________ ጥማድ/ኄክታር,

Share crop አበል/እህል የሚከፈልበት መሬት___________ጥማድ/ኄክታር

Total ድምር ___________ ጥማድ/ኄክታር

2.3. How many years have you been producing finger millet?

2.4. What is the importance of the finger millet versus other crops? (Put in rank related to other crops)

1.

2.

3.

2.5. List the crops and their amount of land allocated in 2022/23 (in timad). How much of the following crops do you usually sell in a normal year (in quintal)? በ2014/15 አ.ም. የተዘሩ ሰብሎች የመሬት ስፋት የተሸጠ መጠንና ደረጃቸው

Crops sown in 2022/23 የተዘራ ሰብል በ 2014/15	Amount of land allocated in 2022/23 የተዘራ ሰብል በ2014/15 area(ha)	Yield q/timad ምርት በኩ/ል/በጥ ማድ	Amount sold in kg/q of listed crops	Amount of seed planted in 2022/23 in kg (for finger millet only) የተዘራ ዘር መጠን ለዳጉሳ	Use (for finger millet only) ጥቅሙ የዳጉሳ	Rank የተፈላጊ ነት ደረጃ ለተዘሩ ሰብሎች

Part III. Knowledge of finger millet varieties

3.1. Do you grow usually finger millet? ብዙ ጊዜ ዳጉሳ ትዘራለህ? 1. Yes 2. No

3.2. If yes, which type of variety was used in the last season? አወ ከሆነ የዘራሀው የዳጉሳ ዝርያ ማን ነው?

1. Local ___________________

2. Improved _________________

3. Both ________________________

3.3. Did you grow other types of finger millet before last season? ከአሁን በፊት የዘራሀቸው ሌሎች የዳጉሳ ዝርያዎች አሉህ? 1. Yes 2. No

3.4. If yes፣ mention their characteristics. ምንድን ነው ባህርያቸው?

Varieties ዝርያ	Yield q/timad ምርት በኩ/ል/ በጥማድ	Seed color የዘር ቀለም	Maturity የሰብል መድረስ	ear sizeየ ዘለላ ርዝ መት	Resistance (dis.drgt. insect, lodg.etc)	Brewing purpose ለመ ጠጥ	Injera	others	Rank ደረጃ

- Yield ምርት = high=1; medium= 2; low= 3
- Seed color የዘር ቀለም =white=1 Dark =2; red=3; Brown= 4
- Ear size የዘለላ ርዝመት= large=1; medium=2; small=3
- Maturity ለፍሬ መድረስ =early=1; medium=2; late=3
- Brewing purpose ለመጠጥ የሚሆን = high=1; medium= 2; low= 3
- Injera ለእንጀራ የሚሆን high=1; medium= 2; low= 3;
- Other characteristics/ሌሎች ባህርያት (disease, insect, drought, lodge. res)= high =1; intermediate=2; low=3

3.5. What are the criteria for choosing the local varieties? የአካባቢ ዝርያ የሚመረጥበት ባህርያት?

1. 3.
2. 4.

3.6. Have you used improved finger millet varieties? ምርጥ ዘር ተጠቅመህ/ሽ ታውቃለህ/ታውቂአለሽ?

1. Yes 2. No

3.7. If yes, when did you use the improved seed on your farm? አወ ከሆነ መቼ ለመጀመሪያ ጊዜ ተጠቀማችሁ?

3.8. Which improved finger millet variety/ varieties did you use the first time? ምን የዳጉሳ ምርጥ ዘር ለመጀመሪያ ጊዜ ተጠቅመህ ታውቃለህ/ታውቂአለሽ?

3.9. What is the selection criterion for preferring a variety? የምትጠቀማቸው ዝርያዎች (አካባቢ፣ ምርጥ ዘር) መመዘኛ መስፈርትህ ምንድን ነው ?

Criteria for selection/farmers perception (✓) የመምረጫ መስፈርቶች	Varieties adapted and grown in the area በአካባቢው የሚዘሩ ዝርያዎች						
Yield ምርት							
Seed color የዘር ቀለም							
Low fertility tolerance ዝቅተኛ የአፈር ለምነት ስለሚቆቆም							
Marketability ለገበያ ተፈላጊ መሆኑ							
Food quality የምግብ ጥራት							
Drought tolerance ድርቅ ስለሚቋቋም							
Disease resistant በሽታ ስለሚቋቋም							
Uniform maturity							
Higher germination rate ከፍተኛ ብቅለት ስላለው							
Pest tolerance ተባይ ስለሚቋቋም							
Lodging tolerance መውደቅ ስለሚቀቀም							
Ear size የዘለላ ርዝመት							
Seed size የዘር ፍሬ መጠን							
Brewing purpose ለመጠጥ የሚሆን							

3.10. If no, why don’t you use it? ምርጥ ዘር ተጠቅመሀ ካላወቅሀ -------------------------------------

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Part IV. Seed Sources የዘር ምንጭ

4.1. From where do you acquire local finger millet seed for the first time? ለመጀመሪያ ጊዜ የአካባቢ ዳጉሳ ዘር መቼ ነው ያገኘሀው? Circle your choice

1. Market ከገበያ 2. Neighbors ከጎረቤት 3. Relatives' ከዘመድ 4. Families ከቤተሰብ 5. Friends ከጋደኛ 6. NGO መንግስታዊ ያልሆነ ድርጅት 7. Other (specify)

4.2. Where is the place? Kebele ቀበሌ_______________Woreda ወረዳ ______________

4.3. How many clocks/distance have the place of local seed you get, far from your area? ዘር ያገኘህበት ቦታ ከመኖሪያህ ምን ያህል ይርቃል?

1. < 2 hrs. 2. 3- 5hrs. 3. 6- 8 hrs. 4. > 9hrs. 5. 0hrs

4.4. How the seed source available it? ከላይ የተጠቀሰው የዘር ምንጭ ዘሩን በምን መንገድ አቀረቡት?

1. Purchase በግዥ 2. Exchange በልውውጥ 3. Loan በብድር 4. Gift በስጦታ 5. Revolving fund በተዘዋዋሪ ፈንድ 6. Others ሌሎች

4.5. Advantages of this/ these local variety seed sources? የዘሩ ምንጭ ጥቅም?

4.6. Where did you get the seed of finger millet in 2023? ለ 2015 አ. ም. ዘር ከየት ነው ያገኘሀው?

1. Own farm ከራሱ 2. Market ከገበያ 3. Neighbors ከጎረቤት 4. Relatives ከዘመድ 5. Families ከቤተሰብ 6. Friends ከጋደኛ 7. NGO መንግስታዊ ያልሆነ ድርጅት 8. Other (specify)

4.7. Where is the place? Kebele ቀበሌ_______________Woreda ወረዳ _________________

4.8. How many clocks have the place of seed you get, far from your area? ዘር ያገኘህበት ቦታ ከመኖሪያህ ምን ያህል ይርቃል

1. < 2 hrs. 2. 3- 5hrs. 3. 6- 8 hrs. 4. > 9hrs 5. 0hrs

4.9. How the seed source available it? ከላይ የተጠቀሰው የዘር ምንጭ ዘሩን በምን መንገድ አቀረቡት?

1. Purchase በግዥ 2. Exchange በልውውጥ 3. Loan በብድር 4. Gift በስጦታ 5. Revolving fund በተዘዋዋሪ ፈንድ 6. Others ሌሎች

4.10. From where do you acquire improved finger millet seed the first time? ለመጀመሪያ ጊዜ የዳጉሳ ምርጥ ዘር የት ነው ያገኘሀው?

1. Trader /market ከገበያ 2. Bureau of agriculture/ Cooperative ከግብርና/ማህበራት 3. NGO መንግስታዊ ያልሆነ ድርጅት 4. Research center ከምርምር 5. University ከዩኒቨርሲቲ

4.11 Where is the place? Kebele ቀበሌ_______________Woreda ወረዳ ______________

4.12. How much distance/clock is the improved seed market far from your area? ምርጥ ዘር ያገኘህበት ቦታ ከመኖሪያህ ምን ያህል ይርቃል?

1. < 2 hrs. 2. 3- 5hrs. 3. 6- 8 hrs. 4. > 9hrs 5. 0hrs.

4.13. How the seed source available it? ከላይ የተጠቀሰው የዘር ምንጭ ዘሩን በምን መንገድ አቀረቡት?

1. Purchase በግዥ 2. Exchange በልውውጥ 3. Loan በብድር 4. Gift በስጦታ 5. Revolving fund በተዘዋዋሪ ፈንድ 6. Others ሌሎች

4.14. Advantages of this/ these improved variety seed sources? የዘሩ ምንጭ ጥቅም?

4.15. Where did you get the seed of improved finger millet in 2023? የዳጉሳ ምርጥ ዘር በ2015 የት ነው ያገኘሀው ?

1. Purchase from the office of agriculture ከግብርና በመግዛት 2. Gift from research/ከምርምር በስጦታ 3. Exchange with other crop/በሌላ ሰብል በመለወጥ 4. Exchange for labor/በጉልበት ስራ በመለወጥ 5. Gift from farmers/ከገበሬ በስጦታ 6. Loan from traders/ከነጋዴ 7. University ዩኒቨርሲቲ

4.16. Where is the place? Kebele ቀበሌ_______________Woreda ወረዳ _________________

4.17. How much distance/clock is the improved seed market far from your area? ምርጥ ዘር ያገኘህበት ቦታ ከመኖሪያህ ምን ያህል ይርቃል?

1. < 2 hrs. 2. 3- 5hrs. 3. 6- 8 hrs. 4. > 9hrs

4.18. How the seed source available it? ከላይ የተጠቀሰው የዘር ምንጭ ዘሩን በምን መንገድ አቀረቡት?

1. Purchase/በግዥ 2. Exchange/በልውውጥ 3. Loan/በብድር 4. Sell/በሽያጭ 5. Gift/በስጦታ 6. Revolving fund/በተዘዋዋሪ ፈንድ 7. Others ሌሎች

4.19. Advantages of this/ these improved variety seed sources? የዘሩ ምንጭ ጥቅም?

4.16. Do you purchase finger millet seed? የዳጉሳ ዘር ገዝተሀል? 1. Yes 2. No

4.17. If yes, how often do you purchase seed of finger millet? በምን ያህል ጊዜ ልዩነት ትገዛለህ?

1. Every year 2. Every other year 3. Rarely (every three or more years) 4. Others

4.18. What is the reason for purchasing certified finger millet seed? ሰርቲፋይድ ዘር የምትገዛው ለምንድን ነው ?

1. Replace old variety ያረጀ ዝርያ ለመተካት 2. Replace old seed ያረጀ ዘር ለመተካት 3. Better seed quality ጥራት ያለው ዘር ለማግኘት 4. No own seed/የራሱ ዘር ስለሌለው

4.19. What reason for purchasing local finger millet seed? የአካባቢ ዘር የምትገዛው ለምንድን ነው ?

1. Replace old variety ያረጀ ዝርያ ለመተካት 2. Replace old seed ያረጀ ዘር ለመተካት 3. Better seed quality/ጥራት ያለው ዘር ለማ ግኘት 4. No own seed/የራሱ ዘር ስለሌለው 5. No certified seed purchased

Part V. Agronomic packages የሰብል አመራረት ፓ ኬጆች

5.1. Are you provided appropriate agronomic packages for each improved variety? ለምርጥ ዘሮች ተገቢውን የሰብል አመ ራረት ፓ ኬጆች ተጠቅመ ሀል? 1. Yes 2.No

5.2. If yes, who gave you the information? አዎ ከሆነ መረጃ ማን ሰጠህ/ሽ?

Source of information	Improved variety	fertilizer	herbicide	pesticide	Storage	Agronomy
Agri. Office(✓)ግብርና						
Research (✓) ምርምር						
University(✓)ዩኒቨርሲቲ						
Media (TV, radio) (✓)						

ሚድያ						
Relatives/friends(✓) ዘመድ/ጎደኛ						
Neighbors (✓) ጎረቤት						
Traders (✓) ነጋዴዎች						
Farmers shops (✓) ከገበሬ ሱቅ						
Other farmers (✓) ከሌሎች ገበሬዎች						
Farming experience						

5.3. How many times do you plow the land for sowing? መ ሬቱን ምን ያህል ጊዜ ለዘር ታርሰዋለህ?

1. One time/አንድ ጊዜ 2. Two time/ሁለት ጊዜ 3. Three time/ሶስት ጊዜ 4. Others ሌላ

5.4. Time of sowing? የዘር ጊዜ? ________________________________

5.5. Method of planting የአዘራር ዘዴ 1. Row/በመ ስመ ር 2. Broadcast/በብተና

5.6. Seed rate? የዘር መጠን Kg/ha? _______________

5.7. Farmer's perception of soil fertility of their land? የገበሬዎች ግንዛቤ በመሬታቸው የአፈር ለም ነት?

1. Good 2. Medium 3. Low 4. I don't know 5. Others

5.8. If soil fertility is low, do you use fertilizer for finger millet? የመ ሬት ለም ነቱ ዝቅተኛ ከሆነ ማ በረያ ትጠቀማለህ? 1. Yes 2. No

5.9. If no, why not use fertilizer? የለም ከሆነ ለምን አትጠቀምም ? -----------------------------------
----

5.10. If yes, what type of fertilizer do you use for finger millet production? አወ ከሆነ ምን አይነት ማደበረያ ትጠቀማለህ?

1. Animal manure የእንስሳት ፍግ 2. Compost ኮምፖስት 3. Urea ዩሪያ 4.NSP

5.11. Where do you get the fertilizer? መዳበሪያ የት ነው የሚገኘው?

1. From market ከገቢያ 2. From cooperatives/ከማህበራት 3. From BOA/ከግብርና 4. From own/ከራሳቸው

5.12. If you use Urea and/or NSP, what is the rate in Kg/ ha for UREA and NSP? ዩሪያና ኤን ኤስ ፒ ከተጠቀምክ መ ጠ ኑ በሄክታር ስንት ኪ/ግ ነው ?

5.13. When is first weeding done? የመጀመሪያ አረም መ ቼ ይካሄዳል? --------------

5.14. How many times do you weed? ምን ያህል ጊዜ ታርማለህ? ----------------------------

5.15. At what growth stage? በምን በምን የእድገት ደረጃ?--------------------------------

5.16. Do you apply herbicide? ጸረ አረም ኬሚ ካል ተጠቅመሀል?-------------------------

5.17. Have you had contractual seed production with ASA, BoARD, NGO, Research centers, University etc…? በኮንትራት የዘር ብዜት ከግብርና፣ ከምርጥ ዘር ኤጀንሲ፣ ከመንግስታዊ ያልሆኑ ድርጅቶች፣ ከምርምር፣ ከዩኒቨርሲቲ ጋር አካሂደሀል ? 1. Yes 2.No

5.18. If yes, when አወ ካልክ መቼ?__________, on what crop በምን ሰብል?_______________

5.19. If not, would you like to have contractual seed production? የለም ከሆነ በኮንትራት ዘር ማባዛት ትፈልጋለህ? 1. Yes 2. No

5.20. If yes, why? አወ ካልክ ለምን?____

Part VI. Seed Management and Protection

6.1. In your household who sorts grain from seed? ቤተሰባችሁ ው ስጥ ዘሩን ከምግብ ሰብል የሚ ለየው ማ ን ነው ?

1. Female farmer only/ሴት ገበሬ ብቻ 2. Male farmer only/ወንድ ገበሬ ብቻ 3. Both male and female farmer/ወንድና ሴት ገበሬዎች 4. Children ልጆች 5. All household members/ሁሉም የቤተሰብ አባላት 6. Does not sort/አይለይም

6.2. When do you sort the finger millet seed you intend to plant? ለመዝራት የምትፈልገውን የዳጉሳ ዘር መቼ ነው የምትለየው ?

1. at physiological maturity before harvesting ከአጨዳ በፊት ፍሬ ሲያፈራ 2. During harvesting በአጨዳ ጊዜ 3. Just after threshing ከውቂያ በሆላ 4. Just before planting ከዘር በፊት 5. Does not sort አይለይም 6. Other (specify) ሌላ ካለ ይገለጽ

6.3. Do you replace seeds of the same/different finger millet variety (ies)? አንድ አይነት ወይም የተለያዩ የዳጉሳ ዘር ዝርያዎች ለው ጠ ሀል? 1. Yes 2. No

6.4. If yes, which finger millet types have you replaced? አወ ከሆነ ምን አይነት የዳጉሳ ዘር ለውጠሀል?

1 ----------------------by----------------------

2 ----------------------by----------------------

6.5. Where did you get the seed from for replacement? የሚ ለወጠውን ዘር ከየት ነው ያገኘሀው ?

Seed source የዘር ምንጭ

Seed source የዘር ምንጭ	Finger millet varieties የዳጉሳ ዝርያዎች					
Market ከገበያ						
Farmer ከገበሬ						
University/research ዩኒቨርሲቲ/ምርምር						
Others(specify)ሌላ ካለ ይገለጽ						

6.6. Why have you replaced the finger millet (intra and inter varietal replacement)? ለምንድን ነው የዳጉሳ ዘርን የምትለውጠው በተመሳሳይ ወይም በተለያዩ የዳጉሳ ዝርያዎች?

6.7. According to your view, what are the five most important characteristics of a good crop seed (for finger millet)? በአንተ አመለካከት ጥሩ የዳጉሳ ዘር አምስት ዋና ዋና ባህርያት ምን ምን ናቸው ?

1 --

2 ---

3--

4 ---

5 ---

6.8. Where do you store SEED of finger millet? Where do you store GRAIN of finger millet? የዳጉሳ ዘርና የምግብ እህል የምትከዝነው የት ነው ?

Storage methods	Seed(✓)ዘር	Grain(✓)የምግብ እህል
Sacks in the house/ኬሻ በቤት ውስጥ		
Dibignit (Gotera) in the house/ጎታ/ጎተራ በቤት ወስጥ		
The underground pit in the house/ጉድጎድ በቤት ውስጥ		
Dibigint (Gotera) outside the house /ጎታ/ጎተራ ከቤት		
Underground pit outside the house/ጉድጓድ ከቤት ውጭ		
Others (specify)ሌላ ካለ ይገለጽ		

6.9. What measures do you take to protect SEED of finger millet from storage pests? What measures do you take to protect spike of finger millet from storage pests? What measures do you take to protect GRAIN of finger millet from storage pests? የዳጉሳ ዘር፣ የምግብ ሰብልና የእጽዋቱ ዘለላ በጎተራ ተባይ እንዳይጠቃ ምን አይነት የመከላከያ ዘዴ ትጠቀማለህ?

Protection measures የመከላከያ ዘዴዎች	Seed (✓) ዘር	Grain (✓)የምግብ እህል
No measures taken ምንም እርምጃ አልተወሰደም		
Chemicals በኬሚካል		
Sunning በጸሀይ		
Smoking በጭስ		

Others (specify) ሌላ ካለ ይገለጽ		

6.10. How do you clean your finger millet seeds? የዳጉሳ ዘርህን/ እንዴት ነው የምታጣራው?

1. Winnowing/በነፋስ በማበጠር 2. Sieving/በወንፊት በመንፋት 3. Small seed cleaner/በትንሽ ዘር ማበጠሪያ 4. Hand/በእጅ በመልቀም 5. Pay to get the service/በክፍያ ማስበጠር

6. Do not clean/አላጣራው ም/ አላስበጥረው ም

6.11. Reasons for cleaning the finger millet seeds? የዳጉሳ ዘር ለማጥራት የፈለክበት ምክንያት ምንድን ነው ?

1. Improve quality/remove inert matter ጥራቱን ለማሻሻል
2. Remove weeds/other crops አረምና ሌሎች ሰብሎችን ማስወገድ
3. Remove small/broken damaged seed የተሰባበሩትን ዘሮ ማስወገድ
4. Reduce seed rates የዘር መጠን መቀነስ
5. Remove insect damaged/diseased seeds በተባይና በበሽታ የተጎዱ ዘሮችን ማስወገድ

Part VII. Seed diversity, Management, and Varietal loss

7.1. Between 2009 and 2013, which finger millet varieties did you stop growing? What caused you to stop growing those/that variety (ies)? ከ2001- 2005 ዓ.ም. ከመዝራት ያቆምከው የዳጉሳ ዝርያ ማን ነው ለማቆምህ ምክንያቱ ምንድን ነው?

Variety ዝርያ	Reason for loss ለመጥፋቱ ምክንያቱ ምንድን ነው	Deliberate loss ሆን ተብሎ ነው የጠፋው	Accidental loss በድንገት ነው የጠፋው

7.2. Between 2019 and 2023, which finger millet varieties did you stop growing? What caused you to stop growing those/that variety (ies)? ከ2011- 2015 ዓ.ም. ከመዝራት ያቆምከው የዳጉሳ ዝርያ ማን ነው ለማቆምህ ምክንያቱ ምንድን ነው?

Variety ዝርያ	Reason for loss ለ መጥፋቱ ምክንያቱ ምንድን ነው	Deliberate loss ሆን ተብሎ ነው የጠፋው	Accidental loss በድንገት ነው የጠፋው

Part VIII. Farmer's breeding (seed selection and maintenance)

8.1. Do farmers practice varietal/ seed selection? ገበሬዎች የዘር/የዝርያ ምርጫ ያካሂዳሉ?

1. Yes 2.No

8.2. If yes, what are farmer’s variety selection criteria? አው ከሆነ ፣ የገበሬዎች የዝርያ መምረጫ ነጥቦች ምንድን ናቸው

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

Please mark (X) the selection criteria indicated below if not cited by the farmers ከዚህ በታች በተዘረዘሩት የመምረጫ ነጥቦች ገበሬው የሚጠቀምባቸውን (□) ምልክት የማይጠቀምባቸውን (X) ምልክት ማድረግ

Criteria used for selection	(✓) ፣ (X)
Early maturity ፈጥኖ የሚደርስ	
Uniform maturity በአንድ ላይ የሚደርስ	
Blast resistance በሽታ የሚቀቀም	
Pest resistance ተባይ የሚቀቀም	
ear size በዘለላው መጠን	

seed yield በምርቱ	
Seed size በፍሬ መጠኑ	
Seed color በዘር ቀለሙ	
Marketability በገበያ ተፈላጊነቱ	
Drought resistance ድርቅ የሚቀቀም	
Lodging resistance መውደቅ የሚቀቀም	
Growth habit የአበቃቀል ባህርይው	
Food quality ለምግብ ተፈላጊነት	
Brewing Purpose ለመጠጥ ተፈላጊነት	

8.3. Do farmers exercise specific selection methods? ገበሬዎች የሚጠቀሙበት የተለየ የዝርያ መምረጫ ዘዴ አላቸው? 1. Yes 2. No

8.4. If yes, breeding methods are: አዎ ከ ሆነ የዝርያ የማሻሻያ ዘዴው ማን ነው ?

1. Pure line selection 2. Mass selection 3. Bulk selection 4. Others (specify)

8.5. Selection for /at what የሚመርጡት ምኑን ነው/ በምን ሁኔታ ያለውን ነው?

1. Select a field or section of field ማሳውን መምረጥ 2. Select plants እጽዋቱን መምረጥ

3. Select spikes within a plant ዘለላውን መምረጥ

8.6. Stage of selection የሚመረጥበት የእድገት ደረጃ? 1. At Pre harvesting ከአጨዳ በፊት 2. At harvesting በአጨዳ ጊዜ 3. At Threshing በውቂያ ጊዜ 4. At Storage በጎተራ ውስጥ

8.7. Finger millet attributes and attribute levels 2016 EC/2023/ - choose and circle the number found under levels

An attribute is a characteristic of a product (e.g. color) that can take on various levels (e.g., red, yellow, blue). Every attribute must have at least two levels.

Attribute name	Variety 1. ----------------		Variety 2. ----------------		Variety 3. ----------------		Variety 4. ----------------	
	Units	Levels	Units	Levels	Units	Levels	Units	Levels
Productivity (1)	Quintal/ha	1=Low 2=Medium 3=High	Quintal/ha	1=Low 2=Medium 3=High	Quintal/ha	1=Low 2=Medium 3=High	Quintal/ha	1=Low 2=Medium 3=High
Disease resistance (2)	Appearance of disease	1=Appeared 2=Not appeared	Appearance of disease	1=Appeared 2=Not appeared	Appearance of disease	1=Appeared 2=Not appeared	Appearance of disease	1=Appeared 2=Not appeared
Straw favorability for animal feed (3)	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High
Straw amount for animal feed (4)	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High
Tiller number (5)	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High
Color (6)	Color	1=Black 2=Red/Brown 3=White	Color	1=Black 2=Red/Brown 3=White	Color	1=Black 2=Red/Brown 3=White	Color	1=Black 2=Red/Brown 3=White
Price(seed) (7)	Price/quintal	1=Low 2=Medium 3=High	Price/quintal	1=Low 2=Medium 3=High	Price/quintal	1=Low 2=Medium 3=High	Price/quintal	1=Low 2=Medium 3=High
Price(grain) (8)	Price/quintal	1=Low 2=Medium 3=High	Price/quintal	1=Low 2=Medium 3=High	Price/quintal	1=Low 2=Medium 3=High	Price/quintal	1=Low 2=Medium 3=High
Number of finger (9)	Short/tall	1=Short 2=Medium 3=Tall	Short/tall	1=Short 2=Medium 3=Tall	Short/tall	1=Short 2=Medium 3=Tall	Short/tall	1=Short 2=Medium 3=Tall

Maturity time (10)	Scale days/mont h	1=3-4 month 2=4-5 month 3=5-6 month	Scale days	1=3-4 month 2=4-5 month 3=5-6 month	Scale days	1=3-4 month 2=4-5 month 3=5-6 month	Scale days	1=3-4 month 2=4-5 month 3=5-6 month
Drought tolerance (11)	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/hig h	1=Low 2=Medium 3=High
Brewing purpose (12)	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/hig h	1=Low 2=Medium 3=High
Food quality (13)	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/high	1=Low 2=Medium 3=High	Low/hig h	1=Low 2=Medium 3=High
Other (specify)								

PART IX: SEED SECURITY

9.1. Are you seed secured የዘር እጥረት የለብህም/ ዘር አለህ?

1. Yes 2. No

9.2. If No, how often are you unsecured? የለም ካለ ዘር የለለህ በመቼ በመቼ ጊዜ ነው?

1. Every year (always) በየ አመቱ 2. Every other year አመት እያለፈ 3.Rarely (>3 year) ከሶስት አመት በሆላ 4. Others

9.3. Reasons for seed insecurity? ለዘር እጥረቱ ምክንያቱ ምንድን ነው?

1. Drought ድርቅ
2. Disease በሽታ
3. Consumption በምግብነት
4. Selling all-out በሽያጭ
5. Postharvest problem በድህረ ምርት ብክነት
6. Insufficient seed production የዘር እጥረት
7. Quality የዘር ጥራት

9.4. What do you suggest to reduce seed insecurity? የዘር እጥረትን ለመቀነስ ምን መደረግ አለበት ትላለህ?

1. Proper harvest management የድህረ ምርት ጥበቃ
2. Proper agronomic and pest management የሰብል አመራረትና ጥበቃ ሂደት ማድረግ
3. Seed aid የዘር እርዳታ
4. Credit services for buying seed የብድር አገልግሎት
5. Change varieties ዝርያ መለወጥ
6. Increasing seed yield ዘር ምርት መጨመር
7. Separation of seed from grain ዘርን ከሰብል ምርት መለየት

INTERVIEW FOR COLLECTING DATA FROM FORMAL SEED SYSTEM

(Bureau of Agricultural Rural Development, Adet Agricultural Research Center, Ethiopian Seed Enterprise, and Amhara Seed Enterprise)

1. Are you involved in finger millet varietal improvement and seed production? 1. Yes 2. No

If yes, on what type of varieties?

2. Is there any demand for finger millet seed for production in your organization?

1. Yes 2. No

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

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4. Who is buying your finger millet seeds?

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

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

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6. What do you think are the factors for the adoption of improved finger millet varieties?

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7. What are the challenges & opportunities of small-scale seed multiplication of finger millet

varieties by farmers?

Challenges____

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Opportunities____

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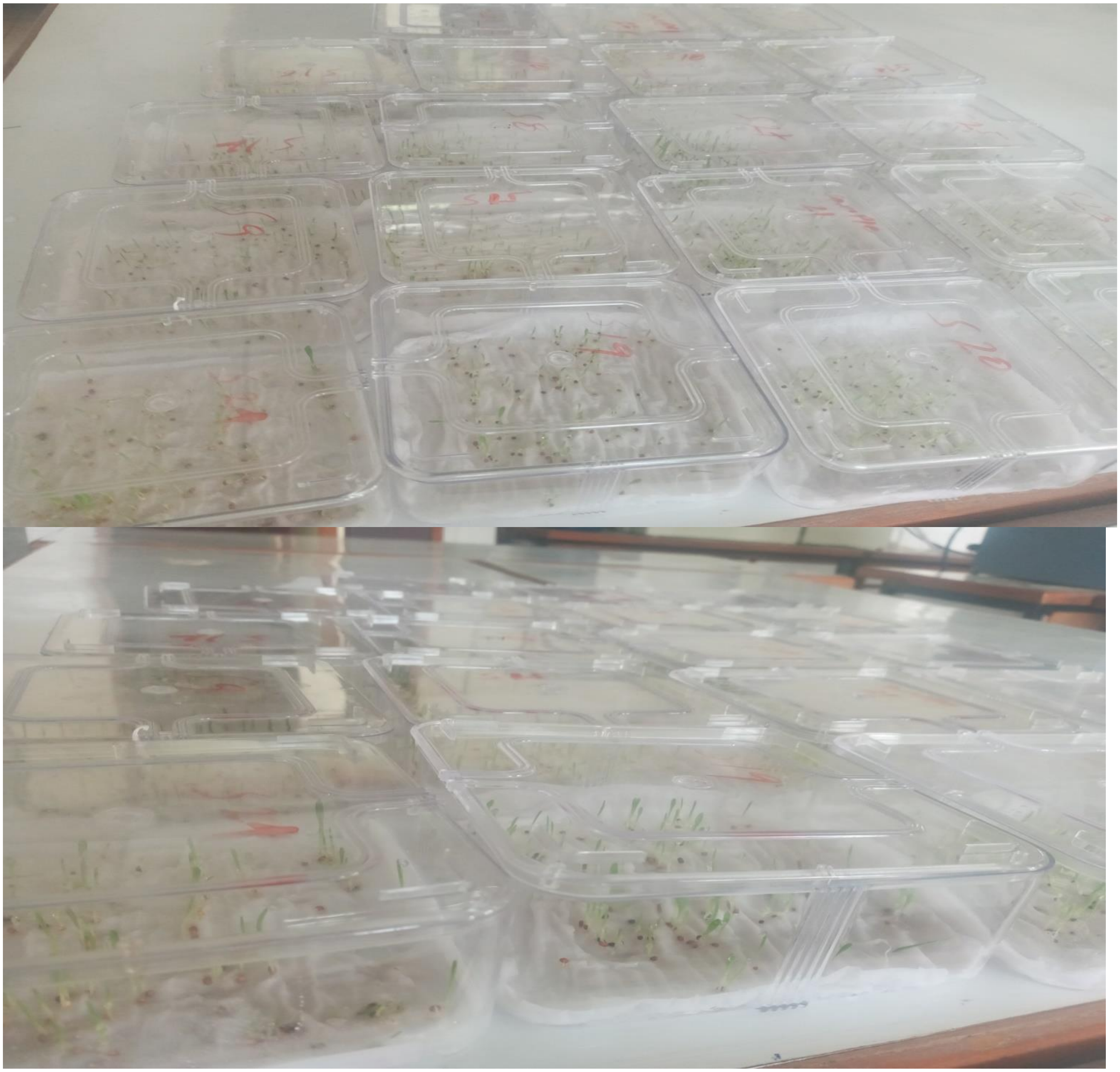
8. Are there any problems that you feel are important in improvement, production and distribution
improved finger millet seeds?

9. Would you please give your general comments on finger millet seed production and distribution?

Appendix 5. List of Appendix figure

Appendix Figure 1: Different finger millet seed samples

Appendix Figure 2: Pictures of equipment used for seed quality test



Appendix Figure 3: Pictures of seed quality experiment

AUTHOR'S BIOGRAPHY

The author, Getasew Msganaw, was born on November 15, 1994, in Tach Gayint Worda of South Gonder Zone Amhara Regional State of Ethiopia. He attended his elementary and Junior Secondary education at Bethlehem Elementary and Junior School from 2002 to 2009. He completed secondary and preparatory education (grades 9-12) at Tatek Lesira Secondary and Preparatory School from 2010 to 2013. In 2014, he joined Debre Tabor University and graduated with a Bachelor of Science degree in Agriculture (Plant Science) with great stature on June 27, 2016. After his graduation, he was directly employed at Sekota Dry Land Agricultural Research Center (SDARC) as a junior technology multiplication and seed researcher. In 2023 he joined Bahir Dar University to study M.Sc. program in Seed Science and Technology.