

**MEKDELA AMBA UNIVERSITY**

**College of Agriculture and Natural resources**

**Department of Plant Science**

**Seed Priming and Organic Nutrient (DFYM) as a New Agricultural Technology in Improving Seed Quality, Cold Stress Tolerance, Yield and Local Nutritional Value of Food Barley** (*Hordeum vulgare* L.) **at Gimba, North West Wollo, Ethiopia**

**By:**

**Mekonnen Gebeyaw Alebel (PhD in Plant Breeding and Genetics)**

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*Mekdela Amba University, Gimba Ethiopia*

1. **GENERAL INTRODUCTION**
	1. **Background and Justification**

Abiotic stresses are the primary cause of crop loss worldwide, resulting in average yield losses of more than 50% for major crops. Among environmental stresses, drought, high salinity, and temperature extremes have deleterious effects on the plant growth. A low temperature and freeze are among the most important environmental stresses (Rana et al., 2017). The reason is that more than 93% of land in the world is prone to cold, of which 81% is exposed to freeze. Hence, plant growth and development are affected by a temperature change in the majority of temperate regions on Earth. Placement in autumn and survival in winter are the comparative advantages of autumn cereals over spring cereals (Rana et al., 2017). This difference is the main factor, which determines the geographic distribution and economic potential of these cereals. The yield of autumn barley cultivars is considerably more than that of spring cultivars. On the other hand, in order to avoid heat and drought stress at the end of the season, it is necessary to plant spring cultivars earlier (Rana et al., 2017). Therefore, it is probable that cold stress will damage both autumn and spring cereals. In order to survive in cold stress, plants utilize strategies, which help them tolerate severe conditions in winter. These mechanisms are genetically controlled and are induced during exposure to low temperatures.

It is believed that the cell membrane is the first possible target of cold. Cold deforms the membrane, thereby disturbing its activity. The damage to cell membranes in cold stress is caused by two conditions: (1) when the intracellular ice is formed and (2) when the climate is getting warmer. Obviously, the intracellular ice formation is detrimental (Rana et al., 2017). Since ice crystals cannot exert the hydrophobic force, which is required to maintain the lipid bilayer, the interaction of ice crystals with a bio membrane leads to the disintegration of the membrane. On the other hand, the so-called antifreeze proteins attach to ice crystals and form a hydrophobic coat, which can mitigate the disintegration caused by ice crystals. In the second condition, membrane damage is caused when the climate is getting warmer (Rana et al., 2017). Considering the fact that cells should absorb water to balance the pressure and this absorption increases the turgor pressure, it could be said that the reason is that upon the melting of ice in cells, the extra pressure damages cytoplasmic membranes and ruptures it at some points (Rana et al., 2017). Therefore; the cell dies of this rupture. Cold brings about the membrane electrolyte leakage for tissues in the sensitive plants, which cannot increase the fluidity of the living membrane by increasing unsaturated fatty acids.

Freeze and cold stress, like other environmental stresses, can create disorder in plant metabolism and increase the production of various active oxygen molecules under the title of free radicals. These radicals, through the oxidation of biotic molecules, cause damage to all kinds of cell macromolecules and impose on the plant a type of secondary stress called plant oxidative stress (Rana et al., 2017). One of the free radicals is hydrogen peroxide (H2O2), which, through the peroxidation of unsaturated fatty acids in membrane lipids, affects their selective permeability, thereby damaging membranes. The destruction of membrane unsaturated fatty acids brings about the production of malondialdehyde, which is regarded as a suitable marker for identifying the rate and intensity of oxidative damage to measured biotic membranes (Rana et al., 2017). In order to resist active oxygen radicals and diminish their detrimental effects, the cell employs the mechanism of producing antioxidants and synthesis or activating antioxidant enzymes. Among important antioxidant enzymes are superoxide dismutase, catalase, ascorbate peroxidase, monodehydro ascorbate reductase, dehydro ascorbate reductase, glutathione reductase, glutathione peroxidase, and melatonin. Several studies have demonstrated that tolerance to cold increases by collecting oxygen free radicals via antioxidants and antioxidant enzymes. This means that tolerant genotypes show more antioxidant activity during exposure to cold stress (Rana et al., 2017).

Alternatively, seed priming is an efficient, practical, and simple technique to increase rapid and uniform emergence, high seedling vigor, and yield in many field crops under unfavorable environmental conditions (Liu X. et al., 2022; Mohapatra et al., 2022). Seed priming is a pre-sowing treatment that induces a physiological state more conducive to effective seed germination. Seed priming controls hydration that starts the normal metabolic process during the early stages of germination before the protrusion of the radical (Johnson and Puthur, 2021; Zhang et al., 2023). Nie et al (2022) also added that seed priming increases the chilling tolerance of rice seeds during germination and growth by enhancing a-amylase activity and soluble sugar content. Furthermore, Zhu et al (2021) showed that priming with salicylic acid (SA), gibberellin (GA3), CaCl2, and abscisic acid improves the germination potential, germination rate, seed vigor index of rapeseed under chilling stress, and shortens average germination time. In addition, Zhang et al (2023) also found that osmo-priming with melatonin and hormonal priming with SA are the most inexpensive treatments for improving the productivity of early planted spring maize by stimulating early seedling growth at low temperatures.

* + 1. **Priming and Priming approaches**

The various approaches include hydropriming, osmopriming, chemical priming, hormonal priming, biological priming, redox priming, solid matrix priming, etc. Although priming improves the rate and uniformity of seedling emergence and growth particularly under stress conditions, the effectiveness of different priming agents varies under different stresses and with different crop species (Jisha et al., 2013).

* + - 1. **Hydropriming**

Hydropriming has been reported to be a simple, economical and a safe technique for increasing the capacity of seeds towards osmotic adjustment, enhancing seedling establishment and crop production under stressed conditions. In this priming method, the seeds are immersed in sterilized distilled water kept at appropriate temperature and the duration of hydropriming is determined by controlling seed imbibition during germination. It is necessary to dry the seeds after soaking, as storing of improperly dried seeds will do more harm than good. After soaking, seeds were re-dried to their original weight with forced air under shade. In hydropriming, the advantageous fact is the enhancement of physiological and biochemical events taking place in seeds even when the germination is suspended by low osmotic potential and negligible matric potential of the imbibing medium (Basra et al. 2003). Moreover, the protoplasm of hydroprimed seeds/plants is found to have a lower viscosity and exhibit higher permeability to water and nutrients and hold water against dehydrating forces. Increase in the seedling growth correlated with higher water uptake by primed seeds is the predominant feature in the case of hydropriming. Various works have shown that hydropriming of seeds have many advantages as compared to non-primed seeds. Hydropriming has resulted in 3- to 4-fold increases in root and shoot length in comparison with seedlings obtained from non-primed seeds in drought condition. This phenomenon was explained to be due to faster emergence of roots and shoots, more vigorous plants, better drought tolerance under adverse conditions. Hydropriming as a simple and inexpensive method of seed priming and according to Abebe and Modi (2009), it is a very important seed treatment technique for rapid germination and uniform seedling establishment in various grain crops. ‘‘On-farm’’ seed priming (soaking seeds in water prior to sowing) has been shown to be effective in producing early germination, better establishment and increased yields in a wide range of crops in diverse environment. Hydropriming was found to be the most effective method for improving seed germination of onion, especially when the seeds were hydrated for 96 h compared to 48 h. The beneficial effects of hydropriming on aged or unaged seeds of cauliflower with respect to germination and percentage of normal seedlings. In basil (*Ocimum basilicum* L.) under saline conditions, the seedling vigor, germination percentage and seedling dry weight was found to increase due to hydropriming. Hydropriming was found to be the most effective in the case of mustard, amongst the different priming methods tried. Moreover, Rashid et al (2006); Jisha et al (2013) have suggested that on-farm priming of barley seeds could be recommended to farmers in North West Frontier Province (NWFP) of Pakistan and in similar environments in other parts of the world. Sung and Chiu (1995) proposed that emergence force and seedling growth were strengthened by hydropriming in watermelon seeds. Hydropriming has been shown to result in the earlier germination of desert cacti (*Allium porrum* L.). On-farm seed priming of maize in the semi-arid tropics has been shown to improve crop establishment and yield, but the benefits can be variable. Priming decreased the temperature optimum and ceiling temperature for germination and also helped in advancing the germination time and did not decrease the final percentage emergence. Furthermore, hydropriming as suitable, cheap and easy seed invigoration treatment for inbred lines of maize, especially when germination is affected by salinity and drought stress. In mungbean, primed seeds germinated and emerged faster and more completely, resulting in the establishment of 45 % more plants per unit area than non-primed seeds. Primed crops produced 80 % more above-ground biomass (3.3 vs. 1.9 t ha-1 ), 264 % more pod yield (1.0 vs. 0.28 t ha-1 ) and 415 % more grain (0.36 vs. 0.07 t ha-1 ) than did non-primed crops (Rashid et al., 2004). On the other hand, hydropriming and hydropriming along with proline can be used as a safe priming method for improving seed germination and growth of Vigna radiata seedlings at low temperature and allowing fast repair of injuries caused by stress. It was suggested that exogenously applied proline protects against lipid peroxidation, by stabilizing membranes during chilling and functions as a source of nitrogen and carbon, improving seedling growth and regeneration.

* + - 1. **Osmopriming**

Osmoconditioning or osmopriming is the soaking of seeds in aerated, low-water-potential solutions. Osmopriming essentially exposes seeds to a low external water potential to restrict the rate and extent of imbibition. The process of osmopriming is akin to a prolonged early imbibition of seeds that sets in motion a gradual progression of various pre-germinative metabolic activities. Thus, it is helpful to use osmopriming as a model to study the transition of seeds from a dry and physiologically quiescent to a hydrated and physiologically active state. A variety of chemicals is used to create low-waterpotential solutions. Polyethylene glycol (PEG) is more commonly used as water potential lowering agent because of its nontoxic nature and large molecular size, which lowers water potential without penetrating into the seeds during soaking. The other chemicals used to lower water potential are KNO3, KCl, K3PO4, KH2PO4, MgSO4, CaCl2, NaCl, mannitol, etc. Osmopriming is methodologically, technically and financially more exacting than hydropriming because the osmotic seed priming produces quicker and easier results and is far less expensive than most water conservation techniques, and offers farmers a highly attractive alternative for improving crop establishment and yields. Jett et al (1996) explained that, osmopriming in comparison with hydropriming can preserve plasma membrane structure and cause seeds to have better responses to germination traits because of controlled long hydration in seeds. In rice, the physiological changes produced by osmohardening enhanced the starch hydrolysis and made more sugars available for embryo growth, vigorous seedling production and later on improved allometric, kernel yield and quality attributes.

Osmo priming with PEG was described as a good technique for improving seed germination of Bromus seeds under salt and drought stress and for increasing the germination percentage and seedling vigor of bersim (*Trifolium alexandrinum*) seeds. Osmopriming with PEG results in strengthening the antioxidant system and increasing the seed germination potential, finally resulting in an increased stress tolerance in germinating seeds of spinach (Chen and Arora 2011). Elkoca et al (2007), recommended hydropriming for 12 h or osmopriming (PEG -0.5 MPa) for 24 h for a better germination of chickpeas under cold soil conditions. Compared to hydropriming, priming with PEG in a proper concentration was found to have a better effect on seed germination and seedling growth under drought stress (Yuan-Yuan et al. 2010). Rouhi et al (2011) suggested that different priming techniques (hydro and osmopriming) had a varying effects on germination on each of the four grass species (Bromus inermis, Festuca arundinacea, Agropyron elongatum and Festuca ovina) and the result showed that, for most evaluated germination parameters, osmopriming treatment (with PEG) was more useful technique to reduce abiotic stress than hydropriming treatment.

* + - 1. **Halo priming**

The higher salt tolerance of plants from NaCl-primed seeds seems to be the result of higher capacity for osmotic adjustment since plants from primed seeds have more Na2 and Cl in roots and more sugars and organic acids in leaves than plants from non-primed seeds. Priming with NaCl solutions may make it possible to establish a crop by direct sowing in saline conditions. The improved seed performance could be attributed partially to osmotic adjustment, metabolic repair processes or a buildup of germination metabolites during treatments. Salt priming with NaCl is an effective pregermination practice for overcoming salinity and droughtinduced negative effects in sugarcane. Sarwar et al (2006) while working with canola and chickpea, respectively, reported salt priming-induced improvement in seed germination, seedling emergence and growth under saline conditions. Priming led to an increased solubilization of seed storage proteins like the beta-subunit of the 11-S globulin in Beta vulgaris L. and reduction in lipid peroxidation and enhanced anti oxidative activity in seeds of Momordica charantia L. Afzal et al (2005) observed that the priminginduced salt tolerance was associated with improved seedling vigor, metabolism of reserves as well as enhanced K2 and Ca2+ and decreased Na accumulation in wheat plants.

In mungbean, pretreatment of the seeds with sublethal dose of NaCl ameliorated the injurious effects of NaCl stress to some extent by increasing growth, photosynthetic pigments, activities of antioxidant enzymes and accumulation of osmolytes for osmotic adjustments (Saha et al., 2010). Seed priming with NaCl in melon (*Cucumis melo* L.) was also found to be a useful strategy to increase the salt tolerance of melon plants in the long term and also help in the establishment of melon crop by direct sowing in a saline medium and the salt tolerance of seedlings is obtained by promoting K and Ca2+ accumulation, besides inducing osmoregulation by the accumulation of organic solutes (Sivritepe et al., 2005). Furthermore, NaCl priming increased salt tolerance of sunflower seeds by promoting K and Ca2+ accumulation and inducing osmoregulation by the accumulation of proline (Bajehbaj 2010). In milk thistle (*Silybum marianum* L.) which is a medicinal plant, seed priming with NaCl and GA3 had higher germination rate than control and produced more dry matter under salinity stress. Moreover, priming with NaCl was found to be simple and cheap, and therefore found suitable to be recommended to the farmers, so they can get better crop stand and synchrony of emergence in medicinal plants under the environmental stresses (Sedghi et al., 2010).

* + - 1. **Nutrient priming**

Nutrient priming has been proposed as a novel technique that combines the positive effects of seed priming with an improved nutrient supply. In nutrient priming, seeds are pretreated (primed) in solutions containing the limiting nutrients instead of being soaked just in water (Arif et al., 2005). Increasing evidence suggests that mineral-nutrient status of plants plays a critical role in increasing plant resistance to environmental stress factors. Of the mineral nutrients, potassium plays a particular role in contributing to the survival of crop plants under environmental stress conditions. Seed priming in Zn2+solutions improves grain yield of chickpea and wheat (Arif et al., 2007). Ascorbic acid, another important vitamin is also used for priming due to its antioxidant nature. It has already been proved that a high level of endogenous ascorbate is essential to maintain the antioxidant capacity that protects plants from oxidative stress (Zhou et al., 2009). Ascorbic acid pretreatment results in improved germination properties of Agropyron elongatum under salt stress condition (Tavili et al. 2009).

* + - 1. **Hormonal priming**

Seed performance of various crops can be improved by inclusion of plant growth regulators and hormones during priming and other pre-sowing treatments. Abscisic acid (ABA) is a phytohormone extensively involved in responses to abiotic stresses such as drought, low temperature, and osmotic stress. At the molecular level, ABA induces the expression of numerous plant genes. Some of these genes encode various signal transduction components such as putative receptors, protein kinases/phosphatases and transcription factors that may participate in salt stress signaling; others encode effectors for stress tolerance (Xiong and Zhu, 2002). ABA priming showed increased rate of germination as compared to nonprimed seeds in Indian mustard. ABA-primed seeds of Brassica napus exhibited earlier (2-7 days) germination and higher final percent radicle protrusion than non-primed control seeds, under salt (100 mM NaCl) or water stress (20 % PEG 8000) and at a low temperature (8 C) (Gao et al., 2002). The beneficial effects of gibberellic acid (GA3) on germination are well known. GA3 (100 mg l-1 ) applied as presowing treatment resulted in the highest K and Ca2+ content in the shoots of both faba beans (*Vicia faba* L.) and cotton (Gossypium barbadense) crops. Recently, auxin is also used for priming. In wheat seed germination, auxin treatments increased the hypocotyl length, seedling fresh and dry weight and hypocotyl dry weight. The growth regulators IAA and GA3 were reported to improve germination of pyrethrum seeds under non-saline condition. In wheat, among the different seed-priming agents like salicylic acid, ascorbic acid, kinetin and GA3, ascorbic acid showed better results (Khan et al., 2011). Salicylic acid priming in fennel seeds also showed better germination under low water potential. Moreover, in Salicornia utahensis, which is a halophyte, priming with growth regulators like fusicoccin, thiourea, kinetin, and ethephon alleviated the inhibitory effects of salinity on the germination, whereas GA3, proline, betaine and nitrate had little effect on germination at all salinities. Furthermore, 3 % KNO3 supplemented with 3 lM methyl jasmonate (MeJA) could promote germination and emergence of dormant Amaranthus cruentus L. seeds (Tiryaki et al., 2005). More recently, seeds of Agropyron elongatum primed with gibberellin (GA) and abscisic acid (ABA) exhibited induced CAT and SOD activities under drought conditions when compared to unprimed seeds. Enhanced replication in root tips has been reported by hormonal and vitamin priming (Shakirova et al. 2003). Vigor enhancement by the incorporation of growth regulators in priming solution might be due to increased cell division within the apical meristem of seedling root, which caused an increase in plant growth. Moreover, hormonal treatments maintain the IAA and cytokinin levels in the plant tissues, which enhance the cell division (Sakhabutdinova et al., 2003).

* + - 1. **Solid matrix priming**

In solid matrix priming (SMP) or matric conditioning, solid or semi-solid medium is used as an alternative to liquid medium. This technique is accomplished by mixing seeds with a solid or semi-solid material and specified amount of water. SMP utilizes the chemical and physical characteristics of a solid material to restrict the water uptake of seeds. Unlike hydropriming, SMP makes use of a small amount of liquid per unit of seed and solid particles. During SMP, water is slowly provided to the seeds and thus, slow or controlled imbibition occurs, allowing repair mechanisms to operate. Commonly used solid matrices include exfoliated vermiculite, expanded calcined clay, Agro-lig, bituminous soft coal, sodium polypropionate gel or synthetic calcium silicate. Locally available materials that are commonly utilized as solid matrices are sawdust, charcoal and volcanic cinder. Many studies on seed invigoration using liquid as medium have been conducted, but only a few were done using solid matrices. In the study of Lorenzo (1991) on SMP using sawdust, ground charcoal and volcanic cinder, soybean seeds responded favorably to shorter incubation periods. The longer incubation periods and higher water levels were harmful to the seeds because they encouraged fungal growth. SMP was effective in invigorating seeds of soybean through improvement in seed germination percentage. It was also found that SMP treatment significantly reduced the negative effect of high temperature on celery seed germination (Parera et al., 1993). According to Pandita et al (2010), SMP in combination with Trichoderma viride can be successfully used to improve seedling emergence and productivity of okra under low temperatures.

* + - 1. **Biological priming/bio priming**

Applying beneficial microorganisms to the seed during priming may further improve establishment of the crop, particularly if seed-applied microorganisms subsequently become established in the root zone of the plant and contribute to longer-term plant health or plant growth promotion (Bennett and Whipps, 2008). Biopriming involves coating seed with a bacterial biocontrol agent such as Pseudomonas aureofaciens Kluyver AB254 and hydrating for 20 h under warm conditions in moist vermiculite or on moist germination blotters in a self-sealing plastic bag and the seeds are removed before radicle emergence. Dual application of beneficial microorganisms to carrot and onion seed during drum priming was demonstrated by Bennett and Whipps (2008). Rhizobacteria are used as inoculants to enhance crop yield and for biological control of fungal pathogens. Certain strains of rhizosphere bacteria stimulate plant growth and are, therefore, called plant growth-promoting rhizobacteria (PGPR). In the roots of rice and tomato plants, mycorrhizal fungi were shown to induce the accumulation of a number of transcripts and proteins, respectively, many of which with a predicted function in plant defense. In Cicer arietinum L., application of PGPR improves the percentage of seed germination under saline conditions and also increased the shoot length, root length and dry matter (Mishra et al., 2010). In wheat, seed biopriming with different salinitytolerant isolates of Trichoderma were effective in improving germination percentage and reducing reduction percentage of germination during salinity stress. Biopriming of sunflower seeds with Pseudomonas fluorescens UTPf76 and UTPf86 enhanced the ability of seeds to invigorate and seedlings to grow uniformly (Moeinzadeh et al., 2010).

* 1. **Significance of the study**

Over the past few years, seed priming has emerged as a promising strategy in modern stress management because it protects plants against various abiotic stresses without heavily affecting fitness. Moreover, seed priming offers a smart, effective and realistic option for effective plant protection. Drought, salinity, extreme temperatures and oxidative stress are often interconnected, and may induce similar damage. As a consequence, these diverse environmental stresses often activate similar cell signaling pathways and cellular responses. It is known that seed priming can activate these signaling pathways in the early stages of growth and result in faster plant defense responses. The exact molecular mechanism behind priming is not completely known, it is speculated that sensitization was associated with accumulation of inactive signaling proteins in primed cells. Upon subsequent exposure to abiotic stresses, a second signaling event could hyperactive the signaling proteins thereby amplifying signal transduction, and thus leading to more rapid and/or more intense activation of defense responses (Conrath et al. 2006). Besides the above, there are various other views put forward by other authors on the mechanism behind priming. According to Nascimento and West (1998), the increase in germination percentage/seed vigor of primed seeds is due to reserve mobilization of food materials, activation and resynthesis of some enzymes and due to the increased DNA and RNA synthesis. Priming is also capable of repairing some of the damages due to seed erosion, which in turn results in increased vigor of primed seeds. Seed priming affects the lag phase of seed germination and thus causes early DNA replication. It is desirable to design suitable seed priming methods for different crop plants to meet the challenges of the environment.

**1.2. General objectives**

* To evaluate the influence of Seed priming, integrated nutrient management on abiotic stress performance of Food Barley at Gimba, North West Wollo Ethiopia
	+ 1. **Specific Objectives**
* To evaluate the influence of seed priming on seed quality traits of food barley
* To evaluate the influence of seed priming and integrated nutrient management on seed quality, yield and yield related traits of food barley
* To evaluate the influence of seed priming and integrated nutrient management on early seedling cold stress tolerance and seed quality traits of food barley
* To evaluate the influence of seed priming and integrated nutrient management on field performance and local nutritional value of food barley based on farmers involvement
* To evaluate the influence of seed priming and integrated nutrient management on Straw quality of food barley
* To understand the association between seed quality traits with yield, and yield related ,local nutritional value and straw quality of food barley
1. **GENERAL MATERIALS AND METHODS**

***ACTIVITY 1:***

**Influence of seed priming on seed quality traits of food barley (***Hordeum vulgare* L**.) at Gimba, North West Wollo, Ethiopia**

* 1. **Introduction**

Seed priming is a seed quality enhancement method used to increase the rate of germination and uniformity and overcome seed dormancy. It is the most important physiological seed enhancement method by allowing controlled imbibition and induction of the pregerminative metabolism. Priming solutions can be supplemented with plant hormones or beneficial microorganisms. The standard method is osmopriming in which seeds are incubated in a well-aerated solution of low water potential and subsequently washed, dried, and planted in the regular manner. Use of primed seeds has a great advantage in adverse conditions in the field such as cold or warm soils and high temperature. There are several examples describing the beneficial effect of seed priming on germination and establishment of a variety of crop species. Barley cultivars primed with water and polyethylene glycol (PEG) show significant impact on germination indices, seedling quality, and better tolerance to drought stress. On-farm seed priming practiced for wheat, rice, maize, sorghum, millet, and cowpea in the dry zones of many Asian countries has facilitated fast and vigorous seedling growth subsequently leading to increased crop yields (Rinukshi et al, 2015).

**1.1.2. Specific objectives**

* To evaluate different priming rate on seed quality traits of food barley
* To evaluate the duration of priming on seed quality traits of food barley
* To assess the impact of different priming techniques on seed quality enhancement of food barley
	1. **Materials and Methods**
		1. **Description of the Study Area**

The experiment was conducted at Mekdela Amba University College of agricultural and natural resource plant science laboratory room in 2017 E.C. using different materials.

* + 1. **Experimental material**

The Seeds of local food barley varieties will be obtain from farmers found around the study area. This variety has been cultivating for a centuries due to their cold stress tolerance potential characteristic. Not only that, the variety can give optimum yield under the harsh environmental conditions (Personal communication, 2025).

* + 1. **Experimental procedure**

The treatments consisting of three priming media (water, 0.2g NaCl L-1 and 9 g urea L-1 solutions), five priming durations (0, 5, 10, 15 and 20 hr.) and one local food barley variety (Farmers variety). The experiment was laid out in a completely randomized design (CRD) in a factorial combination with three replication for seed quality test.

* + - 1. **Priming seeds**

Before priming the seeds, seeds will be surface, sterilize with 1.5% ethanol solution for 2 minutes and sufficiently rinsed with distilled water. Seed samples of the local variety will be divide into three for each priming agent and further sub-divided into five for priming durations. Seed sub-samples, except for unprimed seeds (or control), will be prime in different media (i.e., water, 0.2 g NaCl L-1 and 9 g urea L-1 solutions) for different durations (i.e., 0, 5, 10, 15 and 20 hr.) in an incubator adjusted at 25 ºC under dark condition. After priming seeds will be surface-dry on moisture absorbent cotton sheet and dry to their near-original moisture content of about 11% at room temperature. After drying, the primed and unprimed seeds will be seal in a polyethylene bag and store at room temperature until further use.

* + 1. **Data collection**
		2. **Data analysis**

**ACTIVITY 2:**

**Influence of Seed Priming and Nutrient management on germination and Early Seedling Cold Stress Tolerance of Food Barley (***Hordeum vulgare* L.) **under natural field condition at Gimba South Wollo, Ethiopia**

**2.1. Introduction**

Seed priming involves the soaking of seeds in either water or osmotic solutions to activate pre-germinative biochemical processes after water imbibition and re-drying back to its 46 original weight before the emergence of radicle (Bradford, 1986; Taylor et al., 1998). The triggered metabolic activities persist after re-drying (Asgedom and Becker, 2001). Moreover, primed seeds exhibit activation of cellular defense responses, due to which they can better tolerate subsequent biotic or abiotic stresses in the field (Beckers and Conrath, 2007; Moradi and Younesi, 2009; Conrath et al., 2015). Many seed priming treatments have been used to enhance seed quality, among which hydropriming and osmopriming are the most commonly used. Hydropriming is simply the soaking of seeds in pure water, while osmopriming is the soaking of seeds in osmotic solutions (Farooq et al., 2006; Samad et al., 2014). Nutrient priming is a type of osmopriming in which seed is soaked in nutrient solutions to improve the physiological quality of seed during early germination stage (Mousavi et al., 2012). On-farm seed priming simply involves soaking seeds in water or chemical solutions overnight, surface drying them to facilitate easy handling, then sowing them in the field. On-farm seed priming hastens germination and seedling emergence and promotes vigorous early growth so that moisture and nutrient resources are captured and utilized effectively. Earlier seed priming studies showed that the pre-soaking of seeds is beneficial to improving seedling emergence speed and uniformity, stand establishment and increase yield of treated crops as reported in sorghum (Al-Mudaris, 1998), rice (Farooq et al., 2006), barley (Abdulrahmani et al., 2007), maize (Foti et al., 2008) and wheat (Ghiyasi et al., 2008). The findings of the seed priming research have a practical importance for the farmers practicing crop production under dryland farming conditions to improve stand establishment and to increase yield. However, the results obtained so far with priming were variable depending on the climatic conditions, genotype, and priming techniques used. Priming studies conducted so far in Ethiopia are few. One of such study is by Wondimu et al. (2010) who studied on-farm hydropriming of sorghum (for 8 h) and maize (for 14 h) seeds in Northern Ethiopia reported the hydro-primed seeds were emerged, headed, and matured earlier (2-4 days), good stand establishment, high grain and stover yield than the non-primed seeds. However, the information available regarding nutrient priming effect on sorghum stand establishment, growth and yield for eastern semi-arid lowlands of Ethiopia are scanty. Therefore, there is a need to study and understand the possible benefits derived 47 from seed priming technology especially on barley stand establishment, growth, and grain yield. The objective of this study, therefore, was to evaluate the effects of seed priming on stand establishment, growth, yield components, and yield of grain barley.

Seed germination is the initial step in the life cycle of plants, which begins when the inactive dry seed imbibes water until the protrusion of the radicle from the seed coat (Gins, 2022). The degradation of macromolecular substances, the reparation of genetic material, and the expansion of the embryo and endosperm accompany seed germination, which ultimately leads to the rupture of the seminal peel and endosperm and the appearance of a root (Gins, 2022). The germination process comprises three phases, i.e., in the first phase, the seed absorbs water and swelling occurs; in the second phase, the resumption of metabolic processes occurs; and in the third phase, the appearance of a root from the seed happens (Tetyannikov et al., 2022). Accelerated seed germination is crucial not only for the formation of seedlings but also valuable for enhancing the yield. A simple and inexpensive method pre-sowing treatment of seeds with solutions of plant growth stimulants improves seed germination and the appearance of uniform seedlings by activating physiological and metabolic processes (Johnson and Puthur, 2021). Seed treatment promotes simultaneous germination through enzyme activation, cell regeneration, protein synthesis, and improved antioxidant defense mechanisms. Various types of seed treatments are widely used, such as, seed coating or seed soaking, by using plant growth regulators, osmolytes, and other chemicals to enhance the crop's growth with sustainability (Marthandan et al., 2020). Hormonal seed treatment involves the germination of seeds in an aerated aqueous medium using various substances that stimulate plant growth, such as salicylic acid (SA), gibberellin (GA), abscisic acid, and other phytohormones. Plant hormones regulate plant growth, development, reproduction, and survival, and these mechanisms involve cross communication and signaling pathways, in which plant hormones play a vital role (Gins, 2022)

**2.1.1. Specific objectives**

* To evaluate different priming rate and integrated nutrient management on cold stress tolerance of food barley at early seedling stage
* To evaluate the duration of priming and integrated nutrient management on cold stress tolerance of food barley at early seedling stage
* To assess the impact of priming techniques and integrated nutrient management on cold stress tolerance of food barley at early seedling stage
* To understand the association between cold stress tolerance with seed quality traits

**2.2. Materials and Methods**

**2.2.1. Description of the study area**

The experiment will be conduct at Mekdela Amba University College of agricultural and natural resource plant science demonstration site in 2017 E.C under main season irrigation system. The area is geographically located 481km from Addis Abeba to southwest direction. The latitude is about 10.988962 and 39.255822 longitude its altitude is 3206. 34100ma.s.l. the annual rainfall of the area is 150-750 mm and the annual average temperature is 15-200C0 (south wollo zone Agricultural office, 2019).

**2.2.2. Experimental material**

The Seeds of local food barley varieties will be obtain from farmers found around the study area. This variety has been cultivating for a centuries due to their cold stress tolerance potential characteristic. Not only that, the variety can give a yield as farmers need under the harsh environmental conditions (Personal communication, 2025).

**2.2.3. Experimental procedure**

The experiment will be laid out in randomized complete block design (RCBD) with three replications. The treatments consisting of three priming media (water, 0.2g NaCl L-1 and 9 g urea L-1 solutions), five priming durations (0, 5, 10, 15 and 20 hr.) and one local food barley variety (Farmers variety) and six nutrient management treatments. That is unfertilized control (M1), 46 N/10 P kg ha-1 (M2), 5 t FYM ha-1 (M3), 23 N/5 P kg + 2.5 t FYM ha-1 (M4), 46 N/10 P kg + 2.5 t FYM ha-1 (M5), and 23 N/5 P kg + 5 t FYM ha-1 (M6).

**2.2.4. Data collection**

**2.2.5. Data analysis**

***ACTIVITY 3:***

**Influence of Seed Priming and Nutrient management on Growth, Yield and Yield Related Traits of Food Barley** (*Hordeum Vulgare* L.) **at Gimba North West Wollo, Ethiopia**

**3.1. Introduction**

Quality seed is a unique and fundamental entity that stores genetic information for the consequent life cycle of a plant. As vital propagating units, seeds play a very important role in crop production and human sustenance. Irrespective of the crop species, agricultural region, and growth season, use of good quality seeds ensures a good yield (Rinukshi, 2015). Good quality seed is superior to other standard seed in characteristics such as genetic purity, which include high, and even germination rates, uniform growth pattern, physiological purity illustrated by viability and vigor and good health that ensures seeds are free from seed borne diseases and disorders. Other aspects include uniform size, shape, color, texture, weight, freedom from other crop and weed seeds, insects, and devoid of other undesirable substances (Rinukshi, 2015). Seed Enhancement, in nature, numerous genetic and physical factors are responsible for determining the quality of seeds. Genetic factors that influence quality include genetic makeup and age and nutritional status of the mother plant. Environmental features such as temperature, water status, photoperiod and light quality, soil nutrition at seed setting and development, and physical factors such as injury and damage during planting, establishment, and storage as well as moisture and temperature during storage contribute largely to seed quality. Interaction of genotype and environment ultimately determine the status of the seeds (Rinukshi, 2015). There are many advantages to using good quality seeds in agriculture, the utmost advantage being the full exploitation of the genetic potential of the crop providing high return per unit area. The other benefits include the ability of adapting to extreme growth and climatic conditions, higher degree of resistance to pests, diseases, and weeds, uniformity in plant growth, and maturation allowing easy harvesting and postharvest handling and high market value (Rinukshi, 2015). In brief, good quality seeds are the basic source of a secure food supply. In many regions, especially in developing countries, famers do not have access to good quality seeds for a number of reasons, including insufficient seed production, the unavailability of quality-checked seeds, inefficient distribution, lack of seed certification methods, and higher seed prices (Rinukshi, 2015). The Food and Agriculture Organization (FAO) plays an active role in determining guidelines in seed quality assurance that guarantee the quality of seed from production, harvesting, and postharvest handling until delivery to the farmer (Rinukshi, 2015). With the understanding of seeds as basic and crucial input for increased productivity and profitability, considerable effort has been made to improve seed quality and develop new varieties and hybrids by plant breeding and biotechnology methods. Over the past years, seed companies contributed to enhancing crop production by utilizing seed genetic traits such as insect and pest resistance, water-use efficiency, and higher yields in genetic engineering and breeding programs. This activity focuses on seed quality enhancement methods, and integrated nutrient management approaches in improving seed quality for better yield (Rinukshi, 2015).

**3.1.1. Specific objectives**

* To evaluate different priming rate and integrated nutrient management on seed quality traits of food barley
* To evaluate the duration of priming and integrated nutrient management on seed quality traits of food barley
* To assess the impact of priming techniques and integrated nutrient management on seed quality, yield and yield related traits of food barley
	1. **Materials and Methods**

The experiment was carried out at Seed Science and Technology Laboratory of Haramaya University during February to June 2014. 2.2.1. Seed Materials Seeds of sorghum [Sorghum bicolor (L.) Moench] varieties viz., Abshir (P9403), Dekeba (ICSR24004), Macia, Meko-1 (M36121), Melkam (WSV387), and Teshale (3443-2-OP) were obtained from Melkassa Agricultural Research Center (MARC), National Sorghum Improvement Program. These varieties were released for semi-arid lowlands due to their drought escape characteristic (early maturity that ranges from 90 to 120 days). The seed color for all the varieties are white and have better injera (national flat pancake) making quality and some tolerance to striga weed (MoARD, 2009; EIAR, 2014). 2.2.2. Treatment and Experimental Design The treatments consisted of three priming media (water, 0.2 g ZnSO4 L -1 and 9 g urea L-1 solutions), five priming durations (0, 5, 10, 15 and 20 h) and six sorghum varieties (Abshir, 25 Dekeba, Macia, Meko-1, Melkam and Teshale). The experiment was laid in a completely randomized design in a factorial combination with four replications for the germination test and three replication for seedling vigor test. 2.2.3. Experimental Procedures 2.2.3.1. Priming of seeds Before priming the seeds, seeds were surface sterilized with 1.5% sodium hypochlorite solution for 2 minutes and sufficiently rinsed with distilled water. Seed samples of each sorghum variety were divided into three for each priming agent and further sub-divided into five for priming durations. Seed sub-samples, except for unprimed seeds (or control), were primed in different media (i.e., water, 0.2 g ZnSO4 L -1 and 9 g urea L-1 solutions) for different durations (i.e., 0, 5, 10, 15 and 20 h) in an incubator adjusted at 25 ºC under dark condition. The ratio of seed weight (g) to solution volume (mL) was 1:5 (Farooq et al., 2006). The primed seeds were surface-dried on moisture absorbent cotton sheet and dried to their near-original moisture content of about 11% at room temperature. After drying, the primed and unprimed seeds were sealed in a polyethylene bag and stored at room temperature until further use. 2.2.3.2. Germination test A germination test using a top-of-paper method (ISTA, 2008) was performed in the laboratory at room temperature (about 23 ºC). Four replicates of 100 seeds each taken from the primed and unprimed seeds of each variety were arranged on a double layer of Whatman filter paper No. 2 and moistened with 5 mL of distilled water in each sterilized Petri-dishes (11 cm diameter) and then Petri-dishes were completely randomized. The number of seeds exhibiting 2 mm radicle and plumule were considered as germinated seed. Counts of germinated seed were made daily starting from the first day after sowing until there was no further germination (14 days after sowing). Assessment of final germination percentage (FGP) was made based on counts of the normal seedling as prescribed in ISTA (ISTA, 2008) using Eq. 1 below. 26 Similarly, the assessment of germination index (GI) and mean germination time (MGT) were made by adopting Eq. 2 (AOSA, 1991) and Eq. 3 (Ellis and Roberts, 1981). Where n is the number of seeds that germinated on day D and D is a number of days counted from the beginning of germination.

2.2.3.4. Seedling growth and vigor test

]The second set of laboratory experiment was conducted to determine seedling growth and vigor of sorghum varieties under room temperature. Three replicates of 50 seeds that were taken from the primed and unprimed seeds of each variety were germinated in plastic boxes (14 × 10 × 11 cm in length, width, and depth, respectively) filled with 5 cm layer of sand. The sand was sieved, washed and sterilized in an oven at 200 °C for six hours and moistened to the required moisture level for germination. Germinating boxes were completely randomized and watered as needed. At the end of the germination period of 14 days, the total numbers of normal seedlings emerged were counted to determine the emergence percentage. From each planting box, five normal seedlings were randomly selected, and their length (root + shoot) were measured. Additionally, five normal seedlings were also randomly selected and oven-dried at 60 °C to a constant weight to determine their mean dry weight (root + shoot). Seedling vigor indices were determined using mean values of emergence percentage, seedling length and seedling dry weight as indicated below in Eq. 4 and Eq. 5, respectively (AOSA, 1991). SVI-1 = Seedling length (cm) × Emergence (%) (4) SVI-2 = Seedling dry weight (mg) × Emergence (%) (5) Where SVI-1 and SVI-2 are seedling vigor index-1 and 2, respectively. 27 2.2.4. Statistical Analysis Data collected were subjected to analysis of variance (ANOVA) using SAS statistical software version 9.1 (SAS Institute Inc., 2004) as per standard procedures. Germination percentage values were transformed using Arcsine to fulfill the assumption of ANOVA whenever required but the results were presented in actual values. Least significant difference (LSD) test at 5% probability level was used to compare the treatment means.

* + 1. **Description of the study area**
		2. **Experimental material**
		3. **Experimental procedure**
		4. **Data collection**

**3.2.5. Data analysis**

**ACTIVITY 4:**

**Influence of Seed Priming and Nutrient Management on Seed Quality of Food Barley (***Hordeum vulgare* L**.) at Gimba South Wollo, Ethiopia**

* 1. **Introduction**

Seed priming is a seed quality enhancement method used to increase the rate of germination and uniformity and overcome seed dormancy. It is the most important physiological seed enhancement method by allowing controlled imbibition and induction of the pregerminative metabolism. Priming solutions can be supplemented with plant hormones or beneficial microorganisms. The standard method is osmopriming in which seeds are incubated in a well-aerated solution of low water potential and subsequently washed, dried, and planted in the regular manner. Use of primed seeds has a great advantage in adverse conditions in the field such as cold or warm soils and high temperature. There are several examples describing the beneficial effect of seed priming on germination and establishment of a variety of crop species. Barley cultivars primed with water and polyethylene glycol (PEG) show significant impact on germination indices, seedling quality, and better tolerance to drought stress. On-farm seed priming practiced for wheat, rice, maize, sorghum, millet, and cowpea in the dry zones of many Asian countries has facilitated fast and vigorous seedling growth subsequently leading to increased crop yields (Rinukshi et al, 2015).

**4.1.1. Specific objectives**

* To evaluate different priming rate andintegrated nutrient management on seed quality traits of food barley
* To evaluate the duration of priming and integrated nutrient management on seed quality traits of food barley
* To assess the impact of different priming techniques and integrated nutrient management on seed quality enhancement of food barley

**4.2. Materials and Methods**

* + 1. **Description of the Study Area**
		2. **Experimental material**
		3. **Experimental procedure**
		4. **Data collection**
		5. **Data analysis**

***ACTIVITY 5:***

**Influence of seed priming and Nutrient management on field performance and local nutritional value of food barley (***Hordeum vulgare* L**.) based on farmers involvement at Gimba South wollo, Ethiopia**

**5.1. Introduction**

**5.1.1. Specific objectives**

* To evaluate different priming rate and integrated nutrient management onfield performance of food barley based on farmers participation
* To evaluate the duration of priming and integrated nutrient management on local nutritional value based on farmers participation
* To evaluate the impact of priming techniques and integrated nutrient management on local nutritional value based on farmers participation
* To understand the association between field performance traits with local nutritional value of food barley among farmers participation

**5.2. Materials and Methods**

* + 1. **Description of the study area**
		2. **Experimental material**
		3. **Experimental procedure and data collection**

According to Jemal Mohammed et al (2016) in Ethiopia, barley-based foods are prepared as main, side, and ceremonial dishes (wedding and annual festivals). Sometimes they are primed as recuperating dishes and served to breast-feeding mothers with the belief that they enhance breast milk production. Besides, some dishes are claimed to be a remedy for gastritis, while others are reported to be a good substitute for breast milk or good to heal broken bones and fractures. The major processes in the preparation of some traditional Ethiopian barley-based foods and the socioeconomic and local nutritional roles of these foods are defined in the following sections.

**5.2.3.1. Injera**

Injera is a thin and fermented Ethiopian traditional bread made from flour, water, and starter (ersho), which is a small portion from previously fermented dough [16]. It is the most widely consumed food because it accompanies almost all traditional dishes in Ethiopia, and is served with sauces [9]. Injera is prepared from flour of raw barley grain. Moderately fine-milled flour of barely is sieved and the dough is prepared. When the dough is prepared, the flour is mixed with water and kneaded by hand. A starter, leaven (ersho), is then added to the dough and left for 1e5 days to allow fermentation to occur (in most cases, the mixture is allowed to ferment for 3 days). The duration needed for fermentation depends on altitude: the higher the altitude, the longer the fermentation time required, as the temperature would be lower [7]. Injera from well- and long fermented dough makes a better sourer taste and has good storability. During the preparation of injera, back-inoculation and addition of leaven for fermentation is a general practice commonly followed all over the country [8, 15]. For fermentation, lactic acid bacteria and yeasts are the main fermentative microorganisms [17], and their products increase the acidity of the dough. Before baking injera, a small part of the dough is added to boiling water and the mixture is stirred until it starts to boil again and the whole mixture (called absit) is added to the injera dough. This ensures the dough undergoes suitable fermentation [7]. If necessary, more water is added and after half an hour baking can be started. Injera is baked on a clay pan or mitad. Before baking, the pan is greased with kale or rapeseed, and then heated and cleaned with a piece of cloth for better output. The dough mixture is put on the pan in a circular shape, forming a thin cake. The total baking time for one injera varies from 2 minutes and 30 seconds to 3 minutes and 30 seconds [7]. A good quality injera is soft, fluffy, and spongy with good and well-distributed eyes and it does not break when rolled. The major quality attribute of a good injera is its slightly sour taste, which is due to the acidic nature of injera [18]. Unfortunately, the injera storage period does not usually exceed 3 days at ambient temperature under the traditional storage conditions, mainly due to mold spoilage. There is a common practice to discard moldy injera.

**5.2.3.2. Kita**

Kita is a dry, thin, flat bread with a chew consistency similar to a chewy pretzel. It is an instant bread usually prepared for immediate consumption for children or as an emergency food when no injera or kolo is available. Sometimes by topping with sugar it is used to train children to eat properly [19]. Undeniably, if market bakery (dabo) is an object of desire, it is the focus of satisfaction that many Ethiopians aspire [9]. To make kita, the flour is mixed with water and kneaded by hand with a pinch of salt to make thick unfermented dough. It is then baked immediately on both sides using a clay pan (mitad) or iron pan (biret-mitad). When one side is baked enough, it is turned inside out, so as to allow the other side to bake. Kita is a relatively thicker and harder bread but smaller in size (about the size and thickness of a pizza base) compared with injera. It can be served either alone or with butter, milk, and linseed paste.

**5.2.3.3. Dabo**

Dabo is a leavened homemade bread, which is much thicker and softer than kita. The dough is prepared thick with salt added for an overnight fermentation. A leaven (ersho) is added as an initiator of fermentation, which is also the case with injera. Dabo or Ethiopians bread is baked on both sides by burning fire on both sides after covering the top with leaves and mud/clay. It is usually prepared for holidays or cultural gatherings. In rural Ethiopia, toasted or baked barley dabo is another important element of the daily diet, something without which a meal would be incomplete [8], as it is the quintessential symbol of Ethiopian reciprocity and household hospitality.

**5.2.3.4. Kolo**

Kolo is the most widely consumed roasted whole barley grain in Ethiopia. During the preparation of kolo, the bran from the grain is separated using two consecutive dehulling steps: fitega and shiksheka. The whole grains of barley are first soaked in hot water for few hours, and then rubbed by beating/pounding the grain in a mortar with pestle (i.e., the fitega process). After the bran is removed from the grain by subsequent blowing, the grain is deeply roasted on iron/clay pans. Finally, the roasted grain is dehulled for the second time by mildly beating the grain with a mortar and pestle (i.e., the shiksheka process), or rubbed by hand to remove the remaining hulls. This popular local snack, kolo, is consumed either alone or mixed with peanuts, field pea, faba bean, sunflower, and chickpea. It is usually consumed as a snack dish served before the main dish, and during coffee ceremony and other cultural occasions. As it is already known, coffee is the most common social drink that is shared with neighbors and at that time barley kolo (Fig. 2) is the most commonly served food [20].

**5.2.3.5. Genfo**

Genfo is one of the most widely consumed foods in Ethiopia [19], and it is preferred as a main meal of breakfast, but most commonly consumed during a special celebration such as birth days and weddings [8]. Traditionally, in many parts of Ethiopia, there is a habit to prepare genfo for an expectant mother. For this purpose, barley grain is the number one crop to choose. A postnatal mother eats genfo with spiced butter for breakfast and heguests are also served genfo. Neighbors and close relatives usually prepare barley genfo and give it to the new mother. In addition, genfo is also considered as an appropriate complementary food for children aged between 6 months and 24 months because it is thought to be important to make the baby grow faster and stay healthy [19]. Genfo (Fig. 3A) is prepared from the flour of roasted barley. When barley grain is prepared for genfo, sun drying takes a longer time, roasting is light, and milling is required. These sun-drying and roasting processes are used to gelatinize starch and to increase the water-absorbing capacity of the flour during cooking so that high volume genfo can be obtained from a small amount of flour of gelatinized starch, which generally absorbs more water, and swells more than nongelatinized starch [14]. During the preparation of genfo, the lightly roasted grain is milled and sieved to remove the remaining hull. The flour is then added with some salt in boiled water and cooked with frequent stirring. Genfo is usually prepared with a recipe made up of glutinous ingredients like butter mixed with berbere, honey, or linseed paste [8]. This combination provides the lubrication, which allows the mouthfuls of thick porridge to slip down the throat [8]. A hole is prepared in the middle of the porridge, which is commonly used to put the lubricant. Porridge is most often served immediately when it is hot; there is also an Ethiopian proverb regarding serving porridge: “Porridge and love should be served hot, if cold, they will lose a lot.”

**5.2.3.6. Beso and chuko**

Beso and chuko are basically prepared from the same type of flour that is prepared from roasted barley. The preparation of the barley grain for beso and chuko flour is almost similar to the steps followed for the preparation of flour for genfo. The only difference arises from the level of roastingdflour from lightly roasted barley is used for genfo, whereas flour from intensely roasted barley is used for beso and chuko. Beso is prepared using cold or hot water to moisten the flour on a bowl in such a way that it can be balled/rolled using hand and served (Fig. 3B). Salt is usually added in the water, but sugar or melted spiced butter can also be added, if available. Beso can also be prepared by mixing the flour with cold water and sugar, and served immediately in a cup or glass (Fig. 3C). According to most Ethiopians, beso cures gastritis. Chuko (Fig. 3D) is one of the best traditional barley foods of Oromo people in Ethiopia. It is easy to prepare in a short span of time: first, barley is husked and then roasted over a fire. It is then pounded into powder. Over this roasted beso powder, different spices such as ginger, onion, salt, and sufficient amounts of spiced and clarified butter (ghee) are added and mixed to create a tasty, chewy, and piquant finished product. This dish is usually preferred as both a part of the everyday diet and prepared for special events or for postnatal women or a sick family member. Chuko is prepared for holidays and festivals. It is traditionally related to Oromo weddings, served by the bride's parents to the groom's best men. Furthermore, it is also popular among those on long journeys such as those leaving for education and for military campaigns, zemecha, because it can be stored for up to a year without spoiling. In general, chuko is mainly produced for home consumption sometimes as a variety dish, but can also be found at local markets.

**5.2.3.7. Tihlo Tihlo**

Tihlo Tihlois commonly consumed as a side dish, especially by Tigray communities. The processing of barley for tihlo is similar to that followed for beso but the grain is completely dehulled and the milling requires extra care to avoid mixing with flours from other crops, which might decrease the quality. In addition, more water is used to prepare tihlo than beso. Tihlo is usually balled by hand and served with freshly made hot shiro wot (a sauce made from pulses flour and spices).

**5.2.3.8. Kinche and shorba**

Kinche and shorba for the preparation of kinche and shorba, the grain is dehulled using a mortar and pestle, roasted very lightly, cracked into four or five parts, sieved, and cooked in boiled water with occasional stirring to get a thick consistency. After adding salt and sugar, it is served when it becomes cold and, if available, spiced butter or ghee can also be added. Kinche is considered as a luxury food, and therefore prepared occasionally for changing diet and/or as an alternative dish when other dishes are not readily available. The preparation of barley for soup, shorba, is the same as that of kinche except that more water is added to shorba. Thus, it is a drink served hot in a cup or using a spoon in a bowl. Shorba can be mixed with some vegetables and pulses but it is usually served alone with sugar, salt, and spiced butter (if available). It is a very important dish during Ramadan, when it might be prepared daily.

* + 1. **Data collection**

**5.2.4.1. Farmers' participatory variety evaluation and selection**

The participatory variety evaluation and selection process was conducted using a pairwise and direct matrix ranking based on the guideline developed by De Boef and Thijssen (2007) as follows;

**5.2.4.1.1.** Pair wise ranking and procedures;

When conducting a comparison between different treatments, the facilitators must keep a record of the reasons behind their choice. This process, known as the participatory varietal selection, often involves ranking tools to make decisions about which varieties to proceed with in the selection and evaluation process. The following are the prescribed procedures for this process.

Step 1: Selection criteria’s can be ranked pairwise in a table both in horizontally in the rows and vertically in the columns.

Step 2: every time a participant or the group has to decide, which selection criteria has preference over the other.

Step 3: The informal discussion leading to the decision should be well-recorded as qualitative information.

**5.2.4.1.2. Matrix ranking and procedures;**

Matrix ranking is a method to compare and analyze a range of varieties in both qualitative and quantitative ways. It can be used to compare local varieties or to compare them with introduced or tested varieties. This method shows how farmers evaluate the varieties they use. It is commonly used in participatory varietal selection and participatory plant breeding, just like other ranking methods. Additionally, matrix ranking is useful for comparing and assessing other resources, issues, and ideas. The following procedures are usually followed when using this method:

Step 1: Make a matrix with the criteria in the first column; criteria have been identified through brainstorming or through simple ranking. Put the varieties in the first row (use cards or symbols).

Step 2: Let participants rank the varieties for each character.

Step 3: A weighed ranking of varieties can be calculated as the product of the value for the criteria and the score for each specific variety. In that way, all varieties can be compared with each other.

* + 1. **Data analysis**

The Analysis of variance (ANOVA) of all parameters and measurements was done using linear mixed model of SAS Software version 9.4 represented by the following equation;

Y\_ijr=M+G\_i+Lj+B\_r (Lj )+G\_i L\_j+E\_ijr

Where: Yijr = the observed variable response of the genotype i in the location j and block r, M=grand mean, G = genotype, L= location, B=block effects and Eijr=random error; while the LSD test at 5% and 1% level of significance was made using R software version 4.2 metan and agricolae Packages (R Development Core Team, 2021). A pairwise ranking and direct matrix methods were used to examine the data acquired with the farmers' participation during the variety evaluation and selection process (De Boef and Thijssen, 2007).

***ACTIVITY 6:***

**Influence of Seed Priming and Nutrient Management on local Straw Quality of Food Barley (***Hordeum vulgare*L.**) at Gimba North West Wollo, Ethiopia**

**6.1. Introduction**

**6.1.1. Specific objectives**

* To evaluate different priming rate and integrated nutrient management onlocal straw quality of food barley
* To evaluate the duration of priming and integrated nutrient management onlocal straw quality of food barley
* To evaluate the impact of priming techniques and integrated nutrient management onlocal straw quality of food barley

**6.2. Materials and Methods**

**6.2.1. Description of the study area**

**6.2.2. Experimental material**

**6.2.3. Experimental procedure**

**6.2.4. Data collection**

**6.2.5. Data analysis**

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| Process | **2026** | **2027** |
| Jan-Feb | Mar-Apr | May -Jun | Jul-Aug | Sep-Oct | Nov-Dec | Jan-Feb | Mar-Apr | May -Jun | Jul-Aug | Sep-Oct | Nov-Dec |
| Project inception | Collect proforma |  |  |  |  |  |  |  |  |  |  |
| Procurement | Procurement of equipment and reagents |  |  |  |  |  |  |  |  |
| Research work |  |  |  | Research and analysis |  |  |  |  |  |
| Presentation |  |  |  |  |  |  |  | Conference participation |  |
| Publication |  |  |  |  |  |  |  |  |  | Manuscript writing and submission |