

**ADDIS ABABA UNIVERSITY**  
**SCHOOL OF GRADUATE STUDIES**



**Propagation and management practices of coffee (*Coffea arabica* L.) at the coffee nursery site of Lalo kebele, Didu Wereda, Ilu-Aba-Bora Zone, Oromia Regional State.**



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**Addis Ababa, Ethiopia**

**September, 2018**

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at the coffee nursery site of Lalo kebele, Didu Wereda, Ilu-Aba-Bora  
Zone, Oromia Regional State.**

**BY**

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**A Thesis Submitted to the Department of Zoological Sciences in Partial  
Fulfillment of the Requirements for the Degree of Master of Science in  
Biology, Addis Ababa University**

**Addis Ababa, Ethiopia**

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# ADDIS ABABA UNIVERSITY

## GRADUATE PROGRAMMES

### DECLARATION

This is to certify that the thesis prepared by **BEDILU TEKLE** entitled:

**Propagation and management practices of coffee (*Coffea arabica* L.) at the coffee nursery site of Lalo kebele, Didu Wereda, Ilu-Aba-Bora Zone, Oromia Regional State.** And submitted in fulfillment of the requirements for the degree of Master of Science in Biology complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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**Propagation and management practices of coffee (*Coffea arabica* L.) at the coffee nursery site of Lalo kebele, Didu Wereda, Ilu-Aba-Bora Zone, Oromia Regional State**

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**Addis Ababa University, 2018**

**Abstract**

Coffee is the major agricultural export crop, providing currently 35% of Ethiopia's foreign exchange earnings, down from 65% a decade ago because of the slump in coffee prices since the mid-1990's. This research work was conducted by identifying and providing the necessary information about the propagation and management practices of coffee on nursery site of Lalo Kebele, Didu Wereda, Ilu-Aba-Bora Zone, Oromia Regional State. Data were collected through semi-structured interviews, discussions with the farmers and/or development agents, and field observations. The study found that a combination of forest soil, top soil and compost promoted growth of coffee seedlings. According to the present study, sound fertilization of seedling provides the following advantages: (1) Production of healthy coffee seedlings and subsequently productive coffee plants; (2) Uniform growth; (3) Fast growth of seedlings; and, (4) High post-planting survival rate. Application of commercial fertilizer to seedlings enhanced the growth of these, especially the application of DAP. Sowing coffee seeds at a depth of 1 cm with the grooved side placed downwards and embryo tip upwards improved seed germination. Covering the seed bed with 3-5 cm mulch enhanced higher germination. Transplanting germinants to a freshly prepared nursery bed, followed by watering at two days interval, helped speed up hypocotyls emergence and subsequent seedling development. Further, providing moderate overhead shade and watering to the developing seedlings twice a week until these produced up to four leaves were found to be mandatory for a high quality seedling production. Keeping nursery hygiene and controlling seedling disease are also major activities at Lalo coffee nursery. Sowing mature, freshly collected and clean coffee seeds after soaking these in cold water for 24 hours hastened germination. It was observed that hardening is generally done by reducing the amount of watering about one month before the date of planting.

**Keywords/Phrases:** Coffee nursery, Didu Wereda, Ilu-Aba-Bor, mulching, overhead shade

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## **List of acronyms**

BAP	Best Agricultural practice
CTR	Crooked tap roots
DAP	Di ammonium phosphate
FAO	Food and Agriculture organization
FS	Forest soil
GDP	Gross domestic product
MMC	Media moisture content
MCT D	Ministry of coffee and Tea Development
MTR	Multiple tap root
RWC	Relative water content

# 1. Introduction

## 1.1. Back ground of the study

Agriculture is the main stay of Ethiopian economy, and contributes to more than 50% of GDP, 80% of exports and 85% of employment. Coffee is the major agricultural export crop, providing currently 35% of Ethiopia's foreign exchange earnings, down from 65% a decade ago because of the slump in coffee prices since the mid-1990's. In a country where about 44% of the population is under poverty (Woods, 2003), coffee cultivation plays a vital role both in the cultural and Socio-economic life of the nation. About 25% (15 million) of the Ethiopian population depend directly or indirectly, on coffee production, processing and marketing. The estimated coffee production area (2% of total cultivated land) in the country is measured in the range of 320.000 to 700.000 ha (FAO, 1987), though potentially there exist about 6 million ha cultivable land suitable for coffee production. The coffee cultivation takes place from 900 in Magi (Kaffa) to 2300 m.a.s.l in Gore (Ilu-Aba-Bor) (Fernie, 1966), albeit the Optimum productive plantations are located between 1500 to 1800 m.a.s.l (Paulos, 1994).

Coffee (*Coffea arabica* L.), which is originated in Ethiopia, is the back bone of the country's economy. It is mostly produced in Oromia and Southern Nations, Nationalities and Peoples (Tsegaye *et al.*, 2000). About 70% of coffee is produced as garden coffee by small farmers, 25% is collected in forest and semi-forest coffee systems, and merely 5% is a plantation coffee (Tadesse *et al.*, 2008). There are different coffee production systems in Ethiopia mainly due to varying levels of coffee plant diversity, method of coffee tree regeneration and human interventions in the various coffee production systems. It is generally agreed that there are four coffee production systems in Ethiopia. These are modern plantations, gardens, semi-forest and forest coffee (MCTD, 1999; Workafes and Kassu, 2000; Taye and Tesfaye, 2001). Ethiopia exhibits eighteen major agro-ecological zones and seven of them are said to be suitable for coffee production. These zones have coffee of their own type in terms of quality and marked origin. The sub-humid zones lying between 1500 and 2000 m.a.s.l. are highly suitable for coffee production in Ethiopia and the bulk of Ethiopian Coffee comes from these areas (EARO, 1999). Despite the existence of enormous genetic diversity of coffee and its importance in the national

economy of Ethiopia, the per unit area national average yield of the crop hardly exceeds 0.7 ton per hectare clean Coffee (Central Statics Authority, 2012)

This low productivity of the crop stems from a sundry of reasons. *Inter alia*, use of twisted, forked and whippy seedlings reduces per hectare productivity significantly. Undesirable shoot and root growth for field planting requires enormous management of the plant during the nursery period, and accounts significantly for the low coffee yield in the country. This emanates from use of growing media not suitable for germination and subsequent seedling growth.

The different types of coffee cultivation are discussed, with a focus on practices that promote Best Agricultural Practices (BAP). These deal with the conservation of natural resources, protection of the environment, promotion of global carbon sequestration, avoidance of health problems and enhancing quality of life for farmers and society as a whole.

The four different periods in the life cycle of coffee plantations are described in the light of these BAP principles adopted for sustainable coffee growth. These include: traceability and product identification from site identification, variety selection, nursery practices to planting, and plantation management. Traditional and modern methods of coffee harvest and postharvest treatments, roasting and brewing are analyzed. Finally the high diversity in techniques for preparing hot and cool coffee drinks, the relationship between coffee consumption, and certain medical purpose.

### **1.1. Statements of the problem**

This study was undertaken to assess the current propagation and management practices of coffee (*Coffea arabica* L.) at the coffee nursery site of Lalo Kebele, Didu Wereda, Ilu-Aba-Bora Zone, Oromia Regional State. The study area is found in one of the Oromia regions known for its coffee production. In the past several decades, various research studies related to the propagation and management of coffee vegetation have been undertaken (Legesse Negash, 2010 and the references there in). But knowledge on the propagation and management practices has not been effectively disseminated among the rural communities of the study area. In light of this, this research work was conducted by identifying and providing the necessary information about the propagation and management practices of coffee on nursery site of Lalo Kebele, Didu Wereda, Ilu-Aba-Bora Zone, Oromia Regional State.

## **2. OBJECTIVES**

### **2.1. General objective**

The major objective of the present study was to assess the propagation and management practices of coffee (*Coffea arabica* L.) at Lalo kebele Coffee nursery site, Didu Wereda, Ilu-Aba-Bora Zone, Oromia Regional State.

### **2.2. Specific objectives**

The specific objectives of the present study were to:

- Assess the germination and growth of coffee (*Coffea arabica* L.) seedling on nursery site;
- Assess management practices of coffee seed germination and seedling development on the studied nursery site;
- Identify the factors that affect coffee germination rate on nursery beds;
- Assess factors that decrease coffee seed germination on the nursery.

### **3. LITERATURE REVIEW**

#### **3.1. Origin and distribution of coffee**

All commercial coffee species originate from Africa and belong to the genus *Coffea*. The high quality *Coffea arabica*.L species originate from the rain forest in the south western high lands of Ethiopia. One theory suggests that the Ethiopians took it to Yemen when they conquered the country in 500 AD. Another hypothesis says that Arab merchants brought it initially to Yemen and the Arabian peninsula, where it was cultivated and has contributed to the prosperity of the sea port of Mokka. This explains why Arabica coffee is associated with the name Mokka, although the prime center of origin and diversity is on the African continent.

In the past four decades, the global crises in Coffee production (prices) has had dramatic consequences both at micro and macroeconomic levels across the world. Coffee growing regions from Central America to Africa (an estimated 125 million people) have been affected by collapse of the world Coffee prices (Fritsch, 2002). Ethiopia is the biggest loser. In total, revenue from coffee dropped within a year (Tamworth and Wilson, 2002).

The global production capacity of the organic coffee for export is estimated at 12000 tons to 30000 tons for the years 2000/2001, respectively. Among the major agronomic practices include the use of shade trees like Albizia, Acacia, Cordia, Sesbania, use of coffee berry resistant selections (Vandergraff, 1978), mulching, later cropping with other staple food and cash crops, green maturing, hand weeding and composting with coffee husks/pulps. The use of coffee husks/pulps as compost to improve the soil nutrient status of coffee has been positively reported (Chane,1999). The quality assured organic products have increased the confidence of consumers, which also ensures market stability for organic coffee. The increasing growth of coffee sector in Ethiopia might contribute to a better economic situation of small scale farmers and the conservation of the genetic diversity of high quality Arabica coffee land races. Forest and semi forest (10%), garden coffee (85%) and plantation coffee (5%) are the major convectional production system.

A coffee nursery is a place where coffee seedlings are propagated, managed and grown to palatable size. To ensure a good planting program, good nursery stock is essential. Major causes of coffee seedling mortality on farm include wrong size or poor health of the seedlings at the time of planting. Poor seedlings are likely to have slower growth, to be less able to compete with weeds and drought, and to be liable to damage by insects and pests. Further, in a poor, fewer seedlings will be raised from a given quantity of seed and there will be considerable waste of money and time. After planting, the plants are immediately exposed to harsh environment, and are more susceptible to damage from drought, grazing, fire and insects. Coffee (*Coffea* spp.) is widespread throughout the tropics with more than 70 species, all of them originating from Africa. Economically important are the Arabica (*Coffea arabica* L. 64% of world production) and Robusta (*Coffea canephora* a, var. Robusta, 35%) types, cultivated worldwide on an estimated area of 10.3 million hectares. Brazil, Vietnam, Colombia, Indonesia and Ethiopia are the most important producers. The crop is produced and exported by more than 60 countries and ranks as one of the top cash crops in the developing world.

### **3.2. Global coffee production**

The main botanical origins of coffee are different species; *C. arabica* L. and *C. canephora* the former is almost exclusively cultivated in the Americas and the latter is widely grown in Africa and Madagascar. Production of both species is now expanded in Asia, particularly India and Indonesia. However, small tonnages of coffee from less common species which are cultivated particularly in Africa appear sporadically in European markets. These are mainly *C. excelsa* and *C. liberica* (Coste, 1992). Coffee (genus *Coffea*) is a wide spread throughout the tropics with more than 70 species. Coffee is among the most important agricultural commodities on the world market. It is cultivated worldwide on approximately 10.3 million hectares and represents the sole economic income for more than 60 nations and ranks as one of the top cash crops in developing countries. The coffee plant is a fast growing tropical bush tree with two types of shoot up right growing orthotropic main shoot (stem) and horizontally growing plagiotropic shoots (branches), coffee is a plantation crop well adapted to different eco-physiological conditions of the tropic.

The coffee plant takes approximately three years to develop from seed germination to first flower and fruit production. The fruit of the coffee tree is known as a cherry, and the beans which develop inside the cherry are used as the basic element for producing roast and ground coffee, soluble coffee powders, and coffee liquor. A well-managed coffee tree can be productive for up to 80 years or more, but the economic life span of a coffee plantation is rarely more than 30 years (Wrigley, 1988). Coffee plays vital role in the economic development of the producing countries, being one of the main foreign exchange agricultural commodity earners. Countries like Uganda, Rwanda and Burundi derive more than 80% of their total export earnings from coffee. Therefore, coffee is an extremely important generator of employment and an overriding importance to the social structure and development of the coffee growing countries (Njoroge, 1997).

From commercial point of view only *C.arabica* L. and *C. canephora* Pierre (*Robusta coffee*) are the important representatives from about 100 known species. Arabica coffee grown at medium and high altitudes accounts for roughly 70% of commercial world coffee, and for practically all of that produced in Latin America. This species also produced in some African coffee- growing countries at low altitudes. Some other species is also produced in some African countries such as Ethiopia and Kenya. Robusta coffee is mainly growing in other African coffee-growing countries at low altitudes. Some other species, such as *C. liberica*, *C. dewevei* and *C. racemosa* are only produced for local consumption (Betten court and Podrigues, 1985).

As coffee seed rapidly loses viability, the seeds are stored in cool moist conditions (such as the bottom of a refrigerator). There are 3000 to 4000 coffee seeds Kg. The recommended planting density is 3333 plants/ ha at a spacing of 2.0 m x1.5 m.

### **3.3. Coffee production systems in Ethiopia**

Ethiopia is the primary center of origin and genetic diversity of Coffee (*C.arabica* L.).(Syvain, 1958; FAO, 1968 cited from Tadesse *et al.*, 2008). *Coffea arabica* L. grows under diverse environment including altitude (550-2600m), annual rain fall (1000-2000mm) (Mesfin and Bayetta, 1987 cited from Tadesse *et al.*, 2008).

*C.arabica* L. is the only self-compatible species of the genus. The diploid species are self-incompatible of the gametophytic type. *C. arabica* L. is economically the most important

species of the genus, above some remarkable features which distinguish it from the other species of the genus. First it represents the only polyploidy species so far identified. Finally, the geographic distribution of *C. arabica* is restricted to the plateau of south western Ethiopia (FAO, 1968).

Ethiopia is the second largest coffee producer in Africa and the coffee crop accounts for about 5% of the GDP, 12% of the total agricultural output, 15% of the employment and more than 60% of the foreign exchange earnings whereas, in Tsegaye *et al.*, (2000) cited from Esayas *et al.* (2008) it accounts for 55% of the total export earnings, 10% of the government revenue and employs 25% of the domestic labor force.

There are four type of coffee production system in Ethiopia: forest coffee, semi forest coffee, garden coffee and plantation coffee. About 95% of the coffee productions from these system can be considered as organic, although not yet officially certified (Crown, 2002). These four production systems mainly due to varying level of plants associated with coffee, nature of coffee tree regeneration and human intervention in coffee production system.

### **3.3.1 Wild coffee**

Observation showed that semi- wild or spontaneous and naturalized plants of *C.arabica* are most abundant in ever green forest areas of south western Ethiopia with an average year precipitation of 60 to 80 m.(1500 to2000m)(FAO, 1968). Rain fall is spread over the year, with no rainless month, December and January are the driest months, but heavy rains of brief duration are not uncommon even during this period (FAO,1968).We know that monkeys and rodents relish the sweet pulp of ripe coffee fruit and the animals are certainly responsible for the spread of the coffee plant in Ethiopian forest (FAO,1968).This is found in south and south –western Ethiopia (Bale, West Wolega, Bench Maji, Keficho-Shekicho, Metu and Jimma).These are the centers of origin for *Coffea arabica* L. Forest coffee is self-sown and grows under shade of natural forest trees. Forest coffee offers a wide diversity for selection and breeding so as to have plant stock selected for disease resistance, high yields and top quality in terms of aroma as well as flavor. Forest coffee accounts for about 10% of the total coffee production in Ethiopia (Crown Coffee, 2002).

Forest with *C. arabica* populations occur in the south eastern and south western highlands of Ethiopia mainly at altitudes between 1000 and 2000 m.a.s.l. (Fayera, 2008). By far the greatest amount of coffee in Ethiopia is derived from spontaneous forest coffee (FAO, 1968). In general, wild coffee is defined as Coffee that grows and regenerates spontaneously in its natural habitat and is genetically different from known cultivars and land races. The gene pool of these wild Coffee population is of new Coffee varieties (Kassahun, 2006).

### **3.3.2 Semi-forest coffee**

This production system is also found in southern and south eastern parts of the country. Farmers thin and select forest trees so as to let in adequate sun light to the coffee trees and still provide adequate shade. Farmers slash the weeds once a year to facilitate harvesting of the coffee beans. This system accounts for about 35% of the coffee production (Crown, 2002). Coffee trees under this category are managed with little cultural practice, such as weeding and shade regulation. This type of plantation are known traditionally as semi-forest type and fill in the open spaces with local seedlings, which are found in Ilu- Ababora, Jimma, Kefa, Bench-Maji and west Wollega zones (Demil,1999; Paulos and Demil, 2000). It is estimated that semi forest coffee occupies nearly 136000 ha accounting for 34% of the total production of coffee land in the country (MCTD, 1999). However, Demil (1999) reported that currently semi forest coffee production system represents 24% of the total land covered by coffee 20% of coffee production in Ethiopia.

### **3.3.3 Garden coffee**

Garden coffee is found in the vicinity of farmers residences. It is found mainly in the southern and Eastern part of the country (Sidamo, Gedeo, South and North Omo, Hararghe, Wolega and Gurage Zone). It is planted at low densities ranging from 1000 to 1800 trees per hectare, mostly fertilized with organic material and inter- cropped. It accounts for about 50% of the total production. This production system is on the increase as it is currently being introduced

in south west Ethiopia (Keficho, Shekicho and Bench-maji) (Crown Coffee, 2002; Workafes and Kassu, 2000).

### **3.3.4. Plantation coffee**

Plantation coffee is grown on plantations owned by the state (currently put up for sale /privatization) and on some well managed small holders coffee farms. In this production system, recommended agronomic practices like improved seedlings, spacing, proper mulching, manuring, weeding shade regulation and pruning are practiced. Only state owned plantations are known to use chemical fertilizers and herbicides. Plantation coffee accounts for about 5% of the total production (Crown, 2002).

### **3.4. Botany**

The genus *Coffea* belongs to the family Rubiaceae, and is comprised of more than 70 species. This family forms part of the major group of dicotyledonous sympetals wherein the petals of the flower are fused. The flowers are fragrant, with an anise-like scent. Only three coffee species have commercial significance. One these species is *Coffea arabica* L. This species is divided into several varieties, some are dwarf (e.g., *caturra*, *catuai*) and some are tall (e.g., Bourbon, Typica). It is tetra-ploid that yields a clearly superior coffee taste combining low caffeine content with fine aroma.

*C. arabica* is generally susceptible to coffee leaf rust and unfortunately, the more widespread varieties like Bourbon are more susceptible to the leaf rust. Among the more than 200 existing Arabica varieties the most important tall varieties are:

Typica: Grown mainly in Brazil, where most of the existing varieties originate from;

Bourbon: Has 25% higher yield than Typica;

Mocha: Originated from Ethiopia; and,

Mundo Novo: This is a natural cross between Bourbon and is a variety from Sumatra.

### 3.5. Ecology and Growing Conditions

The natural habitat of all coffee species is the African tropical forest. Coffee is a well-adapted plantation crop to different eco-physiological conditions of tropical highlands. Both altitude and latitude influence the optimal or near-optimal edapho-climatic conditions for cultivation and must be considered along with temperature, rainfall and water supply, soil, slope and aspect when determining where to plant coffee. *Coffea arabica* L. requires an elevation between 1,200 and 2,200 m above sea level at the equator, but the optimal altitude can be less at higher latitudes. Arabica coffee is cultivated between 25°N and 24°S, ranging from more inclined subtropical areas to tropical regions with greater elevations as far as the temperature requirements (15 to 30° C) are fulfilled. Robusta coffee, consequent to its central African origin, is best adapted to less elevated hot and humid forests of tropical regions. The crop is preferably grown between 15°N and 12°S in flat areas and elevations between 300 and 800 m.

Growing coffee under shade trees is one of the fundamental principles in traditional organic coffee growing systems (Beer et al., 1998). Shade trees reduce excessive light, mulch the soil with their litter, create hostile conditions for pests and diseases, and harbor a variety of predatory animals (Beer *et al.*, 1998).

### 3.4 Pollination

*C. arabica* is self-compatible. Pollination occurs mainly by wind and to a lesser extent by insects. Positive effects were observed on initial fruit set in Arabica coffee in the presence of honey bee colonies, and the yield of mature berries increased significantly. These results are suggestive of a pollen grain population effect; as a large number of pollen grains germinate on the stigma and usually several pollen tubes grow within the style. On the other hand, *Robusta* plantations must always employ a variety of different clones so as to ensure diversity and subsequent improved fruit yield. Arabica coffee is a self-pollinated plant initiating heavy flowers that rapidly develop to fruits (Yuniato, 1986). During this period there is increasing carbohydrate absorption from both leaves and wood for flowers initiation and rapid fruits expansion. As a result, roots are damaged, leaves are abscised and branches start dying from the tip and go back to the petiole. But, shade trees assist in maintaining coffee yields in the long by reducing periodic over-bearing and subsequent die-back of coffee branches. In addition, shading delays the

maturation of coffee berries resulting in a better bean filling and larger bean size resulting in better coffee quality (Muschler, 2001).

Coffee plants in direct sunlight also showed higher incidence of premature death (Steiman, 2003). In addition, the genetic resources of *Coffea arabica* L. and its associated biodiversity are disappearing at an alarming rate and environmental degradation, including soil erosion and extreme river discharges, is becoming severe (Gole *et al.*, 2002; Osman, 2001). People in Ethiopia became unable to nourish their families and frequently became dependent on food aid. However, there is a growing worldwide movement to support and enhance organic coffee production systems under shade trees (Mark, 2005). This requires research into the effects of shade on growth, production and quality of coffee. We therefore carried out on-farm research to assess the effects of shade on physiology, growth, production and quality of coffee

### **3.6 Rain fall**

Coffee is a plantation crop adapted to tropical high lands for *C. arabica* and to low lands. It requires well distributed annual rain fall. It is generally considered that the best amount of annual rain fall for *Coffea arabica* is between 1400mm and 2400mm though a range between 800 and 4200mm remain acceptable. It is important that the rain is well distributed over the season or are continuous for about 7-8 months. The nature of rainy season in terms of length and intensity of the rain is a key ecological factor determining the interval between flowering and seed maturation. Likewise, when the annual rain fall exceeds 3000mm, leaf disease from fungal infection develop more easily.

### **3.7. Temperature**

The optimum mean annual temperature ranges from 18 to 22° C. Temperatures above 23°C accelerate the development and ripening of fruits and can provoke loss of physical and beverage quality. A dry season not exceeding five months and an annual temperature between 15-30°C. It tolerates shade share quite similar growth requirements with forest trees. High temperatures above 30°C during blossoming associated with a prolonged dry season may cause abortion of flowers. Ethiopia is the home and cradle of biodiversity of Arabica coffee seeds. More genetically diverse strains of *C. arabica* exist in Ethiopia than anywhere else in the world,

which has led botanists and scientists to agree that Ethiopia is the center for origin, diversification and dissemination of the coffee plant (Ferne, 1966; Bayetta, 2001). *C. arabica* is adapted to cooler temperatures of the tropical high lands above 1000m altitude along equator, somewhat lower at greater latitude. It needs more than seven months of rainy season.

(5%) are the major conventional production systems. There are variations in genotypes, eco-physiology and the biosphere of coffee under different production systems.

Plantation coffee can be regarded as an intensively technician system. The small scale farmers are the major producers, whereby about 140 local coffee land races known to grow as garden with owing on average 0.5 ha of coffee farming systems (Demel et al., 1998). Organic coffee production is based on the use of renewable resources and clearly aims to sustain management of natural resources (soil, biodiversity, water, nutrients, energy etc.) (IFOAM, 1998; Demeter, 1986). It has long been competitive to meet consumers demand, but it has failed to fully develop from conventional coffee production systems, that advocate undesired agrochemical inputs as practiced in some countries like Brazil and Vietnam. For the organic coffee sector, quality control through inspection and certification is compulsory (Kotschi & Adelhelm, 1984). In Ethiopia, onset of certified organic farming is raised from a market deficit of the conventional coffee farming, but there is little information documented about such important segment of coffee production and the country's economy. In Ethiopia, key issues on certified organic coffee production systems and its potential impacts on affecting the poverty line of small scale coffee producers have also been discussed.

### **3.8 .Developmental problems of seed**

Seeds have internal and external problems developmental (Legesse Negash. 2010). Internal problems are; incompatible fertilization and adverse weather failure of the endosperm. The external problems are insect, fungal, bacterial, attacks and water, stress, frost.

#### **3.8.1 Accumulation of food reserves**

Accumulation of food reserves is measured by changes in dry weight of the seed at early stage, increase in weight is due to increase in size. The high quality seed including plump, heavy for its

size, better germination and growth of seedlings. Improper completion of the process is thin, shrunken and light seed, poor germination, and weak seedlings.

### **3.8.2 Seed quality**

Seedling production is one of the key steps in scaling up or domestication of any species. Each step has to be properly planned and implemented. Arabica coffee should be grown from fresh seed of the recommended varieties. Seed loses viability within three months and should not be used after that period unless properly stored at low temperature and high humidity. Select ripe healthy fruit from the required variety and from plants that have good productivity, low or no incidence of rust and good cup quality. Pulp cherries, ferment for one night, wash clean, and dry the parchment slowly in shade on raised platforms or trays with good air movement for two to three days. The moisture content of the seeds should not fall below 10%, otherwise the viability will be seriously affected. The seeds should be sorted to eliminate those that are small or abnormally shaped or are infested with pests.

The way seedlings are handled and managed in a nursery contributes to their survival rate after planting and their subsequent growth performance. Improving seedling quality correlates positively to their survival, growth and productivity. Seedling quality is governed by the genetic make-up of the parent trees and the physical growth of the seedlings. Several types of nurseries exist: individual or private, community or group, or research, commercial and training nursery. Nursery practices must be consistent and the various techniques closely integrated. If one element in the chain is lacking there will be a negative impact on seedling quality. Good quality seedlings cannot be produced without care and tending.

The simple method of determining moisture content of a seed is filling one quarter of a jar with salt and then add the seed sample, close lid tightly and shaking the jar well, allow the seed to settle for about 10 minutes if damp salt sticks on the sides of the jar, then the seeds are too moist for storage, the moisture is above 13-15%, on the other hand if the jar is steel dry and no salt sticks on the side, the seeds have less than 13% moisture and can be safely stored. As coffee seed rapidly loses viability, store the seed in cool moist conditions (such as the bottom of a refrigerator).

There are 3000 to 4000 coffee seeds per Kg. The recommended planting density is 3333 plants/ha at a spacing of 2 x 1.5 m. To calculate the area for a nursery, the area to be planted; plant spacing; the number of plants per hectare; how many seeds per kg; the germination percentage of the seed must be known. Coffee seed is very slow to germinate in December and January (the coldest months) and clear plastic/polyethylene should be used to accelerate germination and plant growth. Coffee seed that is used for planting is actually parchment with the parchment hull still in place. It is not green bean from which parchment hull has been removed.

Figure 1. Illustrates the stages of coffee seedling development. A shade house with timber poles and roof about 1.8 m high is constructed. The top of the shade house needs to be covered with either assorted plant material such as bamboo slats or branches, or commercial plastic shade cloth to give about 50% shade.



**Figure 1:** A typical nursery bed in the Lalo nursery site of coffee. Such nurseries use bamboo structures covered with transparent polyethylene plastic sheets so as to improve internal temperature as well as to conserve moisture,

To achieve faster seedling growth during cold weather, plant seed in a clear plastic/polyethylene tunnel beneath the shade (Figure1). The tunnel is the width of sowing beds and about 75 cm high. Use bamboo hoops for the framework to support the polyethylene sheet cover. The seedbed must be fully and tightly enclosed or temperature inside the tunnel will not increase.

### 3.8.3 Planting coffee seeds on a nursery seedbed

Before planting any coffee seeds, the prepared nursery bed should be properly watered. Using a pointed stick, furrows of 12 mm deep are made across the bed and 100 mm apart. The seeds are then planted flat side down, with seeds 25 mm apart within the row. Following the planting process, seeds are covered with a thin layer of soil mixture. It is very important that the seeds should be only about 12 mm deep after planting. The seedbeds are then covered with straw mulch or palm tree leaves (Figure 2) to give extra heat and to retain soil moisture. The system is then gently watered using watering cans fitted with fine sprays, making sure that the seeds are not exposed when watering. As germination time is highly dependent on soil temperature, it may take from 30 to 50 days before shoots appear. Use of plastic/polythene tunnels to retain heat will speed up germination.



**Figure 2** Seed beds covered with pulm tree leaves as mulching material. The mulching stays until the seed germinates.

### **3.8.4. Vegetative propagation**

According to Behailu et al. (2006) research results showed that combination of single node with soft wood cuttings with one pair of leaves taken from orthotropic shoot and rooting media composed of top soil, sand, manure in 2:2:1 ratio were recommended for propagation of hybrid coffee.

### **3.8.5. Germination**

Germination is induced by placing the seeds in a sufficiently moist environment to absorb water. Germination has three phases, these are phase one: activation, inhibition (physical process) DNA, RNA and some enzymes become active, ATP synthesis and reactivation starts. Phase two, synthesis of new enzymes, structural materials, regulatory compounds. Activation of specific enzymes: digestion and translocation of the cotyledons, endosperm, and perisperm or mega gametophyte: fats and oils, sugars, starch, storage protein, sources of nitrogen. Phase three, Cell elongation and radicle emergence, cell division in the meristems, etc. (Legesse Negash, 2003). Seeds are first germinated in the germination bed before they are planted in polybags. A well-drained area with moderate shade is an ideal site for a germination bed. The germination bed should be established on a flat or level area near a water source within the nursery site. The best kind of germination medium is sand or light soil because germination of seeds will be faster due to aeration and seedlings can be easily pulled out during uprooting with less damage to the roots.

With pure garden soil, the germination of seeds tends to be slower because the soil is too heavy and less aerated. Large seeds of 2cm to 3cm deep in the soil is constructed. Small seeds about 0.5cm to 1cm deep or broadcast and cover them with a small amount of fine soil. Since coffee seed is the dicot it has epigeous germination, the hypocotyl elongates and raises the cotyledons above the ground. Depending on temperature and moisture, the cotyledon leaves develop after four to six weeks for germinating process. Germination is first seen in the appearance of the radicle (young root) three to four weeks after sowing. The hypocotyl (the part between soil and cotyledons) appears 20 to 25 days later and carries the seed which is still covered in its parchment, out of the ground. Shortly afterwards, when this light covering is detached, the two cotyledon leaves open.



**Figure 3** Cotyledons shown in photograph (left); the new primary leaves appear above the cotyledons (right)

These cotyledon leaves look very different from ordinary leaves - they are oval-shaped with undulating edges and 20 to 50 mm in diameter. At the same time, the terminal bud appears and produces two primary leaves - they are opposite and in pairs. The cotyledons will now die having completed their nutritional role. The root system develops actively in the first weeks of germination; the taproot penetrates deeply into the soil and forms a great number of roots and rootlets.

The first lateral branch (plagiotropic branch) appears four to six weeks after emergence; the plant will then have 5 to 11 pairs of leaves. These branches are opposite in pairs at alternate perpendicular points along the main axis. The primary branches have buds at each node that will develop either into secondary (plagiotropic/horizontal) branches or, under certain conditions, into flowers. Do not let the soil dry out, when seedlings are developing. However, take care and do not over-water as seeds can suffer from disease problems such as damping-off. At a height of 200 to 300 mm, the young plants are ready to be transplanted.

Strong black plastic/polyethylene bags with drainage holes should be used. Bag size should be at least 100 mm x 250 mm when filled with soil.

A mixture of fertile topsoil and manure or compost can be used. All soil, manure and compost should be sieved.

Coffee seeds were transplanted at the matchstick or cotyledon (butterfly) stage before the taproot is well developed. Use the best seedlings with a straight tap root. Discard seedlings with either a bent taproot (J root) or those with few root hairs. Avoid using larger seedlings (with more leaves than the matchstick stage) as these will be too slow in growing.

### **Plant seedlings in bags**

- Planting should be done in cool, cloudy weather.
- Thoroughly water the soil-filled bags to settle the soil before planting.
- Lift the seedlings using a stick or trowel to prevent breaking the roots.
- Make a hole about 50 mm deep using either a small stick or a finger and insert seedling in the hole and then lift the seedling slightly to open out the roots.
- When planting, make sure that the taproot is not bent.
- Plant seedlings to the same depth as they were previously planted in the seedbed.
- Water seedlings well.
- Make sure the bags are well supported all around and in between so they do not fall over.
- Use a bamboo or wooden frame to contain the bags and keep them packed together.
- Make sure the plants are supported and are not crowded and remove weeds regularly.
- If soil becomes hard, soften it by using a trowel to break up big, hard clumps of soil into smaller pieces.
- Water as required to keep the soil damp. Don't over-water as this can cause damping-off - a disease caused by a fungus that will kill the plants.
- At three months, apply urea (46:0:0) at 60 g/10 L of water.
- This is enough for 100 seedlings.
- Apply every 15 days.
- If leaves become dark green, stop the procedure.

- If you do not use a chemical fertilizer, apply a small amount of finely crushed dry manure around the plants.
- Check seedlings every day to make sure they remain free from pests and disease.
- Remove bags with diseased, dead or damaged plants.
- Continue to keep plants in shade.
- Two months before field planting, gradually remove the shade to sun-harden the plants.
- As the plants grow, separate the poly-bags so there is sufficient space for the developing plant to spread. If bags are not separated, the plants grow tall and weak.

### **Nursery diseases and pests**

The two common diseases occurring in the nursery are: Damping-off that appears as areas of dying plants. Damping-off is caused by a soil-borne fungi often found in old, diseased potting mixture, over-watering, too much shade or not enough space between plants. Damping-off can be avoided by proper preparation in the nursery. It is also important that new soil is always used in the nursery beds. If the disease is found, immediate drenching with either Benlate (Benomyl) or Captan can be carried out. Cercospora (brown eye spot) is a fungus, which develops when plants are under stress caused by too much shade, too much sun, nitrogen deficiency, over-watering or over-crowding. This can be avoided by following good management practices. Immediate control measures involve using copper sprays. Green coffee scale can also be a problem in the nursery. Scales severely affect plant health as they suck the sap from the leaves. Keep the area free from ants and spray with spraying oils or Carbaryl.

### **3.9. Insect pests associated to world coffee**

Coffee is an ever green perennial crop grown in climates without sever extremes; consequently pests can survive from year to year, but fortunately the same applies to the parasitoids and predators of these pests. Most of this great variety of pests are native to where they occur, and are usually accompanied by effective natural enemies (Wigley, 1988).

The major pests of coffee include boring beetles, scale insects, mealy bugs, other Hemiptera including antestia, Lepidoptera's miners and defoliators. Every part of the coffee tree-roots, stems, leaves, flowers, berries and the seed in storage may all be attacked by insects in some coffee growing area (Wrigley, 1988). Pests of coffee include insects, mites, nematodes, mollusks, birds and mammals. Insect pests are the most serious and numerous, with over 900 species having been recorded (Mitchell, 1985). Where coffee is grown in its natural forest environment in Ethiopia, many pests exist in equilibrium with their parasitoids and predators, so that numbers seldom reach epidemic proportion. In other countries, serious problems have arisen where coffee and its pests have been introduced into a new area where the parasitoids and predators have been destroyed by indiscriminate spraying of insecticide (Mitchell, 1985).

### **Pests of the root**

Several species of cricket including mole crickets (Orthoptera) are harmful to young coffee plants in nurseries or plantations. These include the African mole cricket (*Gryllotalpa africana* Beauv) and *Brachytripes membranaceus* Dury (Coste, 1992). Several species of nematode attack the root system of the coffee tree. The microscopic larvae penetrate the root causing gall to form and the tissues to rot. The roots are eventually destroyed and as a reaction the coffee tree produces mass of rootless in the collar region. The nutrition of the shrub is at first retarded and finally stops (Coste, 1992).

### **Pests of coffee leaves**

The caterpillars of several Lepidoptera attack the leaves of the coffee tree. The most harmful seems to be the *Epicampoptera* Spp or rat tail caterpillars and leaf miners such as *Leucoptera coffiana* W. Several species of caterpillar of the genus *Epicampoptera* are found on coffee trees in tropical Africa

## 4. MATERIALS AND METHODS

### 4.1. DESCRIPTION OF THE STUDY AREA

The study was conducted at Lalo kebele coffee nursery site, Didu Wereda Ilu-Aba-Bor Zone, Oromia Regional State south west of Ethiopia, 657 km south-west of Addis Ababa. The total population of the Wereda is 43, 829. There are 16 Kebeles in the Wereda and there are two big coffee nursery sites which are managed by the government. There are also farmers in the Wereda who have private nursery sites. Lalo Kebele coffee nursery is located at 1,754 m.a.s.l, and has 148 nursery beds. The annual rain fall ranges from 1100 up to 1700 mm per year. The temperature range is 16-22° C. Didu Wereda is one of the most known coffee producers in Ilu-Aba-Bor Zone. The area is highly mountainous, and it is mostly covered with indigenous forest trees. At Lalo Kebele coffee nursery site, it is not only coffee seedling that has been produced but also different plants used for different purpose like coffee shade tree, trees used for commercial purpose and others are animals' fodder that was prepared in the nursery site. Some of the plants are *Cordia africana* Lam., *Podocarpus falcutus*, and *Ficus vasta forssk*, which are very common in addition to *C. arabica* L. seedling. Figure 4. Below shows *Cordia africana* at the study area nursery site *Cordia africana* Lam. (synonym= *Cordia abyssinica*) this is a family whose members are often typified by hairy trees, shrubs and herbs. The generic name *Cordia* was given in honor of 16<sup>th</sup> century German botanist, Valeries Cordus while the specific name; "Africana" (formerly abyssinica refers to the tree's natural home land (Legesse Negash, 2010).



**Figure: 4** A group of young *Cordia africana* seedlings grown at Lalo Kebele coffee nursery site. These seedlings are used for planting in the field where they serve as shade trees for future coffee plantation in the area.

But nowadays exotic species of trees like *Eucalypt Spp* & *Gravilia are* mostly cultivated for commercial purposes. Peoples of the Wereda are mostly farmers and the major product is coffee. Farmers cultivate coffee both in traditional and in modern ways. In addition to coffee, they also produce honey and spices such as ginger (*Zingiber officinale Rose*) and cardamom in the coffee forest. Crops like maize, sorghum and barley are also produced. *Ensete ventricosum* plants are also among the crops produced. There is also quite a large number of livestock in the Wereda.

#### **4. 2. Data sources and methods of collection**

Data were collected through semi-structured interviews, discussions with the farmers and/or development agents, and field observations. Based on the information obtained from secondary data and formal surveys, a semi-structured interviews was developed for the nursery managers and development agents. In addition to this, both primary and secondary data were used to achieve the objectives of the study. The survey was supplemented, and through literature resources on essential information of coffee nursery management practices.

Coffee seedling can be grown on raised beds(15 cm height) or poly ethane tube(10 - 12cm) diameter and (22 -25cm) height filled with forest soil collected from the top 5-10cm depth however in the absence of forest soil (FS) it was recommended to use blends of top soil(TS) , compost and sand soil in a ratio of 1:4:4 had promoted both shoot and root growth of coffee seedlings.

Direct observation of the nursery sites were also made. On top of these, reports concerning cultivation and nursery management of coffee plants were also reviewed. Further, the present researcher monitored and supervised the data collection process closely and had checked the quality and appropriateness of the data.

#### **4.3. Sample size and sampling techniques**

The present study was conducted on Lalo Kebele, Oromia Regional State. There are two coffee nursery sites in the Wereda, Lalo coffee nursery is one of the two nurseries. There are 148 seedling beds which are managed by eight nursery managers. On the study area there are eight nursery managers, 2 of them (25%) are males and six of them(75%) are females. and they have different educational back ground these are 2 (25%) are grade 4-6, four of them(50%) are from grade 7-8 and Two (25%) are grade 10 complete.

**Table 1:** Variables such as sex, educational background, marital status, no. of respondents and percentage of the interviewed nursery managers

<b>Variables</b>	<b>No. of respondents</b>	<b>Percent (%)</b>
<b>Sex</b>		
Male	2	25%
Female	6	75%
<b>Educational back ground</b>		
4-6	2	25%
7-8	4	50%
9-10	2	25%
<b>Marital status</b>		
Single	3	37.5%
Married	5	63.5%

#### **4.4. Method of data analysis**

The collected data from the structured interviews from eight respondents, discussions with the nursery managers, development agent, and field observations and report reviews were summarized and analyzed using tables and graphs, accompanied with computed percentages. Both qualitative and quantitative approaches were employed for interpreting the data.

The seed bed was prepared by plowing the land and the length of the bed was 10 meters and its width was 1 meter and 20 centimeters and stayed for 9 days. The length of the bed is relatively less important, though 5 m to 10 m may be convenient for drainage purposes.

## 5. RESULTS

### 5.1. Composition and sizes of the studied nurseries

The study area oriented from east to west to provide better shade against the midday sun. Paths are 50cm to 60cm wide to provide adequate working space.



**Figure 5** Typical seedbed preparation in the nursery of Lalo Kebele, Ilu-Aba-Bor Zone, Oromia Regional State.

### 5.2. Media amendment

It has been reported that application of 0 g lime and 750mg P and 2.31g lime and 250 mg P/seed (2.5 kg sieved top soil) produced seedlings with the higher dry matter yield. This was primarily associated to the rise in soil pH and precipitation of the exchangeable aluminum that fixes P and increases in solubility and availability of soil P to the seedlings. Maintenance of seedlings in the nursery is very crucial because of the natural fertility of the soil is continuously getting depleted with repeated cropping. With this, replenishing the soil supply of nutrients through fertilizer application is needed. Sound fertilization of Seedlings provides the following advantages: Healthy plants, uniform growth of plants, fast growth of seedlings, and high rate of survival after field planting.

### 5.3 Pre-germination practices

Reports from different data obtained showed that pre germinated and planted seeds had resulted in large percentage of seedlings with deformed roots with multiple and crooked tap roots (MTR and CTR) respectively than sowing in permanent bed the practices can also delay the growth of seedlings and thus large percentage of cotyledon. First pair of true leaves was initiated much earlier from direct sowing than pre germination practice.

### 5.4. Seed sowing

For maximum germination, coffee sown at a depth of 1cm with grooved side of the seed down and the embryo tip up. These enhances maximum germination of the seed. Table 2 shows the depth of sowing, seed position and position of embryo.

**Table 2:** The Seed sowing depth, Seed position and embryo position

Sowing depth by cm	Side of Seed position and percent of germination		Side of Embryo tip and percent of germination		Mean
	Up	Down	Up	Down	
0	80.1	80.9	76.2	85.7	80.7
1	80.9	85.5	90.7	69	81.6
2	64.3	69.1	69.0	69	67.9



**Figure :6** A section of coffee seedbed at Lalo Kebele coffee nursery site. That the grooved sides of the coffee seeds are laid down in the furrows is noticeable.

### **5.5. The number of seed on the seed bed**

On the study area, 4 kg seed or approximately 16000 seeds over a single bed. Seeds are sown on rows. Out of this, 13500 seeds germinated because of the seed quality based on the data obtained from experts. The seed stays on the bed for 45 days and then they transplant it on to another bed.

As different literature shows there must be 25mm gap between the seeds but at Lalo kebele coffee nursery site there is 20 mm gap between two consecutive seeds.



**Figure :7** When the nursery managers planting coffee seed on the prepared seed bed at Lalo Kebele coffee nursery site Didu Wereda, Ilu-Aba-Bora Zone, Oromia Regional State.

### **5.6. Mulching on the seed bed**

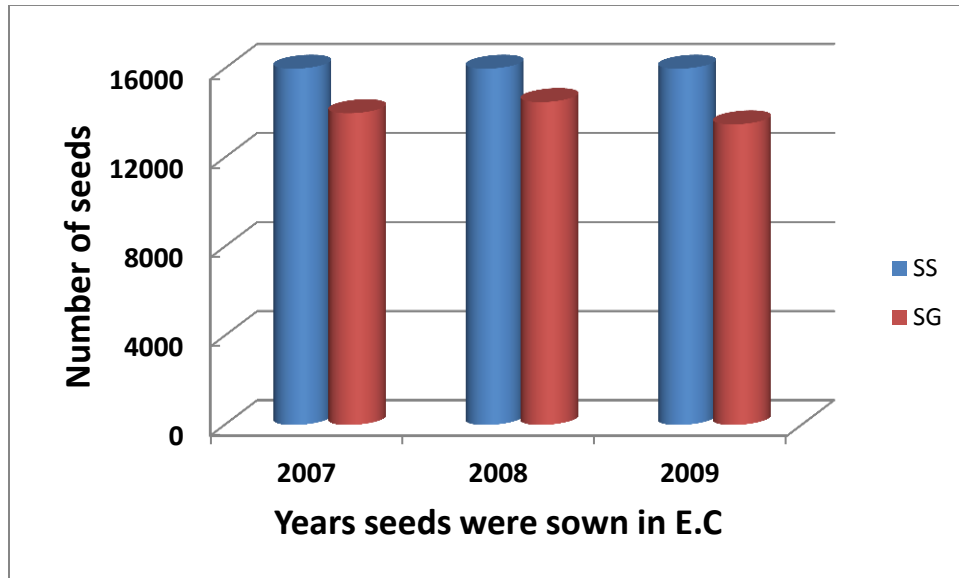
At Lalo Kebele coffee nursery after sowing coffee seed the seed beds covered with 3-5 cm thick mulch of palm leaves and grass immediately after sowing had resulted higher germination percentage than did mulch + shade and shade alone.



**Figure :8** Seed beds covered by mulch on the study area; they put palm tree leaves as mulching material on the seed bed, as shown on the above figure.

### **5.7. Seed germination**

At Lalo coffee nursery site in the year 2009 they sown four kilogram (4kg) coffee seed approximately 16000seeds on a single seed bed out of this only 13500 seeds germinate about 84.37% and 2500(13.63%) cannot germinate this is because of low seed quality and due to poor management practices on the seed bed. The following graph shows the number of seed sown each year and the amount of seed germinating



**Figure: 9** Number of seeds sown on the seed bed and number of seed germinated from the year 2007-2009 at Lalo Kebele coffee nursery site Didu Wereda Ilu-Aba-Bora Zone Oromia Regional State.

Seed germination can be affected by different factors. These factors are related to the quality of seed, management practices and insect pests.

**Table 3:** The factors that affect seed germination and number and percentage of the nursery managers.

<b>Factors</b>	<b>Number of respondents</b>	<b>Percent (%)</b>
1. Seed quality	8	100
2. Poor management of the nursery	2	25
3. Insect pests	6	75

As the data obtained from respondents on table 3 shows seed quality and insect pests are major factors which affects germination of the coffee seed. After germination of the seeds there are insect pests which attacks the young seedling. As a result the number of seed germinating and seedling transferred are not the same or it reduces the number. Root-feeding grubs (*Leucopholis irrorata* Chev.) Grubs live entirely in the soil. They are voracious feeders and may consume the roots of tree and cover crops. Affected young trees have yellow leaves and dying shoots, and in severe cases the trees may die. Sucking insects such as scales, mealy bugs and aphids the adult female of scales and mealy bugs the nymphs and adults of aphids are destructive to plants. The insects excrete honeydew, which attracts ants and sooty moulds.

## **5.8. Transplanting methods**

Method of transplanting had substantial influences on percent's of survival rate of coffee seedlings. Polyethylene pots raised on seed bed (bare root transplanted) seedling showed 92.92% field survival compared to those raised on seed bed (bare root transplanted) seedling with mean value of 62.44% Taye *et al.* (1999). At Lalo Kebele coffee nursery site, the length of the bed used for transplanting is 10 meter and the width is one meter (1m), the spacing between seedlings

is ten centimeter (10 cm) and totally a single bed contains one thousand seedling (1000 seedling) when transferred.



**Figure: 10** Coffee seedlings transplanted to other bed from the place of germination. It stays for ten months until planted to the field by farmers.



**Figure: 11** A young coffee seedling on the nursery site with moderate overhead shade at Lalo Kebele, Didu Wereda, Ilu-Aba-Bora Zone, Oromia Regional State.

**Table 4:** Seedling with overhead shade, Plant height, number of leaf and total dry matter of seedling

Shade level%	Plant height(cm)	Leaf number	TDM(g)of seedling
0	24.7	14.4	5.3
25	28.5	15.3	6.1
50	30.0	17.0	6.6
70	30.2	15.1	6.1

## 5.9. Distribution of seedling for the farmers

The seedlings prepared on the Lalo kebele coffee nursery site was distributed to farmers Wereda, the type of seedling given is bare rooted seedling which the farmers in the locality prepare land for the seedling by digging hole.



**Figure: 12** One of the coffee nursery managers at Lalo coffee nursery site Ilu-Aba-Bora Zone When the coffee seedlings are uprooted for distribution to the farmers.



**Figure: 13** A one year old coffee seedlings grown at Lalo Kebele coffee nursery site Ilu-Aba-Bora Zone Didu wereda ready to be distributed to the farmers.

## 6. DISCUSSION

At the study site forest soil, top soil and compost were applied. However, if this media suspected to be low in plant nutrients, addition of 2 g DAP/seedling after the seedling attain two pairs of true leaves would improve seedling growth (Taye *et al.*, 1999). In proper depth of seed sowing and in adequate or excessive shading and watering during the nursery period (Institute of Agricultural Research, 1996; Anteneh *et al.*, 2008) recognizing the problem several nursery management researches have been conducted aiming at promoting quality coffee seedling production for field planting in the Wereda. This research was conducted at Lalo kebele coffee nursery site they prepare seed bed by first ploughing by oxen then prepare the bed at a length of ten meters and the width is one meter and twenty centimeter (1.20 m).

At the study area coffee was cultivated in this traditional way following the principles that Lammerts van Bueren and Struik (2004) Soils were amended by applying compost, farm yard manure and green manure, while no chemical fertilizers, herbicides or fungicides were used. However, as demands for coffee production expanded, many coffee growers abandoned their traditional coffee growing system and started to grow coffee without shade trees. This insecticides, herbicides and fungicides resulting in blended and inferior coffee quality. The use of coffee husks/ pulps as compost to improve the soil nutrient status of coffee has been positively reported (Chane, 1999), but still there are ongoing studies at the Jimma Agricultural Research Centre.

In Ethiopia, Arabica coffee is predominantly grown on a highly weathered and leached Nitosols which is deficient in nitrogen and phosphorus. Coffee is a heavy nutrient feeder. It has been documented that more nutrients are removed annually by the harvested products in comparison to other tree crops like Cocoa and Tea (Coste, 1992). Than *Sesbania sesban* applied plot in terms of improving the yield performance of coffee plant. The use of decomposed coffee husk compost at rate of 10 ton ha<sup>-1</sup>. At the study site the size of the bed is 1.2 m this agrees with Taye (1998)

Ideal size of the nursery bed is 1m to 1.2m wide. It should not be wider than 1.2m because of the difficulty of reaching the center when weeding, watering or manuring. Seedbeds which are narrower than 1m are a waste of land.

Coffee nursery has different stage of management practices. These are pre sowing coffee seed management and pre germination practices. In pre sowing, different factors affects the germination of coffee seed. These are stage of harvest of the cherries, the condition of processing and drying in line with these red ripe cherries are the best stage of coffee seed maturity. In pre germination practices pre germinated and planted seeds had resulted in large percentage of seedling with deformed roots with multiple and crooked tap roots (MTR and CTR respectively).

For maximum germination coffee seed sown at a depth of one centimeter (1cm) with grooved side of the seed down and embryo tip up on the study area (Lalo kebele coffee nursery site) the coffee sown at a depth of 1 up to 2 cm and embryo tip up table (2) shows that the coffee seed Sown at a depth of 1cm shows maximum germination; However, seed germination rapidly decline with sowing depth greater than 1 cm (Yacob 1986).

On the study area they sow 4kg (approximately 16000) seeds per bed, then they put 3-5 cm mulching over the seed bed for up to 45 days until the seeds germinate. Germination percentage of coffee seeds affected by mulch, shade and their combination Tesfaye (2005). As the data collected from experts and report review shows higher germination response to mulch alone could ascribed to regulation of the diurnal temperature in the nursery beds because it insulate against fluctuation of soil temperature, however, when the seedling start to germinate, the mulch removed and replaced by moderate overhead shade then the seedling start to emerge.

The mulching used are palm tree leaves and they water the seed bed twice a day. After germination of the seed, they transplant on to other bed by providing moderate overhead shade they reduce the amount of water provided. To harden the seedlings, it is recommended that the watering frequency and the overhead shade level should gradually be reduced one month ahead of transplanting to the field at a stage of six to eight pairs of true leaves (Teskaye *et al.*, 2005).Overhead shade Provision of moderate level of overhear shade (25 - 75%, but 50% is the best option) to coffee seedlings upon emergence and removal of mulch resulted in vigorous seedling growth with the highest total dry matter yield and relative water content and improve moisture content of the rooting medium.

To harden the seedlings, it is recommended that the watering frequency and the overhead shade level should gradually be reduced one month ahead of transplanting to the field at a stage of six to eight pairs of true leaves (Tesfaye *et al.*, 2005).

The number of seed germinating on the seed bed in 2009 are only 13500 out of the 16000. This is because of different factors the major factor is related to seed quality as the data obtained from the interview showed that at Lalo kebele coffee nursery site they buy coffee seeds from different farmers and these seeds have different managements during harvesting and drying so this makes difference in seed quality. The one which has high germination rate is the red, ripe and well dried seeds

Identification of seed sourcing, collection and selection is crucial in achieving healthy and uniform sized seedlings. For fruit root stocks, optimum yield cannot be attained even with favorable environment if the root socks used are not well adapted to the environmental conditions.

The performance of seedlings may be predicted based on the performance of parent materials. But at Lalo Kebele Coffee nursery site, the seeds used for sowing sourced from different farmers in different Wereda of Ilu- Aba-Bora Zone. After collection, seeds should be processed carefully otherwise they may become damaged and lose viability (Taye *et al.*, 1999). Nursery plants need to be protected from extremes of environmental conditions until they are strong enough to withstand them. Supply of viable seeds is essential for successful seed propagation. A viable seed is one which has the capacity for germination under suitable environmental conditions. Viability is measured by the germination percentage, generally the conditions which affects germination of coffee seed are: viability (the embryo must be alive), physical and chemical factors and environmental factors such as moisture, temperature, oxygen and light (Legesse Negash., 2010). Seed viability can be tested using different techniques (Taye *et al.*, 1999). Floating method: fill the jar about three-quarter way with water and pour seeds into the water filled jar then seed separation takes place some seeds will float others will sink. Sinkers are viable while floaters are not. Methods of transplanting had substantial influence on percent of survival rate of coffee seedlings.

After germination of the seeds, there are insect pests which attack the young seedling as a result the number of seed germinating and seedling transferred are not the same or it reduces the number. Root-feeding grubs (*Leucopholis irrorata* Chev.) Grubs live entirely in the soil. They are voracious feeders and may consume the roots of tree and cover crops (Esayas, 2008). Affected young trees have yellow leaves and dying shoots, and in severe cases the trees may die. Sucking insects such as scales, mealy bugs and aphids the adult female of scales and mealy bugs the nymphs and adults of aphids are destructive to plants. The insects excrete honeydew, which attracts ants.

## **7. Conclusion and recommendation**

### **7.1 Conclusion**

The survey found that the combination of forest soil, top soil and compost promoted the growth of seedling. The natural fertility of the soil is continuously getting depleted with repeated cropping, with this replenition the soil supply of nutrients through fertilizer application is needed. Application of commercial fertilizer provides this are healthy coffee seedling, uniform growth, fast growth of seedling and high rate of survival after field planting.

Sowing coffee seed at a depth of 1cm with grooved side placed down and embryo tip up improved seed germination. Coffee seeds to be used as a seed material should be prepared from cherries picked at red and ripe stage. Then, after pulping the cherries and removing the floaters, seeds with their parchment intact should be dried under shade and ventilated conditions as these reduces the drying temperature, which otherwise can injure its germinability.

Planting pre-germinated seeds should not be practiced by farmers as it results in large percentage of seedlings with malformed root system and eventual early (forth to fifth bearing) tree death in the field. Hence, coffee seeds should be seeded directly in seedbeds or polythene tube. However, if seed viability is doubtful, two seeds per hole should be seeded and then thinned to one plant. Furthermore, coffee seeds should be sown after removing the hard seed cover (parchment) and soaking the seeds in cold water for 24 hours as the practices enhance germination and seedling growth. These can also shorten the nursery period and reduce the associated costs.

After seed sowing covering the seed bed with 3-5cm mulch enhances higher germination of the seed and watered at two days interval until the seedling emergence. The mulch should be removed when the seedlings start to emerge. After emergence, the nursery beds should be provided with moderate (50%) overhead shade and watering frequency reduced to 4 and 8 days interval within a week until the seedlings attain 2 to 4 pairs of true leaves, respectively.

At Lalo coffee nursery site coffee seed germination rate in 2009 was 84.4%. This decrease in rate of germination is due to different factors these are because of poor seed quality which is obtained from different farmers from different Woredas in Ilu-Aba-Bora zone and have different management practices during harvesting and drying. Coffee for the purpose of seedling should be harvested ripe and well dried for maximum germination. The moisture content of the seed is also one of the factor which affects the rate of germination of the seedling.

The management practices of the seedling on the nursery bed also affects the survival of the seedling on the nursery bed this are the watering frequency, weeding and provision of mulch on the sown seed and moderate overhead shade over the seedling.

After germination of the seed transplanting onto another bed and water until hypocotyl emergence at two days interval had higher germination percentage and providing moderate overhead shade and irrigate twice a week until the seedling produces 2 up to 4 leaves.

Keeping the nursery hygiene and controlling seedling disease is also a major activities at Lalo coffee nursery site .Diseased seedling shows slow growth and coffee seedling may die under severe infections. Most of microorganisms and insect pests live in weeds cause disease therefore at Lalo kebele Coffee nursery site the nursery managers manage the nursery even though there is management practices there are many factors which reduces the rate of germination of the seed as well as the survival of the seedling.

## 7.2 Recommendations

For higher rate of germination of *Coffea arabica* L., seed should be sown in forest soil to a depth of 1cm with grooved side of the seed placed down. In the absence of forest soil divers' type of alternatives potting media with ideal chemical and chemical conditions like forest soil can be prepared by blending decomposed sand in varies proportions.

After sowing, seed beds should be covered with 3-5 cm mulch (the materials used for mulching can be grass, banana, inset or palm leaves.).The seed bed should be watered at two days interval until the seedling starts to emerge and the mulch should be removed and should be replaced by overhead shade and watering frequency should be reduced to 4- 8 interval within a week until the seedling attain 2-4 pairs of true leaves respectively. Watering frequency and shade level should be gradually reduced one month before transplanting the seedlings to the field.

The choice of hole size for planting Arabica coffee in the field depends on agro-ecological conditions. Wider and deeper hole dug early in the dry season are preferable to ensure higher rate of survival and better field establishment particularly in areas with moisture deficit.

Time of transplanting is also important for successful field establishment. In most of the cases, May/June and July/August transplanting seems to be proper time of transplanting, though this has to be supported by a long term rain-fall data of each location for better forecast of the planting time.

Various tillage methods and transplanting techniques improved stand establishment and subsequent growth and yield of coffee especially in the early year of production. On the other hand, a conventional holing on untilled plot and collar level of planting were found to be inferior at the different agro-ecologies.

Thus, initial tillage and deeper planting should be practiced to ensure maximum field establishment of coffee plantations.

For maximum germination and quality seedling the seeds used in the nursery site should keep quality. A quality seed is the one which is red, ripe and well dried. Many factors affect the quality of seed and seedling among those factors sourcing, collection and selection is the crucial ones in producing quality seedling.

At Lalo Kebele coffee nursery, site the researcher will recommend that while buying seeds for nursery they will have to give due attention for the sources, collection, selection and checking viability of coffee seeds.

The size of the area must be large enough to accommodate any possible expansion of the nursery. Location of the nursery site should be near the planting site to minimize injury in handling and during transportation. It must be easily accessible to facilitate nursery field operations and supervision. Access roads should be usable during all seasons of the year.

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## Appendix

### Interview Questions used for the present study

#### 1. General information

1.1 Zone\_\_\_\_\_ 1.2 Wereda\_\_\_\_\_ 1.3 Kebele\_\_\_\_\_

1.2. Name of nursery manager-----

1.3. Sex-----

1.4. Marital status: (1) Married (2) Single (3) Widowed (4) Divorced 6. [Please underline one.]

1.5. Family size -----.

1.6. Educational level of nursery managers: (1) Illiterate; (2) Can read and write; (3) Primary education (grades 1-4); Junior secondary education (grades 5-8); Secondary education (grades 9-10).

#### 1. Seed bed preparation

1. What kinds of soil type were used?

2 .what is the depth of the soil used for sowing?

3 .what is the position (alignment) of the bed?

4 .How do you prepare soil ratio?

5 .How do you space the seed on the bed?

6 .what kind of sowing method were used?

7. How is the plot prepared and How the hole is prepared?

## **2. Seed propagation**

1. What kinds of seedling were prepared (bare root or potted) why?
2. When do the coffee seed is sown on the nursery?
3. How many percent is germinating?
4. What are the main factors that affects the germination rate of coffee seed?

## **3. Management practices**

1. How do you manage coffee nursery site?
2. How many times do you water the bed per day?
3. What kinds of problems are facing you during management of the seedling?
4. When do you put mulching on the bed?
5. How many days do the shade stays on the bed?
6. After germination of the seed how many meters do the height of the overhead shade?
7. what kinds of mulching materials were used for mulching?
8. At what time do you transplant the seedling based on rail fall, temperature?
9. how do you clean the management tools?
10. How many days does overhead shade stays over the bed?
11. How many months do the seedling stays on the bed?
12. Do you apply any fertilizer to the seed sown on the bed?
13. If you apply fertilizer, what kinds of fertilizer is applied?
14. Is there any disease which affects the seedling on the nursery site?