ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE

DEPARTMENT OF ZOOLOGICAL SCIENCES

GERMINATION AND EARLY GROWTH PERFORMANCES OF *Cordia africana* Lam. IN POTTED VERTISOL AND NITOSOL IN BICHENA TOWN, EAST GOJJAM ZONE, AMHARA REGIONAL STATE

By

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Addis Ababa, Ethiopia

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Addis Ababa University, Department of Zoological Sciences

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GRADUATE PROGRAMMES

DECLARATION

This is to certify that the thesis prepared by Wubet Gebeyehu Tamene, entitled "Germination and Early Growth Performances of *Cordia africana* Lam in Potted Vertisol and Nitosol", submitted in partial fulfillment of the requirements for the degree of Master of Science in biology complies with the regulation of the university and meets the accepted standards with respect to originality and quality.

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Chairman

Abstract

Cordia africana Lam. (Synonym: *Cordia abyssinca*) belongs to the family Boraginaceae, and subfamily Cordioideae. *C. africana* is multipurpose species and has various uses, including its suitability for soil conservation and/or soil development, water conservation, as shade tree for coffee plants, source of excellent timber, for use as sources of edible fruits and medicine. The species occurs in primary and secondary forest of woodland at altitudes between 550 and 2600 m.a.s.l. and with annual rainfall of 700 to 2000 mm.

The present study was initiated with a view to contributing to the conservation and development of *C. africana*, which is among one of Ethiopia's most useful tree species. The study focused on the species' seed germination and early growth performances, and was conducted in Amhara Regional State, East Gojjam Zone, Bichena town. Seed germination was achieved in plastic sleeves filled with vertisol and nitosol and arranged on nursery bed conditions. The study found that germination percentage, mean germination time, and germination vigor were better for seeds planted in nitosol than in vertisol. However, data analyses showed that there was no significant difference ($p \leq 0.05$) between the nitosol and vertisol treatments for all the germination parameters measured.

The study results showed that early growth performances of seedlings mean height increment were significantly ($p \leq 0.01$) higher for plants grown in nitosol (40.61 cm) compared to those grown in vertisol (34.95 cm). Similarly, mean internodal length was highly significant ($p \leq 0.01$) for plants grown in nitosol (44.4 mm), compared to those grown in vertisol (34.6 mm). Leaf number of plants was highly significant ($p \leq 0.01$) for nitosol grown plants (mean number of leaves per plant = 16) compared to those grown in vertisol (with mean number of leaves per plant = 13). Likewise, mean leaf area value was significantly ($p \leq 0.05$) greater for plants grown in nitosol (670.88 mm^2) compared to those grown in vertisol (544.22 mm^2). Mean root collar diameter was significantly ($p \leq 0.01$) greater for plants grown in nitosol (4.43 cm) compared to those grown in vertisol (3.6 cm). Total mean dry weight of the seedlings grown in nitosol (17.67 gm.) was significantly ($p \leq 0.01$) larger than those grown in vertisol (11.32 gm.). The study also indicated that seedlings of *C. africana* grown in nitosol attained a height of 41 cm within 7 months suggesting that the species is one of Ethiopia's fastest growing native tree species. From these results, it is concluded that *C. africana* plants grow much better in nitosol than in vertisol, and that restoration and/or afforestation of this species must take into consideration the proper choice of soil type.

Key words/phrases: Boraginaceae, leaf area, mean dry weight, moisture content

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Acronyms

b h d breast height diameter.

CEC cation exchange capacity.

G P Germination percentage.

G V Germination vigor.

mc moisture content.

MDW mean dry weight.

MGT mean germination time.

SE standard error.

1. INTRODUCTION

1.1 Background

Indigenous forests provide multitude goods and services including the regulation of hydrological cycle, climate, the conversion of soil and nutrients (Girema, 2000).

Indigenous forests of Ethiopia have been greatly altered in the past 100 years. In the beginning of 1900s, it was estimated that about 35 % of Ethiopia's land mass with about 110 million hectare, was covered with high forest. By early 1950s, the cover of high forest was reduced to 16 % (Saler *et al*., 1992) of the total land area. It was reported that the forest cover was 3.6 % in the early 1980s, (Anonymous, 2004). According to the World Bank, forest in Ethiopia was last measured 2.7 % in 2011.

The depletion of forest cover of indigenous trees in many regions of the country was observed from time to time with faster rate due to lack of knowledge for their conservation and propagation techniques. According to Legesse Negash (1995), the main reasons for forest depletion in Ethiopia are public economic importance and difficult to propagate indigenous forests species through conventional tree propagation techniques. In the highland of Ethiopia, indigenous tree species have largely been replaced by exotic species, notably, various *Eucalyptus*.species. Certainly, those exotic species are essential for the life of the rural population today, but they are not providing such a wide variety of products and services as do indigenous trees (Azene *et al*., 1993).

Forest depletion results, massive soil erosion, unusual flooding, and decline in agricultural productivity are now rampant throughout Ethiopia (Legesse Negash, 2002a; Zerihun *et al*., 2002). In Ethiopia forest depletion estimates indicate that a quarter of Ethiopia's high lands are eroded and over 40 % of the eroded areas are seriously affected to a stage that it will not be economically productive (Esayas *et al*., 2000; MacDougall *et al*., 1995) estimated soil erosion rate in the high land of Ethiopia land that it can be as high as 300 t ha^{-1}per annum. Today, crop failure due to soil nutrient deficiency is common thus resulting an increasing amount of money incurred for purchasing commercial fertilizer. This in turn results in increased poverty of rural inhabitants, which will also affect urban dweller economic condition. This problem call for urgent and all out

actions for the propagation, cultivation, and domestication of indigenous trees (Legesse Negash, 2002a).

C. africana is the fast growing and highly valued timbre tree, used for high quality furniture, doors, windows, cabinets making, drums, beehives, joinery, interior construction, mortars, paneling, and veneering (Legesse Negash, 1995). The contribution of *C. africana* to various soil properties and its importance as coffee shade tree in traditional agroforestry system has been documented (Demele Teketay and Tegineh, 1991; Yadessa *et al.,* 2001). Despite its several uses, land clearing for farming, fuel wood, and commercial logging has resulted in rapid destruction of forests where *C. africana* has been dominant (Legesse Negash, 1995). Thus *C. africana* was proclaimed endangered (Nigarite, 1994). Therefore, today the progressive natural resource degradation calls for a good nursery practice to produce quality tree seedlings.

According to Bewley (1997), there is much more to be learned about the key processes involved in germination, because seeds from different plants have different responses to various environmental and morphological factors of germination. Even though studies on propagation and physiology of some indigenous trees of Ethiopia such as *Hagenia abyssinica* (Bruce) J. F. Gme. (Teshome Dawit, 2009), *Croton macrostachyus* Hochst.*Ex.* Del. (Legesse Negash, 2010; Kibebew Wakjira, 2007), *Ficus sur* Forssk (Solomon Getahun, 2011) were conducted, there was no information on seed germination and growth performances of *C. africana* in vertisol and nitosol.

1. Statement of the problem

Ethiopia's economy is based on renewable natural resources. The country is also one of world's centers of plant genetic diversity (Hancock, 1992). This is attributed to the country's varied geological formations and physical features (Fichtl and Admassu Adi, 1994). Unfortunately, land clearance for various purposes led to increased product scarcity and/or rarity that in turn resulted in increased demands and led to further forest destruction (Legesse Negash, 1990). The depletion of forest cover of indigenous trees in many regions of the country was observed from time to time with faster rate due to lack of knowledge for their conservation and propagation techniques (Legesse Negash, 1995).

According to Feyissa *et al.* (1994), the silviculture of most indigenous species is not yet very well-known. The problems related with silviculture characteristics, nursery technique, long rotation, late economic return discourage many foresters from using indigenous species on large-scale plantation. Similarly farmers found Bichena do not plant indigenous tree species because they have less information about their nursery technique, silviculture, and management methods. To raise the quality seedling nursery technique begins to know the appropriate soil type (composition) for each type of indigenous tree species. However, only little of such vital information on *C. africana* is present.

2. OBJECTIVES OF THE STUDY

1. General objective

The general objective of this study was to study germination and early growth performances of *C. africana* in potted vertisol and nitosol.

2. Specific objectives

The specific objectives of the study were to:

- Determine germination responses of *C. africana* seeds in potted vertisol and nitosol under open nursery bed conditions:
- Determine early growth performances (height, internodal length, leaf number, leaf area, and root collar diameter):
- Determine and compare biomass of *C. africana* seedlings:
- Determine suitable soil type for conducive germination and growth performances.

3. LITERATURE REVIEW

1. *Cordia africana* Lam

Synonym: *Cordia holstii*, *Cordia abyssinica* R. Br. (ICRAF, 1998).

Vernacular/common name: East Africa *Cordia,* large leaved *Coria* or Sudan teak (English), wanza (Amharic), and Wadessa (Afanoromo) (ICRA, 1998).

3.1.1 Taxonomy and Morphological Features

Cordia africana Lam. belongs to the family Boraginaceae, and sub family Cordioideae (Legesse Negash, 1995).*Cordia africana* Lam. (genetic name after Vales Cordus, a German botanist) is a pan tropic genus about 250 species (ICRAF, 1998). A plant family comprises about 100 genera and 2000 species (Carro, 2006).

C. africana is heavily branched tree with crown spreading, umbrella–shaped or rounded canopy (Legesse Negash, 1995). The diameter of the bole may be up to 1m, and usually curved or crooked (Warfa, 1988; Legesse Negash, 1995). However in high rain fall area the species may attain abreast height diameter (b h d) over 1m. Also when growing one another and competing for light the tree can develop quite straight boles may attain height of over 25 m. The bark of the species usually grayish–brown is smooth in young trees (Legesse Negash, 1995). As the tree matures, the bark becomes rough and longitudinally ferruled, developing shallow to deep cracks as its age.

Leaves are alternate, simple, ovate to sub circular, thinly leathery, dark green above, paler green and velvety below, with prominent parallel tertiary net-nerve (about 7pairs of lateral nerve), rounded to cord ate at apex, margin entire, petiole slender, 2.5 – 7.6 cm long oval, stalk less, pleated buds open flower (Legesse Negash, 1995).

Flowers are bisexual, white, sweet scented, shortly pediculate or sub sessile. Calyx less than 1cm long, ribbed, back of lobes covered with short, soft, and brown hairs. Corolla lobes crinkled, white, long–exerted funnel shaped 2.5 cm long, and cymes many flowered. Fruits a drupe, smooth, spherical, oval tipped, flesh 1.3 – 1.5 cm long, green when young, yellow to orange when mature, with a sweet mucilaginous pulp (Legesse Negash, 1995).

3.1.2 Ecological and Geographical Distribution

C. africana is native to Angola, the Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Ghana, Guinea, Kenya, Malawi, Mozambique, South Africa, Sudan, Tanzania, Uganda, Zimbabwe, and Yemen (Warfa, 1988; Friis, 1992). In West Africa the tree appears to be restricted to montane and sub montane habitat; it has limited distribution in low land habitat of Democratic Republic of Congo (Legesse Negash, 1995).

In Ethiopia it is wide spread in broad leaved Afromontane Rain Forest, Undifferentiated (Dry) Afromonatne Forest (mixed *Podocarpus* forest) and in riverine forest as well as in the Western low lands (Friis, 1992). The species occurs in primary and secondary forest or wood land at altitude between 550 and 2600 m.a.s.l. and with annual rain fall of 700 to 2000 mm (Friis, 1992; Legesse Negash, 1995). But *C. africana* prefers areas that are characterized by moderately high amount of rain fall and sufficiently warm climate (Legesse Negash, 1995). It can also grow under drier condition by minimizing its water consumption through shading its leaves or by closing its stomata (Legesse Negash, 1995; Gindaba; Rozanov and Legesse Negash, 2004).

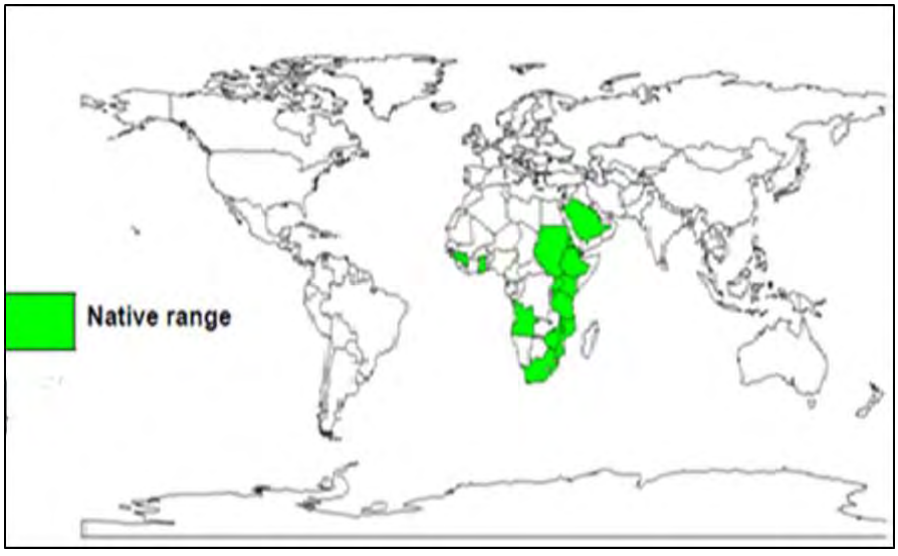

Figure 1: Natural distribution of *C. africana* Source (ICRAF, 2008).

3.1.3 Ecological and Economic Importance

C. africana has biological attributes in soil formation, soil conservation, water retention, and flood control. It is deciduous tree; it shades leaves, the leaves decompose quite readily thus ensure nutrient recycling, and soil formation. The large number of branch let i.e. canopy allows the tree intercept and reduce the kinetic energy of stormy rain fall thus protecting against soil erosion (Legesse Negash, 1995). As the proportion of canopy increases, the water infiltration increases and the surface run off decreases resulting in more water in the soil. The result increases water availability, and great volume, and discharge to spring, and decreases the effective length of dry season similar to other indigenous tree species such as *Podocarpus* flactus (Thumb.) Mirb, and *Ficus* species (Legesse Negash, 1995).

C. africana leaves provide fodder in dry season (Jansen, 1981; Azene *et al.,* 1993; ICRAF, 2008). According to Takele *et al*. (2004), the leaves are threshed, cut or pitted, and collected for live stocks consumption. It is lopped periodically for fodder, and fruits are consumed by cattle, goat, sheep, donkey, and mule (Aklilu *et al.,* 2003).

C. africana is one of the common shade trees of coffee in Ethiopia (Demele Teketaye and Tegineh, 1991). In this association, studies have demonstrated that coffee shade trees have positive impact on coffee quality (Mushecher, 2001; Vaast *et al.,* 2006), by lengthening maturation period of coffee berries and hence a better bean filling, and also through the modification of microclimate for coffee planting growing underneath shade trees (Avelino *et al.,* 2007). Moreover shade improves the quality of coffee by allowing bean accumulate greater amount of sucrose compared to sun grown beans (Steiman, 2003).

C. africana has pure with flower together with their fragrance, and abundant nectar, are attractive to honey bees consequently, *C. africana* is an excellent honey tree. As a tree is capable of flowering with in a relatively short period of time, it has a great potential for apiculture (Legesse Negash, 1995). It supplies abundant pollen and nectar for bees which forage all days (Fichtl and Admassu Adi, 1994). This is one of major honey source of Ethiopia mainly in the western parts. The honey is very aromatic with a slow granulation and light brown in color. According to Fichtl

and Admassu Adi (1994), in Ethiopia beehives are often hung on *C. africana* trees when bees are swarming. In Maal community, South Omo, bee hives are made from *C. africana*.

The mature *C. africana* fruits are edible, used to make sweet drinks which can be used as milk substituent; to make stimulant and alcohol drinks, and are sold in local market in North Ethiopia and Sudan (Demele Teketay and Abeje Eshete, 2004; EL-Tahir, 2004; ICRAF, 2008). Moreover, the fruit was found to be a very good source of total phenol anti-oxidant. In addition, it is good partial source of nutritional important iron, vitamin A as well as some protein, Ca, P, Cu, K, Mg, and vitamin C (Sahar, *et al*., 2013).

C. africana has traditional medicinal use (Smith *et al.,* 1996; Emmauual, 2010). Migraine, broken bone, wound, gastritis, and constipation were noted to be treated with bark, leaf, and fruit (Gebreegziabehere *et al.,* 2012). The flesh juice bark is used to tie a broken bone; this splint is changed occasionally with fresh one until bone is healed (Junsen, 1981; ICRAF, 2008; Royal Botanical Garden, 2009; Kokwaro, 2009). In Congo the bark is macerated, and used to treat madness *via* nasal application (Chifundera, 2001).

A decoction made from the bark is used to treat venereal diseases (Kokwaro, 2009), and that of the root to treat vermin fungus, and the ash as a skin and mucosae treatment (Royal Botanical Garden, 2009). In Tanzania around Lake Victoria region the root is used to treat tuberculosis, cough, and asthma (Otieno *et al.,* 2011). The leaves and root are used to treat liver disease, the root is used to treat amoebiasis, and the root and root bark are used to treat stomach ache and diarrhea (Aberra *et al.,* 2005). For general body ailment, inhalation of boiled leaf vapors is used (Tekelehaymanot *et al.,* 2007). The crushed leaf juice is drunk to treat general ailment, diarrhea, and tonsillitis and rubbed into the eye to treat eye infection (Tekelehaymanot *et al.,* 2007). The crush leaf is also applied to wound for healing (Aberra *et al.,* 2005). Old wounds are crushed using crushed leaves in Tanzania, and intestinal worms are expelled by eating leaves by Massi and Chagga people in Tanzania (Junsen, 1981).

3.2 Soil

Soil is a dynamic natural body developed as a result of pyrogenic process thought weathering rock, consists of mineral and organic constituents, possessing a definite physical and chemical mineralogical and biological property, having a variable depth over the surface of the

Earth, and providing a medium for plant growth (Doran, 1994). Soil is the medium for plant growth. Its physical, chemical and biological properties determine the degree of workability, suitability to specific crop varieties, physical and chemical capacities as well as productivity (Gaikward; S.t.Rao and Verma, 1995).

3.2.1 Soil Texture

Soil texture is determined by the proportions of sand, silt, and clay in the soil (Brand and Weil, 1999). When they are wet, sandy soils feel gritty, silt soils feel smooth and silky, and clay soils feel sticky and plastic, or capable of being molded. Soil texture influences many soil physical properties, such as water-holding capacity and drainage. Coarse-textured sandy soils generally have high infiltration rates but poor water holding capacity. Silt particles are much smaller than sand, have a greater surface area, and are generally quite fertile. Silts do not hold as much moisture as clay soils; however more of the moisture is plant available. Fine-textured clay soil generally has a lower infiltration rate but a good water holding capacity (Brand and Weil1, 999).

3.2.2 Soil Structure

Soil structure is the arrangement of soil particles (sand, silt and clay) and pores in the soil and to the ability of the particles to form aggregates. Macrospores allows good aeration, rapid infiltration of water, easy plant root penetration, good water drainage, as well as providing good conditions for soil micro-organisms to thrive (Brand and Weil, 1999). Microspores hold water against gravity (capillary action) but not necessarily so tightly that plant cannot extract the water (Brand and Weil, 1999).

3.2.3 Soil Organic Matter

Soil organic matter improves soil structure and increases the nutrient and water holding capacity of the soil provides a food supply for soil biology and reduce nutrient leaching (CSIRO, 1999). Organic matter fully break down one of the things that is left is humus. Thus, organic matter also plays an essential role in maintaining a loose, friable soil structure. Humus has some useful qualities in that it adsorbs nutrients, adsorbs much higher quantities of water than clay can, and improves soil structure due to its low plasticity and good cohesion. Thus, organic matter also plays an essential role in maintaining a loose, friable soil structure (CSIRO, 1999).

3.2.4 Vertisol

The basic property of veritsol, that endows them with high water holding capacity in their clay content, which commonly lies between 40 – 60 % and it may be as high as 80 % (Ahmad and Marmut, 1996). The dominant clay mineral in most of the vertisol appears to be montmorillonite. This, plus the high clay content, appears to be the main reason for the high water-holding capacity of vertisol (Ahmad and Marmut, 1996). Vertisol has relatively high water storage capacity in the root zone because of their usually high content of clay dominantly a 2:1 type and have a relatively deep in the soil profile. Vertisol storage of moisture causes swelling; loss of water causes shrinking (Hubble, 1997).

The bulk density of vertisol varies greatly because of their swelling and shrinking nature with changes in soil moisture content. The soil has high bulk density when these are dried and low values when in a swollen stage. According to Doran (1997), the bulk density of a vertisol may vary from approximately 1 to 2 g/cm^3 depending on the moisture content.

The vertisol occurring in India, Australia, Sudan, Ethiopia and other parts of Africa generally have soil pH ranging between 7.5 and 8.5 in the soil profile. Factors which contribute to high soil pH are the presence of $CaCO_3$ and high contents of bases, especially calcium and magnesium in the profile (Doran, 1997). The dark color of the vertisol was earlier suspected to be an indicator of high organic matter content but this was disproved by Singh (1995). Most of the black cotton soils of India rarely have organic matter exceeding 1.0 % (Roy and Barde, 1992).

Figure 2: A sample of vertisol used for the present study. The whole soil employed for the study was collected from Yeqefet-Abo Qebele, Enemay Wereda, East Gojjam Zone, Amhara Regional State.

3.2.5 Nitosol

Nitosol is widely spread throughout subtropical and tropical regions. Nitosol is naturally poor in physical conditions and are also characterized by low pH, cation exchange capacity (CEC), and fertility. Nitosol also has low concentration of P in soil solution and result in frequent P deficiency of plants (Wang *et al*., 2014).

The texture of nitosol varies from sand to clay, the majority being loam. Their other characteristics include porous and friable structure, absence of lime, kankar and free carbonates, and small quantity of soluble salts. Their chemical composition includes non-soluble material (90.47 %, iron 3.61 %, Aluminum 2.92 %, organic matter 1.01 %, Magnesium 0.70 %, lime 0.56 %, $CO_2$0.30 %, potash 0.24 %, soda 0.12 %, Phosphorus 0.09 % and Nitrogen 0.08 %) (Wang *et al*., 2014). However, significant regional differences are observed in the chemical composition.

Figure 3: A sample of nitosol used for the present study. The whole soil employed for the study was collected from Enekora Maryam Qebele, Enemay Wereda, East Gojjam Zone, Amhara Regional State**.**

3.3. Reproduction of *Cordia africana*

C. africana begins flowering when the tree is 3 - 5 years old (Legesse Negash, 1995; ICRAF, 1998). It is monocious species with complete flower (hermaphrodite) and known to be insect pollinated (Legesse Negash, 1995). In Sudan, flowering occurs in October to December and fruiting January to April; in Kenya flowering is from April to June. It is repeated at interval over several weeks and is evidently activated by rain shower. After pollination by insects, fruit development takes place almost 6 months. In Ethiopia the tree can be found in flower or in fruit all the year round, but the main flowering period of the species is from October to March (Fichtl and Admassu Adi1994). A flowering tree is spectacular all the flowers open within a short time and give the tree a white snowy cover. Fruits of *C. africana* are eaten and their seeds dispersed by birds, baboons, monkeys, apes and probably by other animals (ICRAF, 1998).

3.4. Seed

Seed is composed of three generation of plant tissues including the sporophyte that produces an immature seed known as ovule and the gametophyte that develop inside the ovule to

produce ova. The third plant tissue of the seed is the new sporophyte embryo. Endosperm is the nutritive substance of the seed up on which the seed embryo feeds as its development (Konging, 1994). Despite these anatomical structures of seed in higher plants, seed morphology differs from one plant species to another, there are small and big seeds, thin, flat, light, papery, dehiscent, and indehiscent, smooth and hard seed coat.

Seeds are still important starting materials for propagation of many vital tree species (Mo"gomba, 2007). New plant generation starts with a seed, which usually contains a fully developed embryo that can survive the period between seed maturation and germination (Mo"gomba, 2007). Propagation from seeds ensures genetic diversity that is maintained by allowing genetic recombination to occur through sexual reproduction. The genetic diversity makes possible the survival and the natural evolution of species in continually changing environmental conditions. The rearrangement of genes leads to the production of individuals that are different from their parents (Piotto and Di Noi, 2003).

3.5. Seed Germination

Seed germination incorporates those events that commence with the uptake of water by quiescent dry seed, and terminate elongation of embryonic axis (Bewley and Black, 1994). Water uptake by a seed is tripe phase, phase I rapid initial uptake; phase II plateau phase, and phase III further increase of water uptake. However, when only germination occurs (Bewley, 1997; Mansubele *et al.,* 2005). The signs of seed germination are redemption essential process, including transcription, translation, and DNA repair followed by cell elongation, and eventually at the time of radicle protrusion, resumption of cell division (Barroco *et al.,* 2005).Germination is a two process, where testa rupture is followed by endosperm rupture. Following rupture of micropylar endosperm by emerging radicle, germination is complete (Krock *et al.,* 2002; Liu *et al.*, 2005).

During seed germination various stored substrates are reactivated, repaired if damaged and transformed into new building materials necessary for initial growth of the embryo, its subsequence growth, and seedling establishment in its natural habitat (Koller and Hadas, 1982). To initiate the collection process, the condensed insoluble stored substrate must first be hydrated and then hydrolyzed to their basic forms before they can be reprocessing.

The visible sing that germination is complete usually penetration of structures surrounding the embryo by the radicle; the result is often called Visible germination. Subsequent events

includes the mobilization of the major storage revers, are associated with the seedling growth. Virtually all of the cellular and metabolic events that are broken to occur before completion of germination of non–dormant seeds are also occur in imbibed dormant seeds; indeed the metabolic activities of the latter are frequently only subtly different from those the former. Hence, a dormant seed mat achieves virtually all of the metabolic steps required to complete germination yet for unknown reason, the embryonic axis i.e. the radicle fails to elongate.

3.5.1. Factors Affecting Seed Germination

Seed germination of many plants can be influenced by internal and external are declared to affect seed germination (Raven, Ray and Susan, 2005). But according to Legesse Negash (1995, 2010), propagation of many indigenous tree species from seed had been difficult due to lack of precise knowledge on their seed biology and germination physiology, because many native plant species have developed survival strategies through evolutionary process for million years. Understanding these strategies in the context of seed physiology for successful plant propagation.

Hormones contained in various developmental stages, the seed, and enzymes are some of internal factors which in one way or another can affect seed germination (Neff, Sanderson and Tedor, 2009). The most external factors which are declared to affect seed germination include temperature, oxygen (air), and water (moisture). Many researchers also agree that soil dormancy period, seed viability, and thickness or thinness of the seed coat may affect seed germination and hence are factors for seed germination (Finch-Savage and Leubner-Metzger, 2006). Some of the factors that affect seed germination are described below.

3.5.1.1. Temperature

Temperature is the most environmental factor responsible for synchronization of germination establishment (Probert, 2000). Temperature regulates germination by determining the capacity and rate of germination by removing primary and/or secondary dormancy (Bewley and Black, 1994). Thus for any non-dormant seeds germination occurs within well-defined temperature limit, and three cardinal can be organized over short period of time minimum, optimum, and maximum at which germination occurs. The minimum temperature is sometimes difficult to define since germination actually may precede but at lower rate and germination assessment is often made before actual germination is completed. The optimum temperature may be defined as a temperature at which the highest percentage germination with in the short time. The temperature to

most crops (plants) is between 25° C to 40° C. Few plant species germinate 4 °C to 25° C while above 40° C is extremely above optimum seeds will not germinate because some seed enzymes which are protein in nature are denatured including the seed embryo. Some seeds are sensitive to temperature, while other can germinate in wide range of temperature (Michael, 2005).

The maximum temperature is determined by a temperature at which change protein conformation occur that detriments the germination process (Bewley and Black, 1994). For *C. africana* seed the minimum germination temperature is 20 °C and the optimum temperature is 25 °C to 30 °C (Eshetu Yirdaw and Leinonen, 2002).

3.5.1.2. Water and Oxygen

Water and oxygen are basic requirements for seed germination (Hartmann *et al.,* 2004). Mature seeds are extremely dry and to make in significant amount of water relative to the dry weight seed, before cellular metabolism growth can resume. The uptake of water (moisture) is imbibition which leads to swelling and break down of seed coat (Raven; Ray and Susan, 2005). When the seed imbibes water, hydrolytic enzymes are activated which break down the stored resources to metabolically useful chemical which give energy for the seedling (Raven; Ray and Susan, 2005). Protein is chief water imbibing compound of seed, cellulose, and protein also contribute to the swelling of seeds; whereas it was found starch does not result in swelling (Hartmann *et al.,* 2004).

The amount of water (moisture) taken into seed for germination depend anatomically, physiological nature, and plant species (Washa and Nyomora, 2012). Most seeds critical water (moisture) content for seed germination occur i.e. corn *(Zea mays)* 30 %, wheat *(Triticim aesivum)* 40 %, and soybean (*Glycine max*) 50 % (Washa and Nyomora, 2012). If the internal water (moisture) content decreases below or increases above the critical moisture content, seeds essentially decay. Seeds of many species will not germinate at oxygen level considerably lower than the normal present in the atmosphere. In laboratory germination test, seeds of most species germinate well with air available in the germination medium, and with exchange through loosely fitting germination containers. Germination is inhibited by depressed oxygen supply when there is excessive moisture in a medium.

3.5.1.3. Light

The presence or absence light may or may not have effect on seed germination (Neff *et al.,* 2009).

However the light factor is not an important factor as water, temperature, and oxygen. Light requirement for seed germination vary with plant species. Some plant seeds such as verbena, phlox, and most American cultivars of tobacco seeds require darkness to germinate, which is not regarded as a factor. While other plant seeds as begonias, geraniums, Bermuda grass, Kentucky, bent grass, slender wheat grass, and Canada grass require good amount of light which is considered as a factor. Seeds of cultivars of tobacco and grass require certain amount of light for seed germination (Neff *et al*., 2009).

According to (Neff *et al*., 2009), why seeds don't germinate in light is that light is reported to decompose carbolic acid gas, expel oxygen which is germinating factor and fix carbon, thus hardening all parts of seeds which prevent germination. Darkness has no effect to carbolic acid gas, and oxygen remains undisturbed to favor germination.

3.5.1.4. Seed Dormancy

Dormancy is a simple operational bloke to completion of germination of an intact viable seeds under favorable conditions (Bewley, 1997). A more sophisticated and experimentally useful definition of dormancy has recently been proposed by Baskin and Baskin (1998), a dormant seed doesn't have a capacity to germinate in a specific period of time under any combination of normal physical environmental factors that are otherwise favorable for its germination. Species of plants differ in their seed dormancy and requirements for seed germination (Demele Teketay, 2005). The seeds of some species are prevented from completing germination because the embryo is constrained by its surrounding structures. This phenomenon is known as seed coat dormancy (Legesse Negash, 1993) even though; embryos isolated from these seeds are not dormant. The other type of dormancy is found when the embryos of the seeds are dormant, known as embryo dormancy. The third type of dormancy regulates seed germination by the inner tissue of the seed, which is the embryo, the enclosing endosperm and inner integument layer or both (Hartmann *et*

al., 2004). Thus, dormancy must be broken to induce germination and various methods are used for this depending on the plant species and type of dormancy.

Dormancy is self-guard for some seeds and seedling for suffering damage of death and allow some seeds to germinate when there is competition from other plants for light and water. Seeds germinate only after the dormancy is overcome or broken either through natural means such as animal gut activities (Manzano *et al*., 2005), wild fire (vanStaden *et al*., 2000), rainfall (Hartmann *et al.,* 2004) or through artificial means such as scarification, seed coat cracking, removing chemical inhibitors through leaching by water (Legesse Negash, 1995, 2002).

3.6. Seedling Growth and Measurement Techniques

Growth in plants is defined as an irreversible increase in volume. The largest component of plant growth in cell expansion driven by turgor pressure. During this process, cells increase in volume and become highly vacuolated (Taiz and Zeiger, 2002).

Seedling growth is affected by conditions both above the ground humidity, CO_2, temperature, light as well as below the ground water and mineral nutrients, other organisms; either beneficial or harmful, can also influence plant growth (Jaenike, 1999). Healthy seedling need good soil and it should be well drained with maximum of sandy and loam soil, high humus, and nutrient and slightly acidic (Moir *et al.,* 2007). The site preparation with humus layer increase seedling Nitrogen uptake is correlated to root growth (Nordborg, 2001). The seedling growth in height, root collar diameter, number of leaves, leaves area, tap root length, and number of primary roots is distinctly varied with biomass allocation indicated by root shoot ratio. But the growth of root is determined by the physical force of the soil which is highly depending on both soil moisture and bulk density (Daddow and Warrington, 1983). The bulk density of the soil is in turn determined by the texture of the soil.

Growth can be measured in terms of change in fresh weight; that is weight of the living tissue over a particular period of time. However, the fresh weight of plants growing in the fluctuates in response to change water status, so the criterion may be a poor indicator of actual growth. Thus measure of dry weight are often more appropriate than fresh weight (Taiz and Zeiger, 2002).

Measurement above the ground biomass could be made through two basic ways: destructive and non–destructive method. Among the various methods for evaluating forest biomass the most widely used is complete harvest of random selected plots (destructive method). However, such methods are not suited to natural environment, especially if the environment is highly degraded and also with threatened species (Montes *et al.,* 2000). In addition destructive method is expensive in terms of time and expanded for collecting data. Non-destructive method for determining shoot height, root collar diameter, and leaf area of individual trees throughout their growing time are an essential tool in agroforestry research because, researchers of an area need periodic measurements of tree productivity to establish the value and potential of the system under examination (Black *et al*., 2000).

4. MATERIALS AND METHODS

4.1. Study Site

The germination and early growth performances of *C. africana* were conducted from November 1, 2017 to June 1, 2017 at Amhara Regional State, East Gojjam Zone, Bichena town. It is 265 km from Addis Abeba (Figure 4). The altitude of the study area is between 2200 to2430 m.a.s.l. The area receives an average annual rain fall of 1150 mm. The minimum and maximum temperatures are 19 ºC and 25 ºC respectively.

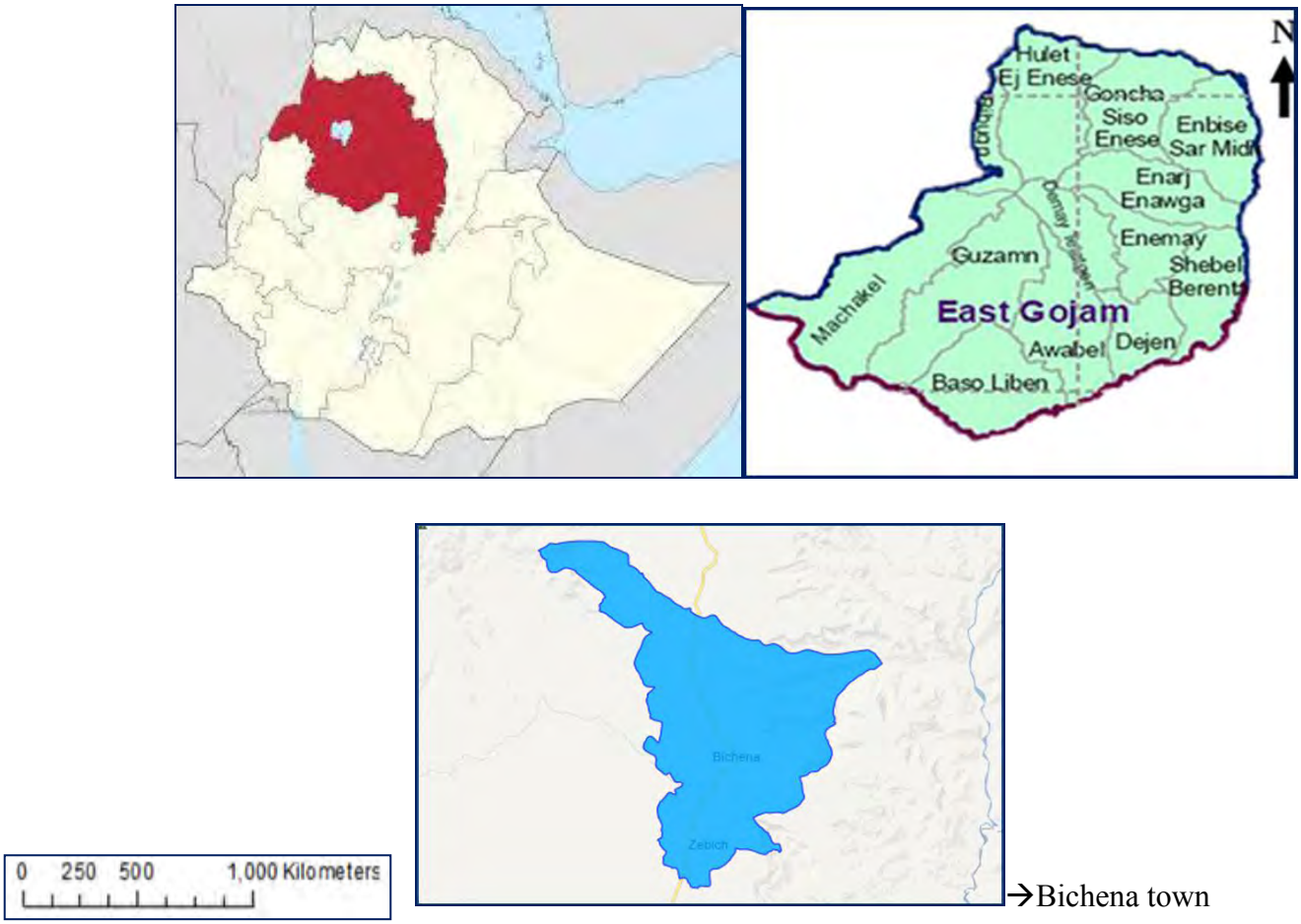

Figure 4: Map of the study area, Bichena town

4.2. Seeds/Fruits Collection

Seeds/fruits were obtained from Enemay wereda agricultural office. I have interviewed Agricultural office forestry department extension workers were interviewed about how/when seeds/fruits were collected, and they explained, matured seeds/fruits were collected in April 2016 directly from the trees estimated 10 – 15 years old natural growing local tree area i.e. Cholemit Maryam monastery. Seeds/fruits were collected from all parts of the crown by selecting matured seeds/fruits (orange fruits) before these fall down to the ground. For fruit collection, an expert in tree climbing was employed.

4.3. Soil Sample and Analysis

For each soil type, 1 Kg of composite soil sample was taken from 8 corners and from the center at distance of 15 m to the center from the depth of 0 – 20 cm from the study site prior to planting seeds. The soil parameters analyzed were pH, organic carbon, available P, cation exchange capacity (C E C), total N, exchangeable Na^+, exchangeable K^+, texture (% sand, % silt, and % clay), and bulk density. The soil analyses work was done in the laboratory of East Gojjam Zone Soil Research Center (Debre Markos).

4.4. Seed Germination of *Cordia africana* Lam. Under Open Nursery Bed Condition

After vertisol and nitosol well dried with sun 50 plastic sleeves with diameter of 20 cm, and depth 25 cm were filled with 1 Kg of vertisol, and 50 plastic sleeves with the same size above were filled with 1Kg of nitosol (Figure.5). Each plastic sleeves with respective soils were picked up by using sharp nail of appropriate size at the bottom 7 narrow holes, and at both sides 14 narrow holes. Totally 100 plastic sleeves containing two type soil were labeled and arranged on prepared nursery bed (Figure 7 A, B).

Figure 5: Plastic sleeves filled with vertisol and nitosol. Each plastic sleeves contained 1 kg with respective soil type measured by beam balance for the present study**.**

Plastic sleeves were watered by using water can, for all plastic sleeves, and five (5) healthy looking, and big size seeds were planted in the middle of each 100 plastic sleeves (totally 500 seeds were planted), and covered with thin layer of the same type of soil, they were not buried too much. Plastic sleeves were watered the same amount of water twice every day (morning and late evening), and dried glass stalk used for conserving moisture (Figure.6 A, B). For each soil type totally 20 plastic sleeves were selected.by simple random sampling technique. The minimum and maximum temperature were 22 ± 3 ^{o}C.

Figure 6: Well dried seeds of *C africana* obtained from Amhara Regional State East Gojjam Zone, Emenay wereda agricultural office used for the present study**.**

Notice: pyrene (drup) is covered by exocarp and mesocarp**.**

A→  **→B**

Figure7: After seeds were planted, in plastic sleeves. Each plastic sleeves watered with equal amount of water **(A)** and covered with leaf stalk (**B).**

Data on germination responses were collected every two days, after the first day of germination, counting of germinates were extended until at least 80 % of plastic sleeves showed no new germination for at least 15 consecutive counts. Seeds were considered germinated at the time when protrusion of radicle. The final germination was recorded, and expressed in terms of germination percentage, mean germination time and germination vigor.

4.5. Germination Parameters and Statistical Analysis

Germination parameters such as germination percentages (GP) mean germination time (MGT), and germination vigor (GV) were calculated according to Lbourian and Agudo (1987), as follows.

1. Germination percentage (GP)

$$G P = (n / N) \times 100$$

Where: n = total number of germinated seeds in plastic sleeves.

N = total number of seeds.

2. Mean germination time (M G T)

$$M G T = (\sum ni\ ti) / n$$

Where: ni = percentage of seeds germinated between consecutive counts.

ti = time (in day) taken since germination experiment started.

n = total number of seed germinated.

3. Germination vigor (G V)

$$G V = \sum (Gi / ti) * 100 / N$$

Where: Gi = number of seeds germinated up to the day under consideration.

ti = Time taken for all germination.

N = total number of seeds used.

Statistical analysis was performed. Germination of *C africana* seeds under nursery bed and growth performances of the seedlings grown with vertisol and nitosol were analyzed by ANOVA single factor using SPSS for windows version 20.Duncan's post hoc test ($p \leq 0.05$) was used to determine the homogeneity subsets whenever significant differences existed among mean values.

4.6. Growth Performances Under Nursery Bed Condition

After germination had occurred among seedlings only, one germinant (seedling) kept, this means seedling germinated vigorously, and looked healthy by visual inspection was selected and the other was removed. For each soil type, 20 plastic sleeves were selected.by simple random sampling technique (appendix 8) The seedlings were maintained under nursery bed, and watered equal amount of water twice a day (morning and evening).

To compare growth responses of seedlings under nursery bed, height increment and internodal length for 20 randomly selected seedlings were measured using mm ruler. Likewise, leaf number and leaf area were measured from 20 randomly selected sample seedlings for every 30 days until the end of experiment. RCD of seedlings was measured at the end of experiment.

To calculate the leaf area, the maps of the sample seedlings were traced out on graph paper which had uniform distribution with area (Bhattand and Chanda, 2003).

After 7 months, follow up of 20 simple randomly selected seedlings were taken for each soil type for biomass determination (Appendix 9, 10). The roots of harvested seedlings were watered (mounted) too much water to minimize the detachment of fine roots (Figure 8 A, B). The detached parts of seedlings were tied on the corresponding part. The shoot and root of the fresh seedlings were carefully separated by cutting with dissecting knife. The respective shoot and root seedlings were properly labeled, arranged and dry matter data has been recorded after drying the seedling in oven for 48 hours until constant dry weight was attained. The dried shoot and root of each seedling were measured by triple beam balance (Florham park, N. J. 07932, USA).

→**A**

→**B**

Figure 8:Asample of *C. africana* seedlings after 7 months taken for biomass determination watered too much water to minimize the detachment of fine hairs **(A**) detached shoot and root cut on their crossponding part (**B**).

5. RESULT

1. Seed germination of *Cordia africana* Lam. Under Open Nursery Bed Conditions

5.1.1 Germination Percentage

Seed germination percentages of *C. africana* germinated in vertisol and nitosol are provided in Figure 9. It was observed that seed germination began on the 38th day after seeds were planted in plastic sleeves filled with nitosol, while those germinated on vertisol emerged on the 44th day of seed planting. Rapid seed germination occurred between days 42th to 56th day in both soil types (Figure 9). Maximum germination percentage was observed in nitosol, which was 75.2 % compared to the vertisol which was (62.4 %). However there was no significant difference observed ($p \leq 0.05$) (Appendix 7 A).

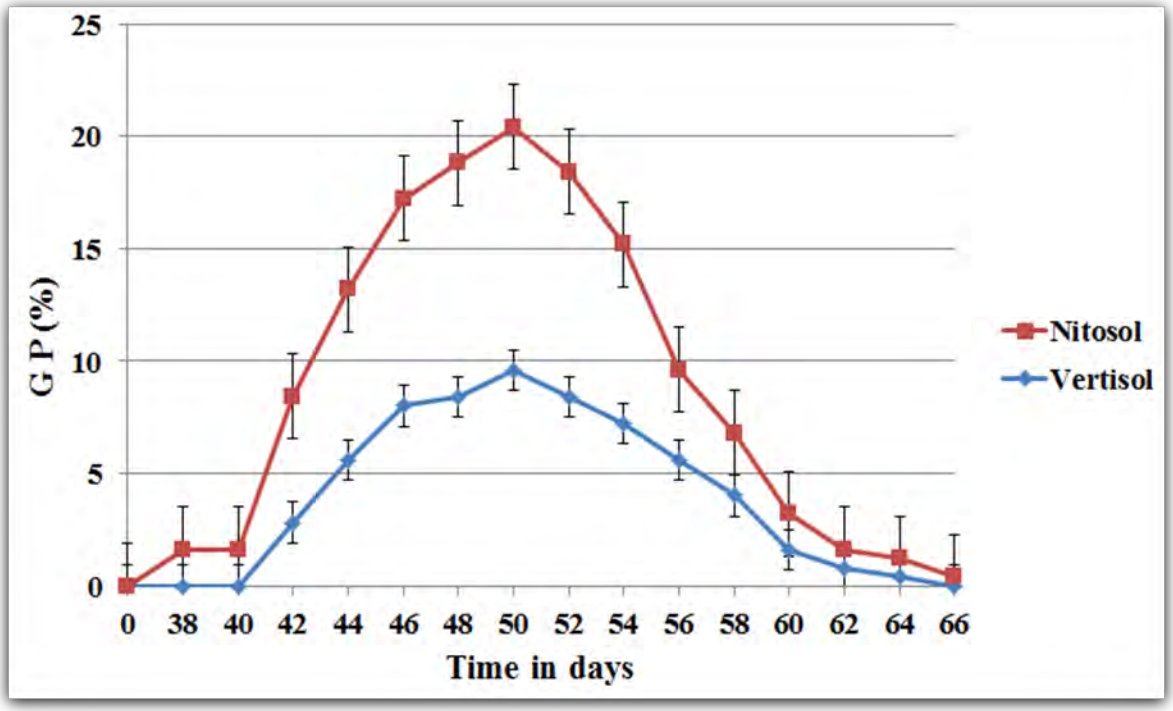

Figure 9: Germination percentage of *C. africana* seeds planted in plastic sleeves filled with vertisol and nitosol under open nursery bed conditions. Data points represent mean germination percentage on the respective days. Vertical bars indicate ± SE (n = 250) randomly placed replicate plastic sleeves each with 5 seeds.

5.1.2 Mean Germination Time

The effects of different soil type on mean germination time are shown (Figure 10). Minimum mean germination time was obtained from seeds planted in plastic sleeves filled with nitosol which was 19.68 % while maximum mean germination time was obtained from seeds planted in vertisol which was 20.24 %. However there was no significant difference observed ($p \leq 0.05$) (Appendix 7 B).

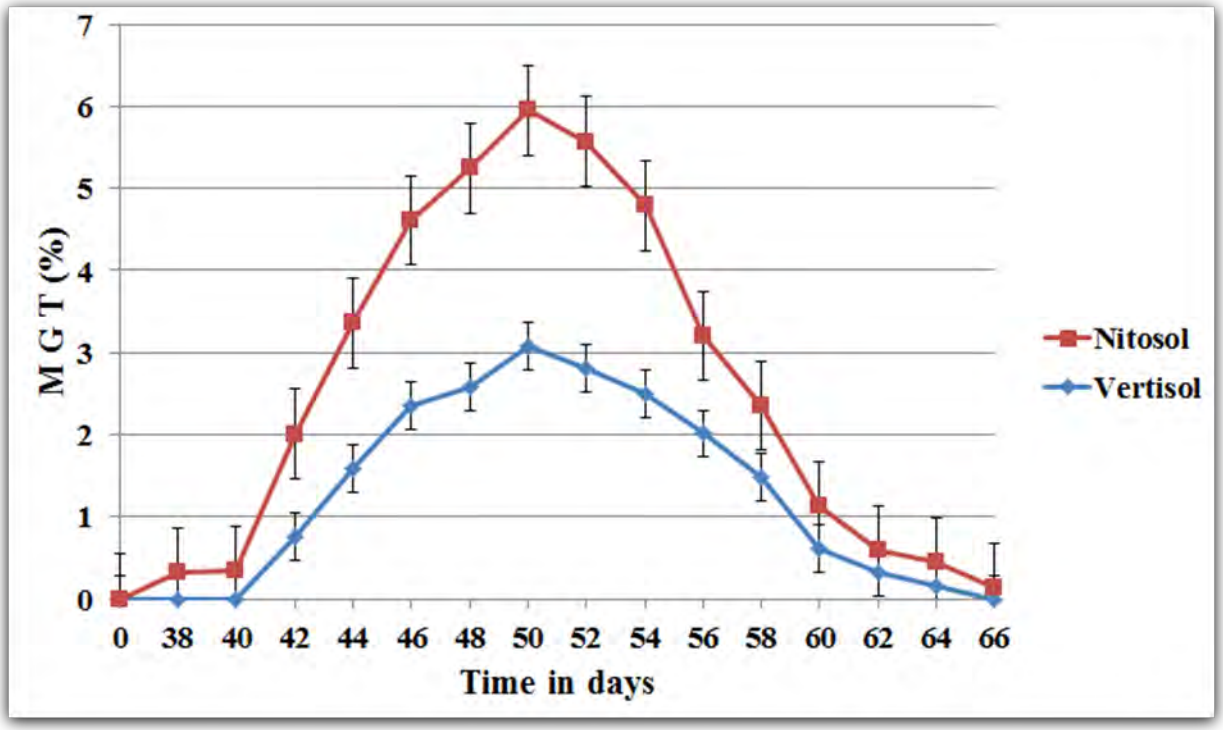

Figure 10: Mean germination time of *C. africana*.seeds planted in plastic sleeves filled with vertisol and nitosol under open nursery bed condition. Data points represent the mean germination time on the respective days. Vertical bars indicate ± SE.

5.1.3 Germination Vigor

Germination vigor percentage of both vertisol and nitosol planted seeds were computed and the germination vigor percentage between different soil types planted has no significant difference at ($p \leq 0.05$) (Appendix 7 C). However maximum germination vigor value was obtained in nitosol which was 1.55 % than vertisol which was 1.42 % as shown (Figure 11).

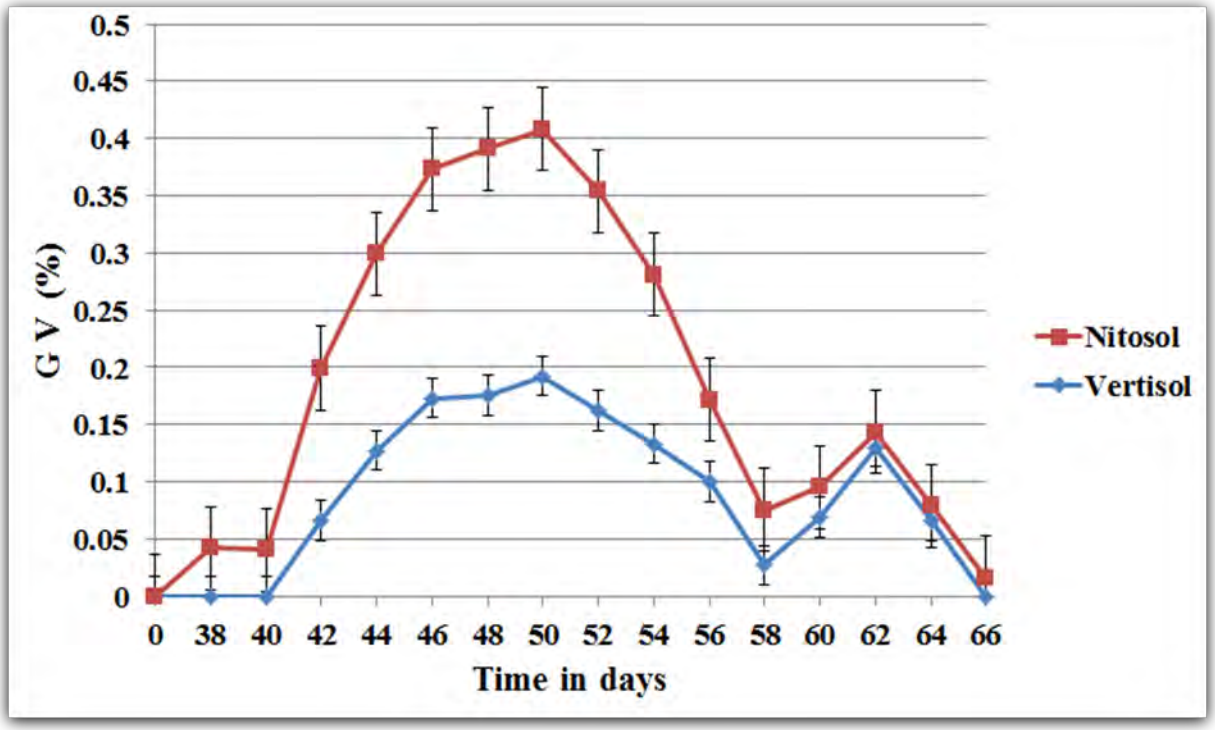

Figure 11: Germination vigor of *C. africana* seeds planted in plastic sleeves filled with vertisol and nitosol under nursery bed condition. Data points represent the germination vigor on the respective days. Vertical bars indicate ± SE.

5.2 Germinant Establishment and Growth Performances of *Cordia africana* Under Open Nursery Bed Condition

5.2.1. Geminants (Seedlings) Establishment

After 3 months follow up, seedlings in plastic sleeves filled with vertisol and nitosol were established under nursery bed conditions (Appendix 8). The survival and establishment of the seedlings in plastic sleeves under nursery bed were 100 % in both vertisol and nitosol.

5.2.2 Growth Performances

5.2.2.1 Height Increment

Seedlings grown in vertisol and nitosol have shown significant difference in their mean height. However, in the first 3rd and 4th months i.e. 90th and 120th day there was no so much height difference observed, seedlings grown plastic sleeves filled with vertisol with mean height (2.9 cm and 6.33 cm) respectively, and nitosol (3.52 cm and 8.34 cm). However, the growth of *C. africana* seedlings filled with nitosol showed better significant growth in height ($p \leq 0.01$) after 5th, 6th, and 7th month with mean height growth in nitosol (16.43 cm, 28.78 cm, and 40.61 cm) respectively than *C. africana* seedlings grown in vertisol with mean height (12.87 cm, 22.08 cm, and 34.95 cm) respectively,.as shown (Figure 12) below, and (Appendix 1).

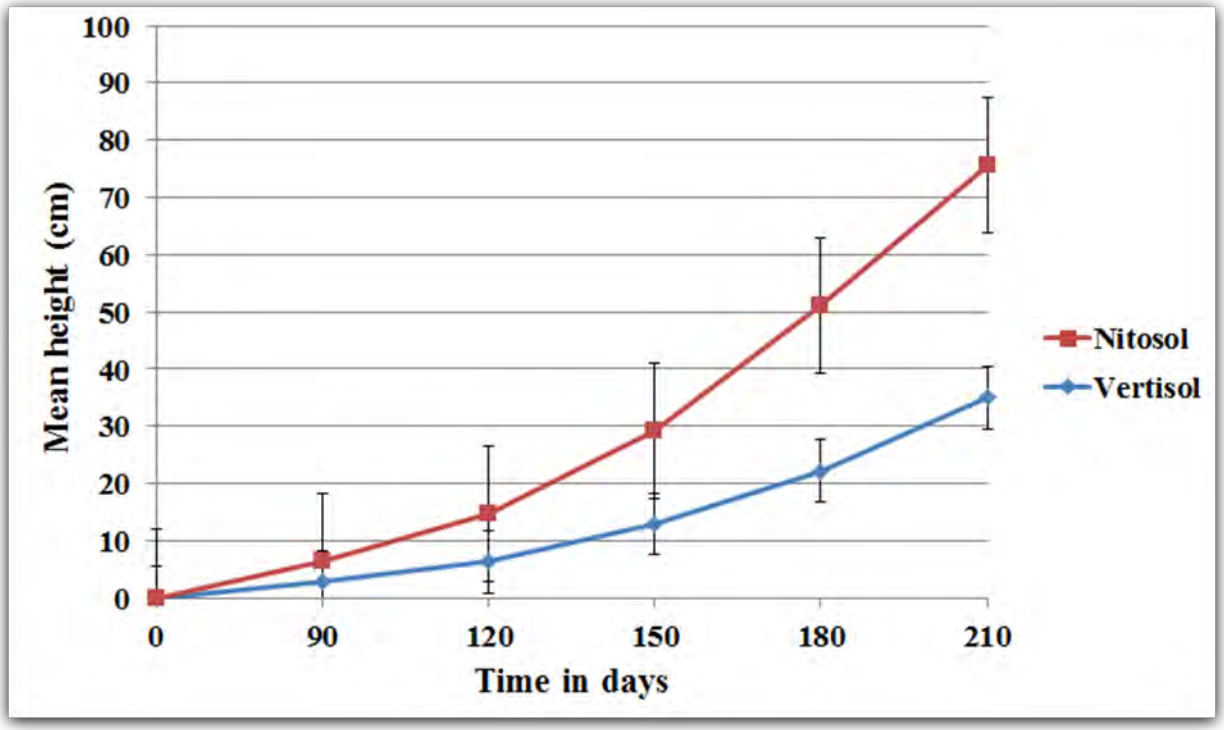

Figure 12: Mean height (cm) of *C. africana* seedlings grown in plastic sleeves filled with vertisol and nitosol.under nursery bed conditions. Data points represent the mean height increment on the respective days. Vertical bars indicate ± SE (n=10).

5.2.2.2 Internodal Length

Seedling internodal length (mm) grown in vertisol and nitosol are provided (Figure 13).The growth response of *C. africana* internodal (mm) parameter like growth in height in the 3rd and 4th month i.e. 90th, and 120th day there was so much internodal length difference was observed vertisol with mean internodal length (6.7 mm, and 10 9mm) respectively, and nitosol (7.2 mm and 13 mm). But *C. africana* seedling grown in plastic sleeve filled with nitosol showed better significant ($p \leq 0.01$) growth internodal length (mm) after 5th ,6th ,and 7thmonth with mean internodal length nitosol (21.7 mm,34.4 mm, and 44.4 mm) respectively than *C. africana* seedling grown plastic sleeves filled with vertisol with mean internodal length (18.8 mm, 27.8 mm, and34.6 mm), (Appendix 2).

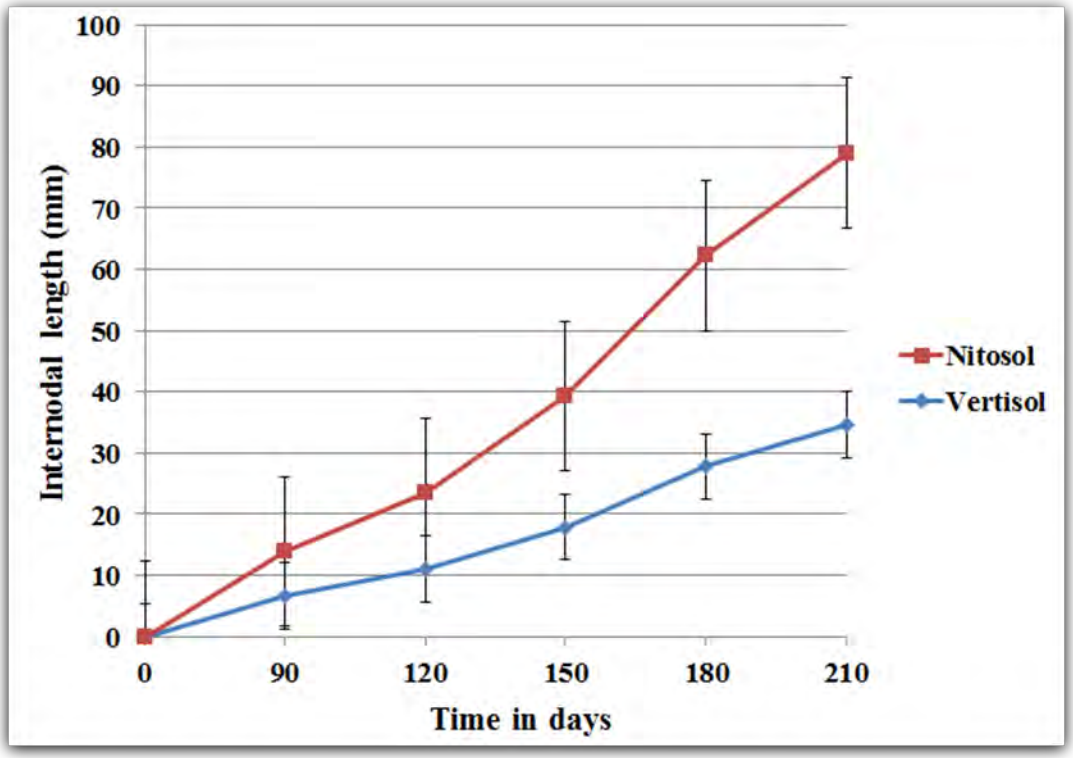

Figure 13: Mean internodal length (mm) of *C. africana* seedlings.grown in vertisol and nitosol under nursery bed conditions. Data points represent the mean internode length on the respective days. Vertical bars indicate ± SE (n=10**)**

5.2.2.3 Leaf Number and Leaf Area

Leaf number and leaf area produced in vertisol and nitosol of *C. africana* seedlings are given (Figure 14) and (Figure 15) respectively. Leaf number of plants was highly significant ($p \leq 0.01$) for nitosol grown plants (mean number of leaves per plant = 16) compared to those grown in vertisol (with mean number of leaves per plant = 13), (Appendix 3). Similarly mean leaf area value was significantly ($p \leq 0.05$) greater for plants grown in nitosol (670.88 mm^2) compared to those grown in vertisol (544.22 mm^2), (Appendix 4).

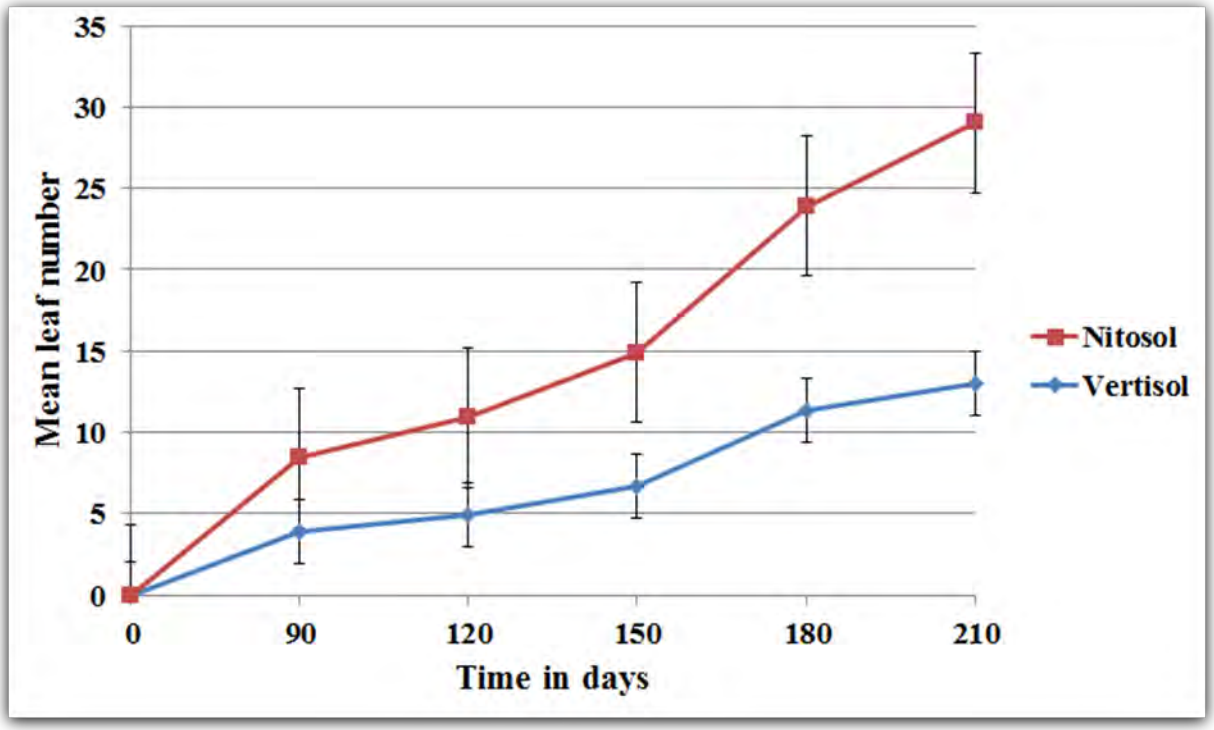

Figure 14: Mean leaf number of *C. africana* seedlings grown in vertisol and nitosol under nursery bed condition. Data points represent the mean leaf number on the respective days. Vertical bars indicate ± SE (n =10).

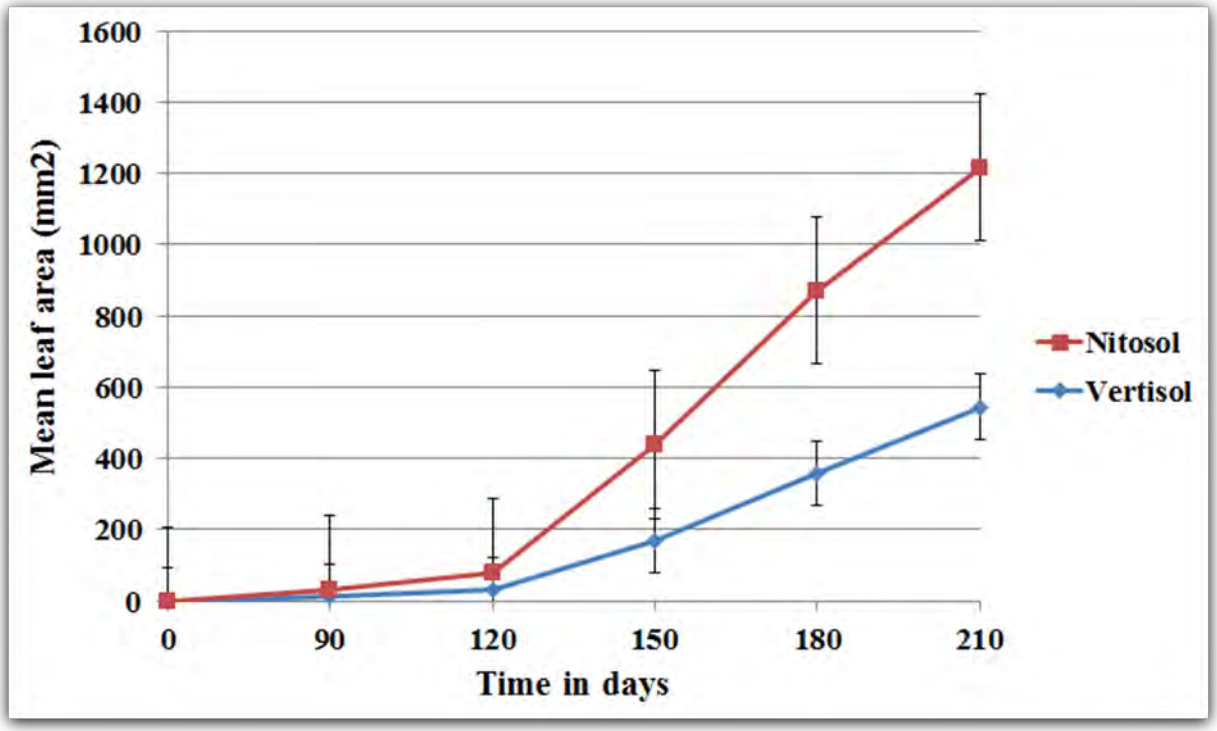

Figure 15: Mean leaf area (mm^2) of *C. africana* seedlings.grown in vertisol and nitosol.under nursery bed condition. Data points represent the mean leaf area on the respective days. Vertical bars indicate ± SE (n=10).

5.2.2.4 Root Collar Diameter (RCD)

Root collar diameter (RCD) measurement of *C. africana* seedlings grown with vertisol and nitosol were taken along with the last growth height measurement. *C. africana* seedlings grown with nitosol was highly significant ($p \leq 0.01$) RCD (4.43 cm) than grown with vertisol RCD (3.6 cm), (Figure 16), (Appendix 5).

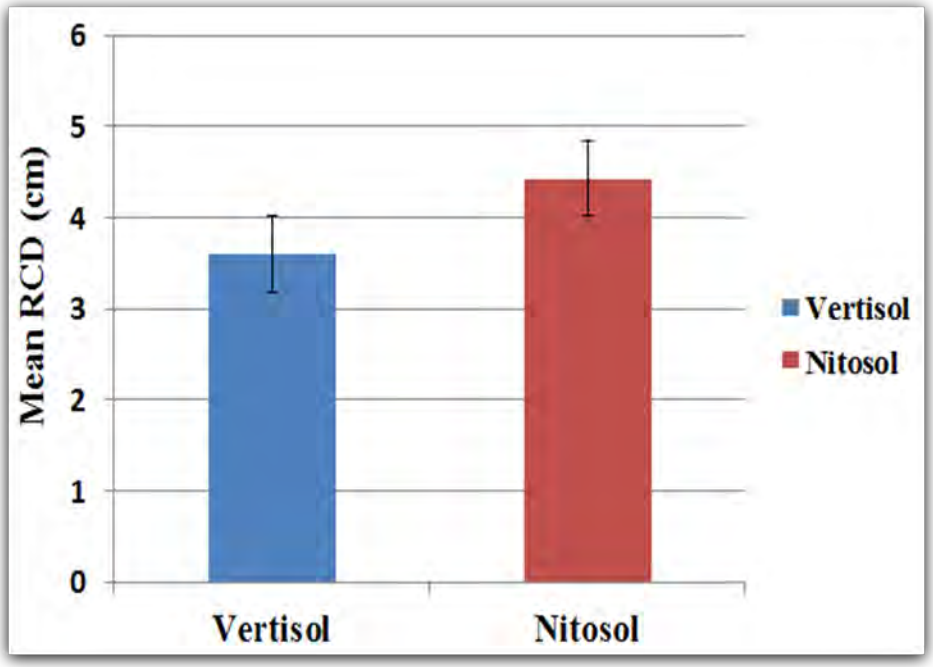

Figure 16: Mean root collar diameter (RCD) (cm) of *C. africana* seedlings 7 months after harvesting in vertisol and nitosol under nursery bed conditions. Data points represent the mean RCD on the respective days. Vertical bars indicate ± SE (n = 10).

5.2.2.5 Biomass Production

Table 1: Mean dry weight of shoot, root, total dry and shoot to root ratio of seedlings of *C. africana* have harvested after 7 months with vertisol and nitosol under nursery bed conditions.

Soil type	Mean shoot dry weight (g)	Mean root dry weight (g)	Mean total dry weight (g)	Mean shoot/root ratio
Vertisol	9.47	1.85	11.32	5.12
Nitosol	12.93	4.74	17.67	2.73

Mean total dry weight was recorded after 7 month developmental stage of growth for *C. africana* seedling provided in (Table 1). Significant difference was observed in biomass among the seedling grown on different soil type. The mean total dry weight of seedling grown in nitosol was (17.67 g.) was significantly ($p \leq 0.01$) larger than vertisol was (11.32 g.), (Appendix 6).

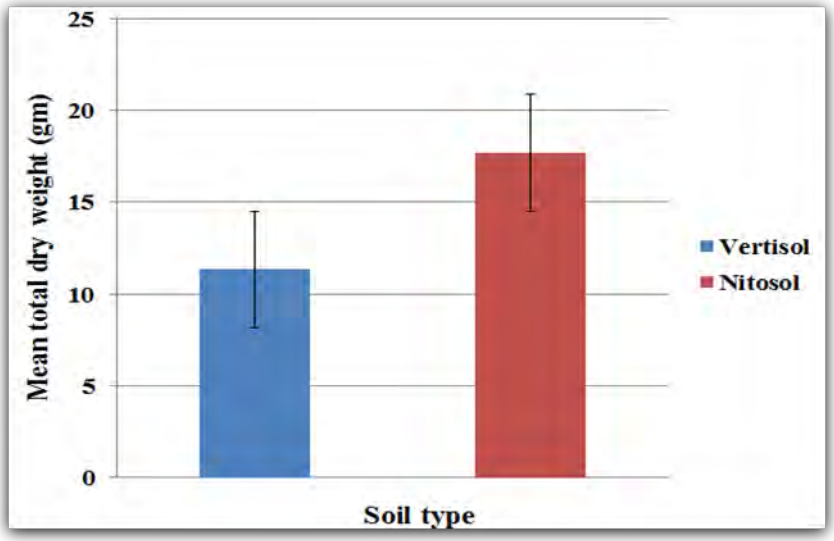

Figure 17: Mean total dry weight (g.) of *C africana* seedlings have harvested after7months with vertisol and nitosol under nursery bed conditions. Vertical bars indicate ± SE (n = 10).

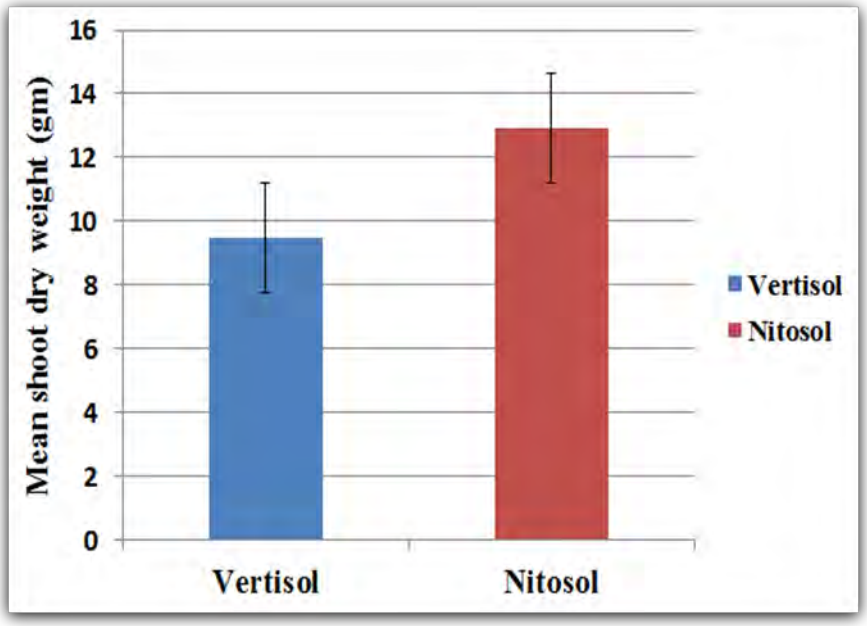

Figure 18: Mean shoot dry weight (g.) of *C. africana* seedlings have harvested after 7 months with vertisol and nitosol under nursery bed condition. Vertical bars indicate ± SE (n = 10).

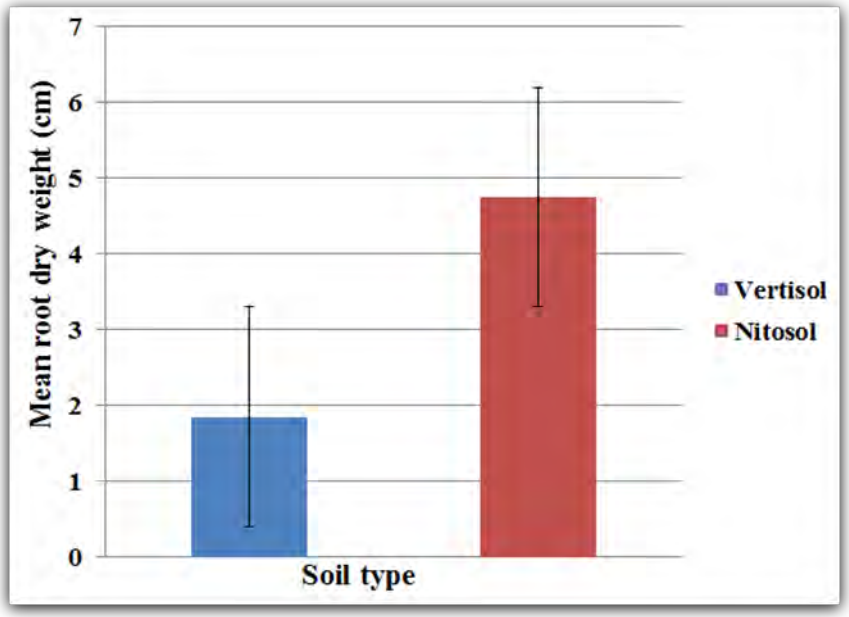

Figure 19: Mean root dry weight (g.) of *C. africana* seedlings have harvested after 7months with vertisol and nitosol under nursery bed condition. Vertical bars indicate ± SE (n 10).

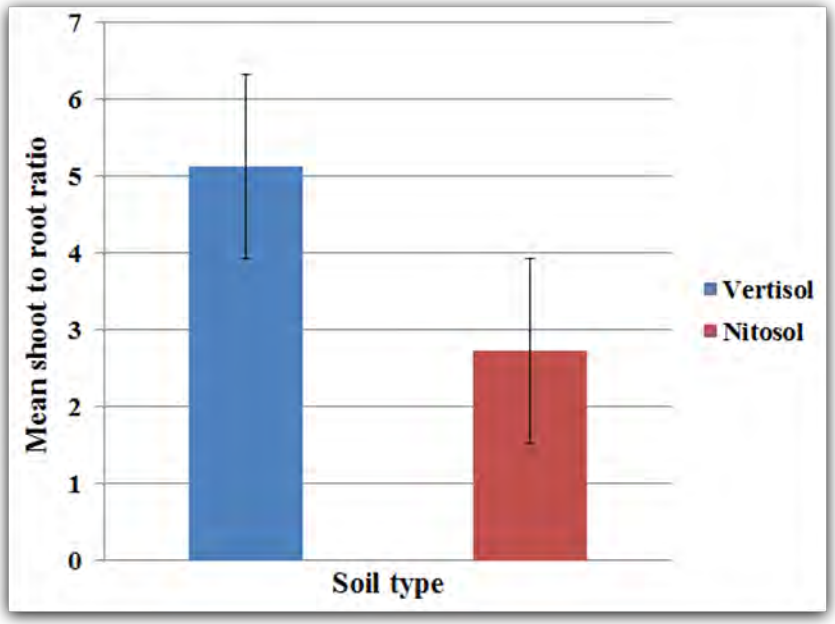

Figure 20: Mean shoot root ratio *C. africana* seedlings have harvested after 7 months with vertisol and nitosol under nursery bed condition. Vertical bars indicate ± SE (n = 10)

5.2.2.6 Results of Soil Analysis

The major soil property of each soil indicated that each soil type is below the standard, organic carbon (1.19 % for vertisol and 2.266 % for nitosol compared to the standard average value of (4-10 %), available P (8 ppm for nitosol and 10 ppm compared to the standard average value (14-19 ppm), and total N (0,059 % for vertisol, and 0.113 % for nitosol compared to the standard 0.2-0.5 %).

Table 2: Soil analyses results of vertisol and nitosol (from the depth of 0–20 cm) weighting1Kg were collected for each respective soil type.

Type of soil	pH (H_2O)	% organic carbon	Available P	CEC	Total N%	Exch. Na^+ mg/Kg soil	Exch. K^+ mg/Kg soil	Texture				Bulk Density g/cm^3
								% Sand	%silt	% clay	class	
Vertisol	7.2	1.19	10	58.22	0.059	66	234	16	20	64	Heavy clay	1.05
Nitosol	6.23	2.266	8	33.96	0.113	36	172	14	28	58	clay	0.97

6. DISCUSSIONS

6.1. Seed Germination Study of *C. africana* Seeds Under Open Nursery Bed Conditions

The results of the present study indicated that germination percentage of *Cordia africana* seeds planted in nitosol was 75.2 %, while seeds planted in vertisol were 62.4 % (Figure 9) and (Appendix 7). Seed germination percentage in nitosol was better than seed germination percentage in vertisol. This may be due to the well-known characteristics of vertisol, which is very clayey (Ahmad and Marmut, 1996), and thus has high water-holding capacity (Table 2). Consequently, poor drainage and impaired aeration, prevented faster germination in vertisol, compared to nitosol (Brady and Weil, 1999).

The seed germination in nitosol began on the 38^{th} day, while in vertisol began at 42^{th}, the extended time was observed in vertisol. The soil laboratory result indicated in (Table 2) relatively higher proportion of sand in vertisol that may have reduced the temperature of seed germination environment to some extent than nitosol (Brady and Weil, 1999).

All seeds planted in the plastic sleeves did not germinate; more than sixty percent seed germination was achieved in the present study. Some seeds did not germinate may be due to the mechanism developed by the species to avoid hazard conditions which is not suitable for establishment of seedling from the germinant (Legesse Negash, 1995; 2010). Extensive surveys of germination of fresh seed planted under suitable conditions indicated that rapid germination is the most common response in tropical rain forests although delayed germination is fairly common (Garwood, 1989). Because, chemicals that accumulate in the fruit seed coat during development and remain in the seed after harvest such as phenols, coumarin, and abscissic acid act as germination inhibitors

6.2 Growth Performances Study of *Cordia africana Seedlings* Under Open Nursery Bed Condition

6.2.1 Height Increment

Seedlings of the same species may have difference in seedling height due to in different factors (Agren and Ingested, 1987).This study showed that *C. africana* seedlings attained maximum height in nitosol. Seedling growth of *C.africana* significant ($p \leq 0.01$) height difference was observed in seedlings that was grown in vertisol and nitosol. The final seedling height in nitosol was higher (40.61 cm) than vertisol (34.95 cm) (Figure 12 and Appendix 1).

From the present study seedlings of *C. africana* grown in nitosol showed better height increment compared to seedlings grown in vertisol, this may be due to high amount of soil organic carbon, available nitrogen, and well physical and chemical property of nitosol, and easy of nutrient up take of the seedling by their root, because low proportion of sand, clay, and bulk density in the nitosol compared to vertisol.

The reduction of height of seedling in vertisol may be due to low amount of soil organic carbon, available nitrogen, and higher proportion of sand, clay, and bulk density. Higher level of sand which increases the level of drainage and nutrient leaching, higher level of clay result poor drainage and aeration. According to Hare (1990), increased bulk density reduces soil water availability, and aeration, and hence reduces height.

Higher content of Nitrogen in nitosol resulted in higher growth parameters and healthiest height of plants compared to vertisol (Sarker *et al*., 2002). Similarly several studies several studies reported Nitrogen is more significant than other nutrient than other nutrients for vegetative growth such as height growth of plants (Hossain *et al*., 2011).

According to Chane (2010), soil organic carbon plays a role improving water efficiency via its effect on soil structure and associated soil properties. Attributes like increased water holding capacity, higher infiltration rate, and higher nitrogen availability arising from increased soil organic carbon. In addition nitosol was very important component of soil mixture establishment of indigenous trees of Ethiopia (Legesse Negash, 1995, 2010).

6.2.2 Leaf Number

In the present study data indicated (Figure 14) leaf number was found higher in nitosol than vertisol i.e. for nitosol-grown plants (mean number of leaves per plant = 16) compared to those grown in vertisol (with mean number of leaves per plant = 13). This might be is higher amount of soil organic carbon and available nitrogen in nitosol (Appendix 3).

Seedling grown in vertisol exhibited lower number of leaves. This may to be due presence of lower amount of soil organic carbon and available nitrogen, and high proportion of sand leaching of nutrients, high proportion of clay, poor drainage and aeration, and high proportion of bulk density, reduce soil water availability and aeration.

Seedlings grown in nitosol revealed better leaf number than vertisol. These trends of increased number of leaves might be due to increased application of Nitrogen. Nitrogen application was essential due to increase in cell number at the leaf base in elongated young leaves, and hence increases leaf number. It was suggested that, the cytokinin may play a role in leaf elongation either through cell division or cell elongation rate following nitrogen may be due to an increasing in availability of cytokinin to the shoot which normally produce in root tip. The production of cytokinin decline under nitrogen stress (Sattmarcher and Marashner, 1998; Goodwin and Erwee, 1983).

6.2.3 Leaf Area

The present study confirmed that better leaf area (670.88mm^2) was found in nitosol than vertisol leaf area (544.22 mm^2) provided (Figure 15) and (Appendix 4). This might be due higher amount of Nitrogen found in nitosol.

Seedlings grown in vertisol exhibited less leaf area and this was due to the presence of lower amount of Nitrogen.

Seedlings grown in nitosol revealed better leaf area than vertisol; this maybe due toincreased application of Nitrogen. Nitrogen application influence plants, increased Nitrogen supply increases the leaf area development and leaf area duration and tiller formation (Nevin and Loomis, 1990).

According to Watson (1994), inadequate nitrogen reduce plant growth, primarily restricting leaf area, subsequently several researchers have shown that decreased leaf area and dry matter production were due to Nitrogen limitation which was mainly responsible for reduction in seed yield at maturity (Sing and Anderson, 1993).

6.2.4 Seedling Biomass

In present study, mean total dry weight among seedlings grown in different soil type was observed, seedlings grown in nitosol showed better mean total dry weight, mean shoot dry weight, and mean root dry weight than grown in vertisol (Table 1), (Figure 17), and (Appendix 6). This could be higher composition of soil organic carbon and Nitrogen.

According to Meldu (2005), it is possible to say that the proportion of soil organic carbon and Nitrogen are influential to enhance biomass since it is they are rich in plant nutrition. Other author Murata (2009), reported that Nitrogen encourage the formation of long lived green foliage with full complement of photosynthetic component and enzyme for Nitrogen assimilation. This results in greater biomass production and higher grain (seed yield).

The study revealed that different allocation of biomass to shoots and roots, which affected growth performance. The presence of higher soil organic carbon and Nitrogen in nitosol increased biomass allocation to shoot more than root. Nitosol from this result showed better growth and distribution of dry matter in the seedlings of *C. africana* than vertisol.

According to Coder (1998), increased biomass allocation to shoots than roots, could be due to a decline in carbohydrate which will initiate more shoot production. The result is a greater allocation of carbohydrate to shoot production and less to root.

6.2.5 Root Collar Diameter (RCD)

From the present study data indicated (Figure 16) RCD was found better seedlings grown in nitosol (4.43 cm) compared to seedlings grown in vertiso (3.4 cm).

The reduction in RCD seedlings grown in vertisol may be because higher amount of clay i e. montomorillonite makes vertisol shrink and swell (Hubble, 1997), and also having higher bulk density reduce aeration, increase water holding capacity this result in water logging. According to Hare (1990), increased bulk density reduces soil water availability, and aeration.

Seedlings grown in nitosol revealed better RCD this may be because of the presence of more organic carbon, and Nitrogen, and good proportion of sand, silt, and clay (soil texture).

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. Conclusions

Seeds of *C. africana* don't require pretreatment with different germination stimulator such as, GAs, KNO_3, and fire (Legesse Negash, 1995). The present study showed that higher germination percentage seeds planted in nitosol which was 75.2 % than compared to seeds planted in vertisol which was 62.4 %. This is because the presence of more clay, and high bulk density in vertisoil, result in poor drainage and aeration for seed germination. Generally the germination percentage of *C. africana* seeds planted in both types of soils was more than 60 %,in addition to that germination began in nitosol on the 38^{th} day, while in vertisol began on the 42^{th} days. According to Legesse Negash (1995), the rate and percentage germination of *C. africana* is very good, however a slow germinating type was stated by Azene et al., (1993).

From the present study *C. africana* grown in nitosol attained a height of 41 cm within 7 months suggesting that the species is one of Ethiopia's fastest growing native tree species. From these results, it is concluded that *C. africana* plants grow much better in nitosol than in vertisol, and that restoration and/or afforestation of this species must take into consideration the proper choice of soil type.

C. africana showed better growth performances of internodal length, leaf number, leaf area, biomass, and root collar diameter, in nitosol compared to vertisol. From the result, nitosol relatively with more organic carbon and nitrogen, better soil texture (sand, silt, clay) and lower bulk density for aeration and water(moisture) holding.capacity.

7.2. Recommendations

Growth performance of seedling of *C. africana* in nitosol resulted in better growth performances (height, intermodal length leaf number, leaf area, root, collar diameter) and mean dry weight than vertisol; therefore nitosol recommended for seedling establishment and growth.

From the present study seed germination of *C. africana* seeds planted in vertisol and nitosol, showed better seed germination percentage, mean germination time, and germination vigor

seeds planted in nitosol than vertisol under open nursery bed conditions. However, data analyses indicated (appendix 7 A, B, and C) showed there was no significant difference ($P \leq 0.05$) between vetrisol and nitosol treatments for all germination parameters measured. So that it requires further study on germination parameters under glass house conditions.

Indigenous trees are important for soil conservation, hydrological cycle, medicine, but now a day they are decline in alarming rate, so that responsible authors give attention and priority for indigenous trees conservation, sliviculture nursery technique, and propagation.

8. REFERENCES

Aberra Geyide, Dawit Abebe, Asefaw Debella, Zewdeneh Mekonnen, Frehiwot Aberra, Frehiwot Teka, Tesfaye Kebede, Urga, K.,Kidist Yersaw, Tekele Biza. (2005). Screening of some medicinal plants of Ethiopia for their anti-microbial properties and chemical profiles. *Journal of Ethno pharmacology*. **97**(3): 421 - 427.

Aklilu Agidie, Belayneh Ayele, Alemayehu Wassie, Kiros.Hadgu, Ermias Aynekulu, Jeremias Mowo. (2013). Agroforestry Practices and Farmers' perception in Koga watershed, upper blue Nile Basin, Ethiopia. *Agroforestry Practices and Agriculture & Forestry*. **59** (3): 75 - 89.

Alemayehu Wassie. (2004). Opportunities constraints and prospects of Ethiopian Orthodox Tewahdo Church conserving forest resources. M.Sc. Thesis. Faculty of Forestry Swedish University of Agricultural Sciences, Sweden. **70.**

Avelino, J., Banora, B., Davrieux, F. and Gylyot. (2007). Shade effect on sensory and chemical characteristics of coffee from very high land altitude plantation in Costa Rica. Second International Symposium on Multi-strata agroforestry consumer and environment, September 17 – 21, 2007, Turrialba, Costa Rica.

Agren, G. I. and Ingestad, T. (1987). Root: shoot ratio as a balance between nitrogen productivity and photosynthesis. *Ann. Bot.* **10**: 579 –5 85.

Anonymous, A. (2004). *Forest Resources of Ethiopia*. Woody Inventory and strategic Planning Project, Addis Ababa, Ethiopia, 20 Pp.

Azene Bekele, Binie, A. and Tengnäs, B. (1993). *Useful Trees and Shrubs of Ethiopia Identification, Propagation and Pastoral Communities.* Regional Soil Conservation Unit (SIDA) Nairobi, 314 Pp.

Barroco, R. M., Van, P. K., Bergervoet, J. H., De, V. L., Groot, S. P., Inze, D. and Engler, G. (2005). The role of the cell cycle machinery in resumption of post development *Plant Physiol***. 137**: 127 - 140.

Baskin, J. M. and Baskin, C. C. (1998). *Seeds Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, New York, 666.Pp.

Bewley, J. D. and Black, M**.** (1994). *Seeds: Physiology of development and germination* 2nd edn. Plenum press, New York, 445.Pp.

Bewley, J. D. (1997). Seed germination and dormancy. *Plant Cell.* **9:** 1055 - 1066.

Black, C. R., Howard, S. B., Lott, J. E. and Ong, C. K. (2000). Algometric estimation of above ground biomass and leaf area in managed *Grevillea robusta* agroforestry systems. *J. Agroforestry Systems.* **49**: 1 - 15.

Brady, N. and Weil, R. (1999). *The nature and properties of soils*, 12th ed, Prentice-Hall **In**: Sydney.

Carr, G. D. (2006). *Boraginaceae. WWW.botany.hawaii.edu/faculty/Carr/boragina.htm.*

Chan, K. Y., Oates, A., Lui, D. L., Prangnell, R., Poile, G. and Conyers, M. K. (2010). A farmer's guide to increasing soil organic carbon under pastures, Industry &Investment NSW, Australia. ISBN 978 1 74256 010 6.
http://www.dpi.nsw.gov.au/pubs/increasing-soil-organic-carbon.

Chifundera, K. (2001). Contribution to the inventory of medicinal plants from the Bushi area, South Kivu Province, Democratic Republic of Congo.Fitoterapia. **72** (4): 351 - 368.

Coder, K. D. (1998). *Control of Shoot-root balance in trees*, publication for 98 - 003. The University of Georgia, School of Forest Resources Extension.

CSIRO. (1979). *Organic Matter and Soils*, Discovering Soils Booklets, Division of Soils, common wealth Scientific and Industrial Research Organization.

Daddow, R. L. and Warrington, G. E. (1983). Growth-limiting soil bulk densities as influenced by soil texture. Watershed systems development group, USDA forest service, Fort Collins, Colorado, 80524.

Demele Teketay and Abeje Eshete. (2004). Status of Indigenous Fruits in Ethiopia. In IPGRI-SAFORGEN (ed.). *Review and Appraisal on the Status of Indigenous Fruits.* Eastern Africa. Nairobi, Kenya: AFREA/FORNESSA. Pp. 3 - 35.

Demele Teketay. (2005). Seed and regeneration ecology in dry Afromontane forests of Ethiopia: I. Seed production - population structures. *Trop. Ecol.* **46**: 29 - 44.

Demele Teketay and Tegineh, A. (1991). Shade trees of coffee in Hararghe, Eastern Ethiopia *International Tree Crops Journal*. **7**: 17 - 21.

Doran, J. W. (1997). Defining soil quality for sustainable environment, SSSA Special Publ. No. 35, Madison, Wisconsin, USA.

Eghball, B. (1999). Liming effects of beef cattle feed lot manure or compost. Communications **In**: *Soil Science and Plant Analysis.* **30**: 2563 – 2570.

El-Tahir, B. A. (2004). Status of Indigenous Fruits in Sudan. **In**: IPGRI-SAFORGEN (ed.). *Revised.and Appraisal on the Status of Indigenous Fruits in Eastern Africa*. Nairobi, Kenya: AFREA/FORNESSA. Pp. 63 - 80.

Emmanuel, N. (2010). Implications of Fuel Wood Yield, Availability and Harvest in Tubah Mountain Forest, Cameroon. *Global Journal of Human-Social Science Research*. 10 **(3)**: 49 - 55.

Esayas Dagnew. (2000). Soils erosion research in Ethiopia (1981 - 1998). **In**: *Sustainable development of dry land areas of East Africa,* (Feoli, E., Pottier, D. and Zerihun Woldu, eds.). Proceedings of the International Workshop, November 9th-12th, Addis Ababa.

Eshetu Yirdaw, Leinonen, K. (2002). Seed germination responses of four afromontane tree species to red/far-red ratio and temperature. *For Ecol Manag.* **168**: 53 – 61

Feyissa Abate and Mebrate Mihretu. (1994). Provenance Trials of some Exotic and Indigenous Tree Species.

Finch-Savage, W. E. and Leubner-Metzger, G. (2006). Seed dormancy and the control of germination *New Phytologist*. **171**: 501 - 523.

Fichtl, R. and Admassu Adi (1994). *Honeybee Flora of Ethiopia*. Margraf/Verlag, Germany, 510 Pp.

Friis, I. (1989). *Moraceae*: **In** Flora of Ethiopia. Pp 271-286. (Hedberge, I. and Edward, S., eds.), *Pittosporaceae* to *Araliaceous*. Addis Ababa University and Asmera, Ethiopia; Uppsala, Sweden, The National Herbarium. Vol. **3**.

Friis, I. (1992). Forests and forest trees of North East tropical Africa. Kew Bull., additional. Series (XV), 396 Pp.

Gaikwad, St.Rao, Y. S. and Verma, H. K. (1995). Indian Soc .*soil Sci.*22 (**2**): Pp**.** 181 - 190.

Garwood, N. C. (1989). Tropical soil seed banks: a review. Pp. 149-209. **In**: Leck, M. A., Parker, V. T. and Simpson, R. L. (eds.). *Ecology of Soil Seed Banks*. Academic Press San Diego & California.

Gebregziabehere Zenebe, Zerihun, Zewdie Solomon. (2012). Anethno botanical study of medicinal plants **In**: Asgede Tsimbila district, Northwestern Tigray, Northern Ethiopia. Ethno botany Research and Applications. **10**: 305 - 320.

Gindaba, J, Rozanov, A., Legesse, L. (2004). Response of seedlings of two *Eucalyptus* and three *deciduous tree species* from Ethiopia to severe water stress. Forest Ecology and

Management. **201**: 119 - 129.

Girma Balcha. (2002). Conservation & sustainable use of Forest Genetic resources: Proceedings a natural conference on Forest Resource of Ethiopia: status, Challenges and opportunities. Pp. 27 - 29.

Goodwin, P. B. and Erwee, M. G. (1983). Hormonal influence of leaf growth; **in**: *The Growth and functioning of leaves* Pp**.** 207 – 232 eds Dle, J. E. and Milthorpe, F. L. (New York: Cambridge University press.

Hadas, A. (2004). Seed bed preparation the soil physical and environment of germinating seeds: **In:** Handbook of seed physiology applications to agriculture, Pp**.** 3 - 49. (Roberto, L., Benech, A. and Sanchez, R. A. eds). Food Products Press and The Haworth Reference Press, imprints of The Haworth Press, Inc., 10 Alice Street, Binghamton, NY 13904 - 1580.

Hare, C. J. (1990). Some observations on various soil physical properties and their bearing on yield of sugarcane on a Berbice sugar estate. Proc. Brit. West Indies Sugar Technol. Pp. 80 - 86.

Hartmann, H. T., Kester, D. E., Davis, F. T. and Geneva, R. L. (2004). *Plant Propagation Principles and Practices*.6th ed. Prentice Hall of India Press, New Delhi, 770 Pp.

Hedberge, I. and Edward, S. (1990). *Pittosporaceae* to *Araliaceous*. Addis Ababa University and Asmara, Ethiopia; Uppsala, Sweden, the National Herbarium, Vol. **3**.

Hossain, M. A., Ishimine, Y., Akamine, H., & Kuramochi, H. (2004). Effect of nitrogen fertilizer application on growth, biomass production and N-uptake of torpedograss (*Panicum repens* L.). *Weed Biology and Management, 4*, 86 – 94.10.1111.

Hubble, G. D. (1997). *The Properties and Utilization of Cracking Clay Soils*, *Review in Rural Science*, University of New England Arm dale, New South Wales, Pp. 3-13.

ICRAF. (1998). International Centre for Research in Agroforestry. Agroforestry data base*: Cordia africana* Lam.

ICRAF. (2008). *Cordia africana*. A tree species reference and selection guide World Agroforestry Centre database. Nairobi: ICRAF. Available. at:*http*://www.world agroforestry.org/treedb2/ /AFTPDFS/Cordia_africana.pdf (accessed: 4 10 2008).

ISTA. (1999). International rules for seed testing association. *Seed Science and Technology* 27 supplement.

Jaenicke, H. (1999). Good Tree Nursery Practices: Practical Guidelines for Research Nurseries. Majestic Printing Works Nairobi, Kenya**,** 91 Pp

Jansen, P. C. M. (1981). *Spices, Condiments and Medicinal Plants in Ethiopia: Their Taxonomy and Agricultural Significance.* Wageningen, the Netherlands, 91 Pp.

Kokwaro, J. O. (2009). Medicinal plants of east Africa. 3rd ed. Nairobi, Kenya: University of Nairobi press. Pp. 478.

Koller, D. and Hadas, A. (1982). Water relations in the germination of seeds. **In**: *Encyclopedia of Plant Physiology*, Vol. 12B, Pp. 401 - 431 (Lange, O. L., Nobel, P. S., Osmond, C. B., and Zigler, H. eds), Berlin.

Krock, B., Schmidt, S., Hertweck, C. and Baldwin, I. T. (2002). Vegetation derived abscisic acid and four terpenes enforce dormancy in seeds of the post-fire annual, *Nicotiana attenuata*. Seed Sci. Res. **12**: 239-252.

Legesse Negash. (1990). Ethiopia's Indigenous Forest Species and the Pervasive Effects of Deforestation.*SINET newsletter.Vol.* **14***.* No. 2.

Legesse Negash. (1993). Investigations on the germination behavior of wild olive se Eds and the nursery establishment of the germinates. *SINET: Ethiop. J. Sci.* **16:** 71-81.

Legesse Negash. (1995). *Indigenous trees of Ethiopia: Biology, uses and propagation techniques.* Printed by the SLU Reprocentralen, Umeå, Sweden, ISBN 91-7191-105-285 Pp.160 – 285.

Legesse Negash. (2002a). Review of research advances in some selected African trees with special reference to Ethiopia. Review article. *Ethiop. J. Biol. Sci*. **1**: 81-126.

Legesse Negash. (2004). Rapid seed-based propagation method for the threatened African Cherry (*Prunus africana*). *New Forests.* **27**: 215-227.

Liu, P. P., Koizuka, N., Homrichhausen, T. M., Hewitt, J. R., Martin, R. C. and Nonogaki, H. (2005). Large-scale screening of Arabidopsis enhancer-trap lines for seed germination-associated genes. *Plant J.* **41**: 936-944.

MacDougall, I., Morton, W. H. and Williams, M. A. J. (1995). Age and rate of denudation of the trap series basalts at Blue Nile Gorge, Ethiopia. *Nature.* **254**: 207-209.

MacLachlam, M., Getaneh Eshetie and Terfera Getahune. (2001). *Manual of high land trees: prepared for development agents of "dega'' area in region 3;* SIM Forestry study project. 310 Pp.

Manz, B., Muller, K., Kucera, B., Volke, F. and Leubner-Metzger, G. (2005). Water uptake and distribution in germinating tobacco seeds investigated in vivo by nuclear magnetic resonance imaging. *Plant Physiol*. **138**: 1538-1551.

Meludu, N. T. (2005). Use of human waste in sustainable crop production in Nigeria.*J. Environ.Extn*. **5**: 65-70.

Michael, M. C. (2005). Determining the Effects of Water temperature and exposure terms on Seed Germination; California State *Science Fair.*

Mog‟omba, S. A., DuToit, E. S. and Akinnifesi, F. K. (2007). Germination Characteristics of Tree Seeds: Spotlight on Southern African Tree Species. *Tree and Forestry Science and Biotechnology*, South Africa, Pp. 1 - 8.

Moir, K., Vandenbosch, T. and Scull-Carvalho, S. (2007). Growing trees and Gardens for life; Practical Tips for healthy tree nurseries and home gardens, Jacaranda Designs Ltd, ISBN 9966-956-54-9Nairobi, Kenya, 85 Pp.

Montes, N., Gauquelin, T., Badri, W., Bertaudiere, V. and Zaoii, E. (2000). A nondestructive method for estimating above ground forest biomass in threatened woodlands. *Forest Ecology and Management.* **130**: 37-46.

Murata, Y. (2009). Physiological response to nitrogen in plants; in Physiological Aspects of Crop yield.Pp.235 – 259 (eds). Eastin, J. C., Heskins, F. A., Sullivan, G. Y. and vanVele, C. H. M. (madidson, Wiscons: Amer.Soc. Agron).

Mushecher, R. (2001). Shade improves coffee quality in a sub–optimal coffee zone Costa Rica. Agroforestry system. **85**: 113 – 139.

Negarit Gazeta. (1994). Forestry Conservation, Development and Utilization proclamation of the Federal Democratic Republic of Ethiopia.Proclamation no 94/1994 Addis Ababa. Ethiopia.

Neff, M. N., Sanderson, L., and Tedor, D. (2009). Light-mediated germination in lettuce Seeds: Resurrection of a classic plant physiology lab exercise. American Biology Teacher. **71**(6): 367 - 370.

Nevin, D. T. and Loomis, R. S. (1990). Nitrogen nutrition and photosynthesis in sugar beet (*Beta vulgaris* L.); *Crop sci*. **10**: 21–25.

Nordborg, F. (2001). Effects of Site Preparation on Soil Properties and on Growth, Damage and Nitrogen Uptake in Planted Seedlings.Swedish University of Agricultural Sciences, Doctoral thesis.

Otieno, J. N., Magadula, J. J., Kakudidi, E., Kirimhuzya, C., Orodho, J. and Okemo, P. (2011). Use of ethno botanical criteria for conservation assessment of plants used for respiratory diseases in Lake Victoria region, Tanzania. *International Journal of Biodiversity and Conservation*. **3** (11): 610 – 617.

Piotto, B. and Di Noi, A. (2003). Seed propagation of Mediterranean trees and shrubs. Agency for the protection of the environment and for technical services Via Vitaliano Brancati. 48-00144 Roma–Italy.

Probert, R. J. (2000). The role of temperature in the regulation of seed dormancy and germination **In**: Fenner, M. (ed) Seeds: ecology regeneration of plant communities. CABI Publishing, Wallingford.

Raven, P. H., Ray, F., Evert, Susan, E., Eichhorn. (2005). *Biology of Plants, 7th ed*. New York: W. H. Freeman and Company Publishers. Pp. 504–508.

Roy, B. B., Barde, N. K. (1992). *Soil Sci.* 93, 142.

Sahar Tewolde-Berhan, Fagertun, R. S., Kebede Abegaz, Judith, N., Feniet Abay, Trude, W., Ferric. (2013). Reducing Antioxidant Power and total Phenols in *Cordia africana. Journal of Biochemistry Research.* 7(**11**): 215 -224.

Sarker, M. A. Z., Murayama, S., Akamine, H., & Nakamura, I. (2002). Effect of nitrogen fertilization on photosynthetic characteristics and dry matter production in F1 hybrids of rice (*Oryza sativa* L.). *Plant Production Science, 5*, 131–138.10.1626/pps.5.131.

Sattelmatcher, B. and Marscher, H. (1998). Nitrogen nutrition and cytokinin activity in S*olnum Tuberosum: physiol. Plant*. **42**: 185–189.

Singh, R. P. and Anderson, R. G. (1993). Nitrogen dry- matter accumulation and dwarf wheat verities as influenced by nitrogen fertilization; *India J. Agric. Sci*. **43**: 570-579.

Slaye, J. A., Harcourt, C. S. and. Collins, N. M. (1992). The conservation Atlas of Tropical Forests of Africa. Macmillan, basing stroke**.** 288 Pp.

Smith, W., Meredith, T. and Johns, T. (1996). Use and conservation of woody vegetation by the Bateman of Ngorongoro District, Tanzania.*Economic Botany*. **50** (3):290 - 299

Steiman, S. (2003). Shade versus sun coffee a review. *http*:// www.grey skies.net/ honey bear/ shade.hmt.

Takele Geta, Getachew Animute, Lisaneworke Nigatu, (2014). Evaluation of potential yield and chemical composite of selected indigenous multi-purpose fodder trees in three districts of Wolayta Zone, Southern Ethiopia. IDOSI Publications, *World Appl Sci J*. **31**(3):399- 405.

Taiz, L. and Zeiger, E. (2002). *Plant Physiology*. 3rd ed Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, ISBN: 0878938230, 690 Pp.

Teklehaimanot Ghebreyesus and Haile, M. (2007). Women in Backyards: Root Crop Production and Biodiversity Management in Back yards. Oslo: Dry land Coordination Group. Pp. 1–63.

Tilahun Teklehaymanot, Mirutse Giday, Girmay Medhin and Yalemtsehay Mekonnen. (2007). Knowledge and use of medicinal plants by people around Debre Libanos monastery in Ethiopia. *Journal of Ethno.pharmacology*. **111**(2): 271 - 283.

Ton, G. (2008). Challenges for small holder market access: a review of literature on institutional arrangements **in**: collective marketing. *Stewart Postharvest Review*. **4**(5): 1-6.

Vaast, P., VanKanter, R., Dzib, B., Franck, N. and Harmand, J. M. (2006). Shade key for coffee sustainability and quality, 887 – 896. ASIC 2006, Montpellier France.

VanStaden, J., Brown, N. A. C., Jager, A. K. and Johnson, T. A. (2000). Smoke as a germination cue. *Plant Species Biology.* **15**: 167 - 178.

Wang, Y. L., Tang, J. W., Zhang, H. L., Schroder, J. L. (2014). Phosphorus availability and sorption as affected by long-term fertilization. **106**: 1584 – 1592.

Warfa, A. M. (1988). *Cordia (Boraginaceae*) **in**: New Tropical Africa and Tropical Arabia. Ph.D. Thesis, Uppsala University. 78 Pp.

Washa, B. W. and Nyomora, A. M. S. (2012). The effect of moisture and seed treatment on the In-situ and ex-situ regeneration of *Dabergiamel anoxylon* (African Blackwood) **in**: Pugu Forest reserve. *HURIA Journal*. **10**: 56 - 70.

Watson, D. (1994). Comparative physiological studied on the growth of field crops II. The effect of varying nutrient supply on net assimilation rate and leaf area; *ann. Bot*. **11**: 375 – 407.

Yadessa, A., Itanna, F. and Olsson, M. (2001). Contribution of indigenous trees to soil properties: The case of scattered trees of *cordial africana* Lam. **In**: crop lands of western Oromia. *Ethiopian Journal of Natural Resources.* 3(**2**): 245 - 270.

Yürekli, F. (2008). Giberellinler: Bitkilerde uzamayı düzenleyiciler. Bitki Fizyolojisi *(Plant Physiology* 3rd. ed. Taiz, L and Zeiger, E. (Translation ed. İ.Türkan).Pp. 461 - 492. (in Turkish).

Zerihun Woldu, Dragan, M., Feoli, E. and Fernetti, M. (2002). Reducing soil erosion in Northern Ethiopia, Adawa zone, through application of a Spatial Decision Support System (SDSS).*Ethiop. J. Biol. Sci*. **1**: 1-12

9. APPENDICES

Appindix 1: Mean height in cm *Cordia africana* seedlings grown in vertisol and nitosol

A . At 90 th days

Samp. No	Vertisol	Nitosol
5	2.8	3.5
12	2.5	3.5
21	3	3.5
24	3.2	3.5
27	3	3
33	2.5	3.5
37	3.5	3.5
39	3	3.7
43	2.8	3.5
48	2.7	4

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	29	2.9	0.09556
Column 2	10	35.2	3.52	0.05956

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	1.922	1	1.922	24.7822	9.73341E-05	4.41387
Within Gr	1.396	18	0.07756			
Total	3.318	19				

B. At 120 th days

Samp. No	Vertisol	Nitosol
5	5.5	8.5
12	5	8
21	7	7.5
24	5.5	8
27	9	6.5
33	5	9
37	9	9.5
39	5.3	9.6
43	5.5	8.8
48	6.5	8

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	63.3	6.33	2.37789
Column 2	10	83.4	8.34	0.89378

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	20.2005	1	20.2005	12.3488	0.002478027	4.41387
Within Gr	29.445	18	1.63583			
Total	49.6455	19				

C. At 150 th days

Samp. No	Vertisol	Nitosol
5	12	18
12	13.5	16.5
21	17	17
24	10.5	17.5
27	14	15
33	8.5	15.5
37	18.5	15.5
39	10.7	16.7
43	11.5	16
48	12.5	16.6

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	128.7	12.87	9.180111
Column 2	10	164.3	16.43	0.889

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	63.368	1	63.368	12.58661	0.002299351	4.413873
Within Gr	90.622	18	5.034556			
Total	153.99	19				

D. At 180 th days

Samp. No	Vertisol	Nitosol
5	18.5	24.5
12	25.5	28.5
21	28	31.5
24	21	31
27	24	28
33	12	28.3
37	29	29.5
39	17.8	27.8
43	19.5	29
48	25.5	29.7

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	220.8	22.08	27.84178
Column 2	10	287.8	28.78	3.770667

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	224.45	1	224.45	14.2001	0.001407366	4.413873
Within Gr	284.512	18	15.80622			
Total	508.962	19				

E. 210 th days

Samp. No	Vertisol	Nitosol
5	30.5	39.5
12	38.5	37
21	35.5	43
24	37	42.5
27	37.5	45.5
33	26.5	39.6
37	40	40
39	33	37
43	35	38.6
48	36	43.4

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	349.5	34.95	16.13611
Column 2	10	406.1	40.61	8.189889

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	160.178	1	160.178	13.16928	0.001919487	4.413873
Within Gr	218.934	18	12.163			
Total	379.112	19				

Apendix 2: Mean internodal length in mm *Cordia africana* seedlings gr in vertisol and nitosol.

A. At 90 th days

Samp.No	Vertsol	Nitosol
5	6	8
12	6	8
21	7	8
24	6	7
27	8	7
33	7	6
37	7	7
39	6	8
43	6	6
48	8	7

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	67	6.7	0.67778
Column 2	10	72	7.2	0.62222

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	1.25	1	1.25	1.92308	0.18245	4.41387
Within Gr	11.7	18	0.65			
Total	12.95	19				

B. At 120th days

Samp.No	Vertisol	Nitosol
5	10	12
12	11	13
21	11	14
24	10	16
27	10	13
33	13	11
37	11	12
39	11	14
43	11	13
48	11	12

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	109	10.9	0.76667
Column 2	10	130	13	2

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	22.05	1	22.05	15.9398	0.00085	4.41387
Within Gr	24.9	18	1.38333			
Total	46.95	19				

C .At 150 days

Samp.No	Vertisol	Nitosol
5	18	19
12	17	22
21	28	25
24	18	25
27	17	19
33	19	20
37	19	22
39	18	24
43	16	20
48	18	21

Anova single factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	188	18.8	11.2889
Column 2	10	217	21.7	5.34444

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	42.05	1	42.05	5.05611	0.0373	4.41387
Within Gr	149.7	18	8.31667			
Total	191.75	19				

D. At 180 th days

Samp.No	Vertisol	Nitosol
5	27	32
12	28	35
21	31	36
24	26	31
27	24	37
33	29	37
37	33	31
39	29	32
43	24	39
48	27	34

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	278	27.8	8.17778
Column 2	10	344	34.4	8.04444

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	217.8	1	217.8	26.8521	6.3E-05	4.41387
Within Gr	146	18	8.11111			
Total	363.8	19				

E. At 210 th days

Samp.No	Vertisol	Nitosol
5	33	42
12	37	45
21	38	48
24	34	45
27	31	47
33	35	43
37	40	47
39	34	39
43	31	43
48	33	45

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	346	34.6	8.71111
Column 2	10	444	44.4	7.37778

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	480.2	1	480.2	59.6934	4E-07	4.41387
Within Gr	144.8	18	8.04444			
Total	625	19				

Apendixe 3: Mean leaf number *Cordia africana* seedlings grown in vertisol and nitosol

A. At 90 th day

Samp. No	Vertisol	Nitosol
5	4	5
12	4	5
21	4	4
24	4	5
27	4	4
33	3	4
37	5	4
39	3	5
43	4	5
48	4	4

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	39	3.9	0.32222
Column 2	10	45	4.5	0.27778

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	1.8	1	1.8	6	0.02477	4.41387
Within Gr	5.4	18	0.3			
Total	7.2	19				

B. At 120 th days

Samp. No	Vertisol	Nitosol
5	5	6
12	5	7
21	5	6
24	5	7
27	5	8
33	4	5
37	6	8
39	6	6
43	5	7
48	5	7

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	51	5.1	0.32222
Column 2	10	67	6.7	0.9

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	12.8	1	12.8	20.9455	0.00023	4.41387
Within Gr	11	18	0.61111			
Total	23.8	19				

C. At 150th days

Samp.No	Vertisol	Nitosol
5	6	9
12	7	8
21	6	9
24	7	9
27	8	7
33	5	6
37	8	8
39	6	9
43	7	8
48	7	9

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	67	6.7	0.9
Column 2	10	82	8.2	1.06667

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	11.25	1	11.25	11.4407	0.00332	4.41387
Within Gr	17.7	18	0.98333			
Total	28.95	19				

D. At 180th days

Samp.No	Vertisol	Nitosol
5	12	13
12	10	12
21	12	13
24	11	14
27	12	12
33	11	12
37	11	12
39	11	13
43	11	12
48	12	13

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	113	11.3	0.455556
Column 2	10	126	12.6	0.488889

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	8.45	1	8.45	17.89412	0.000503	4.413873
Within Gr	8.5	18	0.472222			
Total	16.95	19				

E. At 210 th days

Samp.No	Vertisol	Nitosol
5	14	16
12	14	15
21	14	17
24	13	16
27	14	15
33	14	15
37	15	16
39	14	16
43	12	15
48	13	15

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	137	13.7	0.67778
Column 2	10	156	15.6	0.48889

ANOVA

Source of	SS	df	MS	F	P-value	F crit
Between (	18.05	1	18.05	30.9429	2.8E-05	4.41387
Within Gr	10.5	18	0.58333			
Total	28.55	19				

Appendixe 4: Mean leaf area in mm2 Cordia africana seedlings grown in vertisol and nitosol

A. At 90 days

Samp.No	Vertisol	Nitosol
5	9.36	24.62
12	12.85	15.95
21	18.65	18.65
24	10	17.12
27	12.85	14
33	6.31	21.63
37	20.15	18
39	9.5	24
43	9.58	18.79
48	15.63	16.33

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	124.88	12.488	19.8153
Column 2	10	189.09	18.909	12.1723

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	206.146	1	206.146	12.8891	0.00209	4.41387
Within Gr	287.888	18	15.9938			
Total	494.035	19				

B. At 120th days

Samp.No	Vertisol	Nitosol
5	28	53
12	18.04	50.42
21	40.46	41.21
24	20.33	50.16
27	45.46	43.05
33	12.65	57.87
37	62.96	34.42
39	15.25	43.71
43	24.14	54.13
48	42.86	42.13

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	310.15	31.015	264.815
Column 2	10	470.1	47.01	52.0665

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	1279.2	1	1279.2	8.07367	0.01083	4.41387
Within Gr	2851.94	18	158.441			
Total	4131.14	19				

C.At 150 th days

Samp.No	Vertisol	Nitosol
5	122.54	273.35
12	181.37	277.33
21	250.54	309.83
24	97.13	348.56
27	198.37	271.33
33	60.58	187.75
37	329.29	236.87
39	120.4	255.11
43	108.5	232.54
48	223.35	290.58

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	1692.07	169.207	6823.52
Column 2	10	2683.25	268.325	1967.55

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	49121.9	1	49121.9	11.1754	0.00362	4.41387
Within Gr	79119.6	18	4395.53			
Total	128242	19				
Total	128242	19				

D. At 180th days

Samp.No	verti sol	red soil
5	291.25	457.25
12	420.79	485.58
21	383.66	623.92
24	235.92	635.17
27	466.13	505.87
33	195.04	458.21
37	581.75	467.37
39	305.5	462.31
43	264.55	471.89
48	423.15	564.89

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	3567.74	356.774	14221.2
Column 2	10	5132.46	513.246	4797.23

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	122417	1	122417	12.8736	0.0021	4.41387
Within Gr	171166	18	9509.22			
Total	293583	19				

E. At 210 th days

Samp.No	**verti sol**	**red soil**
5	512.15	557.66
12	679.75	576.13
21	546.95	835.54
24	519.13	831.04
27	677.25	700.63
33	227	601.46
37	701.19	647.13
39	452.15	602.39
43	515.54	588.79
48	611.12	768.08

Anova: Single Factor

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	5442.23	544.223	19641.6
Column 2	10	6708.85	670.885	11300.7

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	80216.3	1	80216.3	5.18491	0.03522	4.41387
Within Gr	278480	18	15471.1			
Total	358696	19				

Appendix 5: Mean root collar diameter in cm s *Cordia africana* seedlings grown in vertisol and nitosol

Samp.No	Vertisol	Nitosol
5	3.1	4.3
12	3.4	4.4
21	3.8	4.8
24	4.3	4.5
27	3.2	4.6
33	2.5	4
37	4.3	4.5
39	3.9	4.3
43	3.7	4.2
48	3.8	4.7

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column	10	36	3.6	0.3133
Column	10	44.3	4.43	0.0579

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between	3.4445	1	3.4445	18.558	0.000423655	4.4139
Within G	3.341	18	0.1856			
Total	6.7855	19				

Appendix 6: Mean total dry weight in g. *Co Cordia africana* seedlings after harverting 7 months

Samp.No	Vrtisol	Nitosol
5	9.6	18.6
12	12.2	16.3
21	13.2	16.6
24	12.4	21
27	10.1	21.5
33	9.1	12.2
37	16	15.9
39	8.5	17.4
43	10.6	18
48	11.5	19.2

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column	10	113.2	11.32	5.0284
Column	10	176.7	17.67	7.2468

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between	201.61	1	201.61	32.849	1.96267E-05	4.4139
Within G	110.48	18	6.1376			
Total	312.09	19				

Appendixe 7: Germination percentage , mean germination time, and germination vigor *Cordia afriicana* seeds planted i in vertisol and nitosol

A. germination percentage (GP)

DAYS	Vertsol	Nitoso
38	0	1.6
40	0	1.6
42	2.8	5.6
44	5.6	7.6
46	8	9.2
48	8.4	10.4
50	9.6	10.8
52	8.4	10
54	7.2	8
56	5.6	4
58	4	2.8
60	1.6	1.6
62	0.8	0.8
64	0.4	0.8
66	0	0.4

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	15	62.4	4.16	12.8183
Column 2	15	75.2	5.01333	15.6084

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between	5.46133	1	5.46133	0.38424	0.54035	4.19597
Within Gr	397.973	28	14.2133			
Total	403.435	29				

B. Mean germination time

Days	Vertisol	Nitosol
38	0	0.323
40	0	0.34
42	0.754	1.251
44	1.579	1.778
46	2.359	2.251
48	2.585	2.655
50	3.077	2.872
52	2.8	2.766
54	2.492	2.297
56	2.01	1.191
58	1.487	0.864
60	0.615	0.511
62	0.318	0.264
64	0.164	0.272
66	0	0.14

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	15	20.24	1.34933	1.30528
Column 2	15	19.775	1.31833	1.05407

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between	0.00721	1	0.00721	0.00611	0.93825	4.19597
Within Gr	33.0308	28	1.17967			
Total	33.038	29				

C. Germination vigor

Days	Vertisol	Nitosol
38	0	0.042
40	0	0.04
42	0.066	0.133
44	0.127	0.172
46	0.173	0.2
48	0.175	0.216
50	0.192	0.216
52	0.162	0.192
54	0.133	0.148
56	0.1	0.071
58	0.027	0.048
60	0.069	0.026
62	0.13	0.013
64	0.066	0.013
66	0	0.016

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	15	1.42	0.09467	0.00458
Column 2	15	1.546	0.10307	0.00657

ANOVA

Source of Vari	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between	0.00053	1	0.00053	0.0949	0.76032	4.19597
Within Gr	0.15615	28	0.00558			
Total	0.15668	29				

Appendix 8: Seedlings *of Cordia africana*. under open nursery bed conditions.

Appendix 9: Seedlings *of C. africana* (7 months) grown in vertisol.

Appendix 10: Seedlings *of C. africana* (7 months) grown in nitosol.

A

B

Appendix 11**: Roots of *C. africana* (7 months old) grown in vertisol** (A) **and nitosol** (B)

DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented to any other university and all sources of information used for the thesis have been fully acknowledged.

Name: _____

Signature_____

Date: _____

This is M.Sc. thesis has been submitted for examination with my approval as an advisor.

Name Prof. Legesse Negash

Date _____