Effect of Seed Treatment, Nursery Potting Media and Watering Frequency on Emergence and Seedling Growth of Korarima (*Aframomum corrorima* (Braun) P.C.M. Jansen)

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Effect of Seed Treatment, Nursery Potting Media and Watering Frequency on Emergence and Seedling Growth of Korarima (*Aframomum corrorima* (Braun) P.C.M. Jansen)

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MASTER OF SCIENCE IN AGRICULTURE (HORTICULTURE)

By

Jafer Dawid Mohammed

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DEDICATION

I dedicate this thesis manuscript to my wife **RAHIMA ABDULKADIR,** my sons **RAMADAN** and **AHMAD** my daughter **HIKMA** for their affections and love in my academic success.

STATEMENT OF THE AUTHOR

I, the undersigned, declare that this thesis is my work and is not submitted to any institution elsewhere for the award of any academic degree, diploma or certificate and all sources of materials used for this thesis have been properly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University Library to be made available to borrowers under the rules of the library.

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BIOGRAPHICAL SKETCH

The author was born in 1960 in Ghimbi Woreda, in former Ghimbi Awraja, now West Wellega Zone. He attended elementary and junior Dejazmach G/Egzihaber School, secondary school at Ghimbi Compressive School, from September 1966 to June 1976. Then he joined Alemaya Agricultural College, now Haromaya University, in September 1977 and graduated with Diploma in Biology in July 1978. After graduation, he was recruited by Ethiopian Institute of Agricultural Research in May 1979 and assigned to work on Field crop Agronomy to December 1996 and from 1996 up to now soil and water research processes at Jimma Agricultural Research Center (JARC). In October 1994, he joined College Of Agriculture and Veterinary Medicine, Jimma University and graduated with B. Sc. Degree in Horticulture in June 1997. In Mach 2003, he joined School of Graduate Studies of College of Agriculture and Veterinary Medicine, Jimma University for Master of Science Degree in Horticulture.

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LIST OF ABBREVIATIONS

ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
AOSA	Association of Seed Analysts
BD	Bulk Density
CAT	Catalase
CSA	Central Statistical Authority
CV	Coefficient of Variance
DF	Dilution Factor
DM	Dry Matter
EC	Electrical Conductivity
ER	Emergence Rate
FAO	Food and Agriculture Organization of the United Nations
G/CC	Gram Cubic Cent Meter
GD	Girth of Stem Diameter (cm)
GLM	General Linear Model
GR	Growth Rate
IAR	Institute of Agricultural Research
ISTA	International Seed Testing Association
JARC	Jimma Agricultural Research Center
JUCAVM	Jimma University College of Agriculture and Veterinary Medicine
LSD	Least Significant Difference
masl	Meter Above Sea Level
MC	Moisture Content
MCF	Moisture Correction Factor
MDE	Mean Days to Emergence
MSFCTD	Ministry of State Farms, Coffee and Tea Development
MSP	Mean Sum Product
NSIA	National Seed Industry Agency
OC	Organic Carbon
RCBD	Randomized Complete Block Design
RCD	Root Collar Diameter
RGR	Relative Growth Rate
ROS	Reactive Oxygen Species
RW	Root Weight
SAS	Statistical Analysis System
SOD	Superoxide Dismutase
SVI	Seedling Vigor Index
UCH	Un composed Coffee Husk
USD	United State Dollar
V/W	Volume per Weight
W/W	Weight per Weight
WFP	World Food Program
WHC	Water Holding Capacity

ABSTRACT

Korarima (Aframomum corrorima) is native crop to Ethiopia, tropical herbaceous, perennial and aromatic spice and medicinal crop widely used in traditional dishes, and sold at higher prices. Despite its importance, genetic variability and favorable ecology, production of the crop is much lower mainly due to production constraints such as :Lack of improved variety, Poor agronomic practices , Inappropriate propagation techniques and Shortage of planting material for production . Korarima can be propagated by seed and vegetative parts. The seed propagation method need for bulk as planting materials and not susceptible to unknown diseases is one of these major qualities. On the other hand, germination of seeds has problem of seed dormancy, which may be associated with the hard and impermeable seed coat. Seed treatment to break dormancy and good nursery media composition and optimum watering frequency for improved seed emergence and seedling growth constraints have not been well studied and documented. Thus, the current study was conducted with the objective of determining the effect of different seed treatment methods, media composition and watering frequency on seed emergence and subsequent seedling growth. Two experiments were carried out. Experiment I has two factors. Seed treatment at five levels((0 hrs,24 hrs , 48 hrs , 72 hrs) water soaking, & 50% sulfuric acid soaking for 60 minutes) &Soil media of seven levels (Forest, Top , Forest : Top , Forest : compost , Top : compost , Forest : Top soil : compost, Top : compost (3:1)), & laid out in 7x5 factorial arrangement using RCBD with three replications. Experiment II has two factors. Soil media seven levels as indicated in experiment I and Watering frequency days four levels (every day , two , three & four) was conducted using split plot design with three replications.The data recorded on korarima seed emergence and early seedling growth were subjected to Analysis of Variance using statistical analysis system version 9.2 software. Treatment means were separated using LSD at 0.05 probability level. The interaction effect of seed treatment by soil media and watering frequency by soil media were highly significant ($p<0.01$) for mean days to emergence, emergence % and seedling growth *parameters.* The highest score of mean days (14) & emergency percentage (90) and seedling growth parameters were obtained under seeds soaked for 24hrs followed by 48 hrs in pure water and sown on media of forest soil, top soil & compost in (3:1), forest & top (1:1) and top & compost (1:1). Other treatments shown low *emergence % Korarima seeds sown in mixed forest and top soil and also top soil and compost soil media combination in equal ratio with watering frequency every days gave days (15) or shown early emergence* ***and*** *(85.63) emergence percentage. Watering frequency every four days shown late emergence days. The correlation among some growth parameters and relative growth rate were also highly significant ($p<0.01$). In general, all treatments showed highly significant ($p<0.01$) variation in terms of shoot height, root length, stem girth seedling vigor index, leaf area ,leaf number, total dry weight, root volume, relative growth rate. It can be concluded that pre-sowing seed water treatment 24,48 hrs , Watering frequency every one or two days and media of top soil and compost combinations improved both seed emergence and growth of seedlings. it would be advisable for nursery operators to irrigate korarima seedlings every two days or three days interval with compost soil combination under the prevailing conditions.*

Key Words: *Aframomum cororima, korarima Seed treatment, Korarima* Emergence, *Korarima seedling*

1. INTRODUCTION

Korarima (*Aframomum corrorima* (Braun) P.C.M. Jansen) belongs to the family *Zingiberaceae* and genus *Aframomum*. It is a perennial tropical aromatic herb, often of large size, bearing flowers and capsules, and grows usually with strong fibrous subterranean scaly rhizomes and leafy stems reaching 1–2 m height. Korarima is usually self-pollinated and occasionally cross-pollination by insects is possible due to the presence of large nectar at the top of the ovaries (Jansen, 2002).

As the crop is believed to be indigenous to Ethiopia, there could exist high genetic diversity in the country (Girma *et al.,* 2008). Moreover, the presence of *Aframomum zambezicum sp*. *Puberulum*, the so called 'monkey's korarima', in the same habitat with *Aframomum corrorima* indicates that there is a high diversity and, hence, greater chance for further genetic improvement of the crop in the country. *Aframomum corrorima* is a spice only known from Ethiopia. It certainly deserves more attention, as its seeds have a milder and sweeter flavour and a less peppery pungent taste than those of the better known West African species, *Aframomum melegaeta.* Hence, it is economically important aromatic species used as traditional medicine and food preservative, to flavor coffee and bread, as source of income from local and export markets, for soil conservation and as substitute of Indian cardamom (Eyob *et al*., 2007). In Ethiopia, korarima grows naturally at 1,700–2,000 m.a.s.l., annual rainfall varying from 1300 mm to 2000 mm, and annual average temperature of about 20^0C. It is a shade loving plant that grows in almost the same habitats as wild Arabica coffee in high rain forests of southern and south western Ethiopia (Jansen, 2002).

Korarima is most popular spice in all parts of Ethiopia highly demanded by traders and consumers. Despite its enormous genetic variability and economic importance as well as favorable ecology for its production, both productivity and quality of the crop are quite at a lower- level in the country Edossa (1998)

Most importantly, poor seed germination, weak seedling growth and poor establishment, thus, low rate of plant survival and forest destruction are among the major factors contributing to low level of production of the crop in the country. Enhancement of korarima seed germination and emergence and early growth of the seedling is, therefore, important for further agronomy and breeding studies and to improve production, productivity and quality of the crop. Besides, the production and harvesting techniques as well as the farm management skills for this high value crop are also very traditional, indicating that there is a big room to improve productivity and quality of the crop (Farm Africa, 2004).

According to formal survey carried out in southern Ethiopia, recent attempts to encourage farmers to cultivate korarima have not been successful due to several production constraints (Eyob *et al.*, 2009). Among all production constraints, farmers emphasized that lack of improved varieties and agronomic practices like propagation techniques are among the major production constraints emphasized by farmers. The agronomic practices which need major emphasis involve appropriate seed treatment, nursery media and watering frequency for effective seed germination and seedling growth are the basic activities.

Korarima can be propagated by seed and vegetative parts (rhizomes), which is often used for planting small areas. Clonal propagation by tissue culture permits large scale planting of high yielding selections but is not advisable because of transmition of viral diseases. In such cases, raising seedlings from seeds is advisable way, as virus disease is not transmitted through seeds (Bhattacharya and Khuspe, 2001) . Plants propagated vegetatvely come to bring one year earlier than those propagated by seeds. The vegetatiely propagation method using one year old rhizomes, however, needs bulk of rhizomes as planting materials and slows multiplication rate (Bhattacharya and Khuspe, 2001)

The destructive harvesting of the rhizomes for vegetative propagation also seems not feasible because there is always the possibility of losing the mother plant during this process. Moreover, rhizomes are prone to damages due to different factors during transportation. Susceptibility to unknown diseases is also one of the major problems faced by korarima growers during vegetative propagation by rhizomes in Ethiopia (Bhattacharya and Khuspe, 2001). On the other hand, although propagation by seeds seems more advantageous, germination of korarima seeds is often poor and irregular, thus, has certain problems. Seed dormancy, which may be associated with hard and impermeable nature of the seed coat, had been reported to be the major problem of korarima germination (Eyob *et al.*, 2009). But, seed propagation has great advantage over vegetative method, allowing the production of a large number of diseases (virus) free seedlings (Bhattacharya and Khuspe, 2001). It also extends the economic life of population and gives higher yield, (Eyob *et al.*, 2008). The inhibitory effects of high constituents of hydrocarbon monoterpenes on germination and growth of seedling have been investigated in different plants (Kordali *et al.*, 2007). To make hard seed coats permeable to water and gas and hasten germination and subsequent growth of seedlings, some sort of seed treatments is commonly used in different crops (Bhattacharya and Khuspe, 2001). Pre sowing treatment by soaking in water or other chemicals for certain period can reduce the time required for germination. However, information on the use of such practices in korarima is very scarce.

Germination of seeds can be influenced by many factors such as the type of substrate used and environmental factors such as supply of oxygen and water, temperature and light (Hartmann *et al,* 2007). Growth medium has been found to be the most critical factor determining seedling quality in the nursery (Baiyeri and Mbah, 2006), acting as a reservoir for nutrients, moisture and oxygen supply to the growing plant (Grower, 1987, Baiyeri, 2005).

It is very important to optimize water use efficiency through proper irrigation scheduling and soil fertility management for increasing crop yield (Li and lin, 1998). It is well known that Irrigation scheduling based on seasonal crop water requirement maintains soil water at optimal level and has been found to significantly enhance yield and N uptake of crops (Foster *et al*., 1995). In line with this, Tesfaye (1995,2005)and Tesfaye et al.,(2008) have shown that watering nursery grown coffee seedlings once or twice a week resulted in higher growth of both root and shoot parts and total dry matter yield than did both more and less fragment applications. Similarly, yield and crop quality of coffee orchards significantly imported by optimum rate of irrigation application (Tesfaye, 2005; Tesfaye et al., 2008, 2013).

Rooting medium water deficit stress is one of the important factors restricting imbibitions and seed germination and inhibiting seedling growth (Mantovani and Iglesias, 2010). Establishing optimal watering frequency for normal germination of korarima seeds and growth of the seedlings in the nursery is believed to promote sustainable production of the crop. However, our knowledge on optimal watering frequency for germination of korarima seeds and normal growth of the seedling is limited.

Nursery rooting media mixtures play a key role in improving soil physical and chemical properties and, thereby, increasing, the rate of seed germination and seedling growth and penetrating capacity of roots. When suitable environment with proper aeration, sufficient water and nutrient supply was offered by the medium, excellent root system developed, which, in turn, resulted in luxurious growth of plants (Neelam and Ishtiaq, 2001). Forest soil, which is rich in humus content with high water holding capacity, is used for korarima nursery at Tepi National Spice Research Center. For coffee nursery, it has been found that the best soil media is forest soil (Yakob *et al*., 1998). However, in the absence of forest soil which is rich in organic matter blends of top soil and compost are recommended for coffee nurseries. This can also be the best option for korarima nurseries, since the crop grows in association with wild Arabica coffee in its natural habitat and now days pure forest soil may not be available in krorima growing areas because of increasing rate of deforestation.

In line with this, in Ethiopia, information on korarima propagation by seed and optimum nursery management practices is lacking. Although the crop is important in the spice industry in general, and in the national economy of the country in particular its seed treatment method to hasten germination and optimum nursery rooting media composition and watering frequency for improved seedling growth have not been well studied and documented. This piece of information could benefit many nursery operators and taking this fact into account, this research was designed to address the following main issues:

General Objective:

- To study the effect of different seed treatment methods, nusery media compositions, and watering frequency on seed germination and subsequent growth of korarima seedlings during the nursery period.

Specific Objectives:

1. To evaluate the effect of different seed treatment methods on seed germination and early growth of seedlings,
2. To determine optimum media composition for optimum seed germination and seedling growth
3. To evaluate the effects of water application frequency on seed germination and subsequent seedling growth of korarima

2. LITERATURE REVIEW

2.1. Botany and Morphology of Korarima

Korarima (*Aframomum corrorima*) or called Ethiopian cardamom is herbaceous, perennial and aromatic spice and often of large size medicinal crop of the species in the monocotyledonous family, of Zingiberaceae, bearing flowers. Korarima grows usually with strong fibrous subterranean scaly rhizomes and with leafy stems reaching 1–2 m high. It is usually self-pollinated and occasionally cross-pollination by insects is possible due to the presence of large nectar at the top of the ovaries (Jansen, 2002).

It is a shade loving plant that grows wild in moist and open woodlands, in the same habitat with wild coffee Arabica in south and south western Ethiopia. It is also widely cultivated by farmers in different parts of the country. The plant consists of an underground rhizome, a pseudo stem, and several broad leaves and resembles Elettaria species morphologivally. The genus Aframomum comprises about 50 species and is widely distributed in the wetter parts of tropical Africa. Aframomum zambesiacum one of the species, occurs in similar habitats with Aframomum corrorima both of which are native to Ethiopia. The seeds of the former species, howver, are not used, and in Ethiopia it is called 'monkey's korarima'. It differs from the real korarima in its leaves are less aromatic upon crushing, and its inflorescences bear 25-50 flowers red (korarima bears only up to 5) (Eyob *et al*., 2008).

Species of Korarima or Ethiopian cardamom is herbaceous, perennial and aromatic spice and medicinal crop of the species in the monocotyledonous ginger family, Zingiberaceae native to Ethiopia (Eyob *et al*., 2008). The plant consists of an underground rhizome, a pseudo stem, and several broad leaves and morphologically resembles *Elettaria* species. The genus *Aframomum* comprises about 50 species and is widely distributed in the wetter parts of tropical Africa. It is closely related to *Amomum* species *of* tropical Asia origin and was formerly included in this species. In Ethiopia *Aframomum zambesiacum* occurs in similar habitats with *Aframomum corrorima* (Eyob *et al*., 2008). Its flowering season starts in May and continues up to August, It takes about four months for the fruits to mature (Pruthi, 1993). Two major differences with the real korarima are its leaves less aromatic upon crushing, and its inflorescences bear 25–50 flowers (korarima only up to 5) (Eyob *et al*., 2008).

Reproductive shoots in korarima arise from the rhizomes at the base of the leafy vegetative parts. In korarima, vegetative shoots are sparsely spaced along the rhizomes, the inflorescence arises at each joint and is highly dispersed, and the panicles, are born on the thick short stalk and produce whitish to purple flowers that are few in number but large in size. The wracking top of the panicles bearing the flowers forms the stalk of the capsules and these pollinated flowers develop in to capsules, Korarima produces; usually 2-4 large capsules per spike, which bear large sized dark brown aromatic seeds (Ansari *et al*., 2004).

2.2. Ecological Requirements of Korarima

Several important crop plants including korarima and Arabica coffee have their origin in Ethiopia, Korarima is an important spice and medicinal plant cultivated in large areas of Ethiopia, but it is not well little known outside the country. As it is an indigenous spice of the country, korarima is known as Ethiopian or cardamom, or false cardamom. Usually dried seeds of which are and is extensively used in Ethiopian and Eritrean cuisines.

Ethiopian Korarima is believed to be originated in high rain forests of south, south western and western part of the country (Jansen, 1981). It grows abundantly and widely distributed in Kefa, Illubabor, south Omo, Wollega, Gamugofa and Sidama areas (Abera, 1993). According to Zenebe and Berek Tshehy (1985), the distribution of korarima ranges from 1700 – 2300 m.a.s.l. It thrives best and is mostly cultivated near the banks of small rivers and stream with natural forest shade in these regions, as well as in the vicinity of Lake Tana north western, and Gelemso, easrern parts of the country. Besides, it is also believed to be native to south western Sudan, western Uganda, and Tanzania.and cultivated in Eritrea (http://en.wikipedia.org/wiki/Aframomum_corrorima).

Southwestern Ethiopia, where natural (montane) forests found, is an important centre of spice crops production and collection (Agize and van der Zouwen, 2008). Korarima grows naturally at an altitude of 1700–2000 m.a.s.l (Jansen, 2002). Korarima and cardamom are delicate plants that do not tolerate direct sunlight. They are shade loving plants under natural conditions. Korarima favors the southwestern Ethiopia pre climax rain forest. (Purseglove *et al*., 1981). The shade level requirement for both korarima and cardamom were studied at Jimma and Bebeka using artificial black polythene screen.the shade levels were in both experiments plants under 55% up to 63%shade levels gave highest capsule yield (Edossa,1998) for its proper development and hence grows in the lower strata of natural forests of Ethiopia (EIAR, 1999). Over shade causes etiolated growth and over exposure to sunlight retards growth and causes scorch (Wrigley, 1988). Too much shade or too much openness of area is not advisable for Korarima cultivation as it affects growth and yield. Usually, these areas are located at altitudes ranging from 1000 to 2300 m.a.s.l. and receive an average annual rainfall of 1500mm and more. Korarima generally grown in forest loamy soils rich in available phosphorus and potassium, but well drained deep loamy soils abundant in humus are believed to be ideal (KAU, 1996).Nevertheless, korarima growing zones of the country have different farming systems and agro-ecologies (Eyob *et al.,* 2008).

2.3. Production and Uses

According to Eyob *et al*., (2008), the ' actual average yield of dried pods or capsules recorded in farmers field in the 1980s was in the range of 700 to 950 kg/ ha when the korarima plants received filtered sunlight all the day through permanent tree shades. Presently the yield is reduced to 250–400 kg per ha. The production is declining mainly due to destruction of the plant's natural habitat for expansion of arable and grazing lands; new settlements and forest fire. Farmers acknowledged that shortage of shade trees; and lack of improved varieties and agronomic techniques had also contributed to decreases in production area and lower yields of the crop. This has led to the disappearance of unidentified korarima landraces from farm fields and natural habitats (Eyob *et al.,* 2008).

Spices and herbs are the rich storehouses of different bioactive compounds and are well known for their beneficial effects on health (Ansari,*et al*,2004). The use of korarima is only known from Ethiopia and Eritrea. It occurs as a cultivated crop only in Ethiopia. The seeds (usually dried, sometimes fresh) are used to flavour all kinds of sauces locally called ‘wot’, for which they are ground and usually mixed with other spices. Korarima is sold in all the markets in Ethiopia, and is daily used by most families in rural areas.

It is the most important crop mainly used as source of spices in traditional Ethiopian dishes and curies, cakes, bread, “Wot” and for many other culinary purposes, flavoring coffee, tea and other beverage and liquors, and for manufacturing in pharmaceutical, cosmetics and perfumery preparations (Purseglove *et al.*, 1981). Like other spices and herbs korarima is rich storehouse of different bioactive compounds which are well known for their beneficial effects on health (Ansari *et al*., 2004).The seeds of korarima contain different types of essential oils having typical odour (Eyob *et al.,* 2007) and are traditionally used as tonic, carminative and purgative drug. Results of a formal survey showed that korarima seeds, pods, leaves, rhizomes and flowers are used in southern Ethiopia as traditional medicine for human and animal ailments caused by unknown agents; and particularly used to treat any part of the animal body upon swelling (Tefera and Wannakrairoj, 2006). The fruit pulp around the seed is eaten especially before maturity and is chewed as stimulant (Ravindran *et al*., 2002).

It is an important source of income for growers as its seeds fetch high price in local and export markets. It is also an important plant for soil conservation, as the rhizomes and leaves spread on the ground, covering and protecting the soil from erosion in hilly areas (Eyob *et al.*, 2008). Korarima is the most important spice that entered the western trade as a substitute of the true cardamom (Purseglove, 1981). Its seed has a mild, sweet flavour and is less peppery or pungent than seeds of *Aframomum melegueta K.Schum*. Besides the large domestic consumption, Ethiopia exports the crop to Sweden, Finland, Sudan, India, Egypt and Saudi Arabia and earns a huge amount of foreign currency. In this line, Ethiopian cardamom had notably penetrated the Scandinavian market and was priced at 9 USD per kilogram in early 1978 .The taste of korarima is similar to Indian cardamom, and has been used as a substitute of cardamom (Tefera and Wannakrairoj,2006).

2.4. Pre-Sowing Seed Treatment

Some korarima cultivars are late to ripe and, hence, seed happen to be not ready for sowing in the right season. Seeds of such cultivars require longer time to germinate and seedlings may not attain the appropriate growth stage for field transplanting during the wet season. The fate of such seeds is unavoidably storage for the next season, which would implicitly affect their viability (Personal observation).

Seed germination and emergence affecting factors depends on both internal and external conditions. The most important external factors include rooting media (soil nature) temperature, water, oxygen and sometimes light or darkness; internal factors are dormancy, impermeable seed coat status of reserve food or endosperm Raven *et al*., (2005). Various plants require different variables for successful seed germination; often this depends on the individual seed variety and is closely linked to the ecological conditions of a plant's natural habitat. For some seeds, their future germination response is affected by environmental conditions during seed formation; most often these responses are types of seed dormancy Raven *et al.,* (2005).Hence, by pre-sowing seed treatment, one can escape erratic and poor germination of seeds and hasting emergence of seedlings. Soaking seeds as a means to hasten germination and subsequent growth of seedlings in different seed treatment method for different hrs or day’s right before sowing has been used in some crops.

In line with this, it has been observed that Scarifying the seeds in concentrated sulfuric acid increased imbibitions, and improved germination, seedling establishment and growth characteristics of *L. varius* as the duration of scarification increased up to 16 hrs at 24°C (Ahmadi *et al.,* 2007). However, some seedling growth characteristics such as shoot height and dry weight and root length and dry weight decreased, and abnormal (spirally) geotropic growth occurred in radicles when seeds scarified in sulfuric acid for 20 and 24 hrs (Osman,2004). Similarly, acid scarification of cardamom with 25 per cent nitric acid for 10 minutes has broken the seed coat and enhanced seed germination (Spices Board India, 2009).

Besides, it has also been observed that boiling seeds for two minutes and scarifying in concentrated sulfuric acid for two hours did not provide adequate germination percentages (38.9% and 31.1%, which were 6.7% and 15.3% respectively, for untreated seeds), while mechanical scarification was the most effective treatments to obtain uniform and rapid germination and seedling establishment in a native *L. varius* population (Ahmadi *et al.*, 2007).

Ahmadi *et al.,* (2007) have reported that hydro-priming clearly hastened emergence and increased vigor index of wheat seedlings. Similar works have also been reported for rapeseed (Bijanzadeh et al., 2010). As reported by Frimpong *et al*., (2004) hot water (50°C) treatment before sowing also gave better germination percentage in Chinese and Manipintar groundnuts.

Renugadevi *et al*., (1994) have observed that seed pelleting of ash gourd and ribbed gourd with arappu leaf powder was found to be the best pre-sowing seed management practice, as it enhanced field emergence and seedling vigour index. Ahmedi *et al*., (2007) has also found that treating seed coat with arappu leaf powder at 500 g per kg seed increased vigour and germinability of seeds of onion. Pre-soaking of sunflower seeds for 12 hrs in one percent calcium chloride solution increased field emergence (by 20 % and seedling vigour).

Seeds of *L. varius* have impermeable seed coat inducing dormancy, which is harder to overcome than those of other *Lupinus* species. Breaking down impermeability of seed coat by means of scarification methods or certain level of seed coat treatments has resulted in considerable increase in imbibitions and germination percentage (by 100%) in relatively short time. Besides, mechanical scarifications also provided rapid seedling establishment the highest values of seedling growth characteristics, such as shoot height and root length, shoot and root dry weight and leaf area (Osman, 2004).

Soaking in hot water and boiling are believed to be useful techniques for many leguminous crops.but the duration of boiling or soaking time is critical (Osman, 2004).It has been reported that embryos of *Lupinus varius* seeds boiled for 6 min., could survive and germinate to 80.0%, and germination percentages in seeds boiled for 8 and 10 min., were 71.7% and 63.3%, respectively. These results allude to the fact that the seed coat of *L. varius* seeds is not only impermeable but also heat resistant,

On the other hand, it has been observed that soaking seeds in pure water for prolonged time increased emergence percentage of coffee seeds, where seeds soaked for 12 hrs had better emergence (13.28%) than those non-soaked seeds (2.87%) (Wosene *et al.,* 2010). Similarly, coffee seeds soaked for 72 hrs have shown better emergence (49.80%) as compared to non-soaked ones (22.66%).Growth Parameters such as total leaf area, leaf dry weight, stem dry weight and total dry matter yield have also increase with increasing soaking-time (Wosene *et al.,* 2010). Farooq *et al.,* (2006) have reported that not only water treatment but also the duration of soaking affected seed germination in rice, where maximum vigor was obtained from seeds soaked for 48 hrs.

2.5. Korarima Propagation and Nursery Management

Cardamoms can be propagated vegetativily by division of the rhizomes or by seedlings usually raised from seeds sown in nurseries Jansen, P.C.M., 1981. Although propagation method used by growers depends upon the region and the area to be planted, the use of rhizome parts seems easier and faster. For vegetative propagation rhizomes from large clumps of growing plants are taken out, separated in to small clumps each consisting of at least one old and one young shoot and planted in prepared pits. The method is simple and reliable and permits the use of selected clonal materials. Besides, it is less costly and gives an earlier yield than is obtained from seedlings raised from seeds. It is difficult, however, to obtain sufficient planting material for large areas and very dangerous when diseases and pests are prevalent (Lock, J.M., 1985).

Korarima seeds are capable of germination when sown as soon as after harvesting, but thereafter, due to presence of dormancy, they lose their viability quickly (Spices Board, 2009). Therefore, with prolonged storage time for greater than two weeks, decline in percentage seed germination and thus, variable and poor seedling development is common phenomenon. Without seed treat, korarima seeds need 40-45 days for germination (Parthasarathy V. A.., 2009).However, seed treatment before sowing is believed to alleviate the problems associated with korarima propagation by seeds.

Even after pre-sowing seed treatment, for effective propagation of planting materials or production of seedlings in nurseries, attention should be given to nursery management practices, such as water requirements of the crop at early stages of growth and development, nature of germination and growth media in the seed bed , mulch, to reduce loss watering evaporation, to suppress weed growth and to maintain optimum soil temperature, the entire plantation and particularly the soil surface at plant base should be covered with mulch.

2.5.1 Nursery media

Besides seed dormancy, germination of seeds and growth of seedlings during the nursery period largely depend on the nature of soil in the seedbed. With the exception of light and atmospheric carbon dioxide, soil is the medium which supplies the major environmental inputs affecting growth of plants. It supplies water, nutrients and air provides mechanical support and regulates temperature to enhance bio-chemical reactions in plants (Brady, 1991). Both physical and chemical properties of the soil may affect growth and development of plants. In line with this, mixed rooting media are blended to have improved structure and texture, which, in turn, increases metabolic activities in germinating seeds, leading to better seed germination and growth of the plants (Hafeez-ur-Rahman *et al*., 2007). It has been reported that mixture of top soil from continuously cropped land and well decomposed organic materials from different sources resulted in higher percentage germination of coffee seeds and improved growth of the seedlings (IAR, 1994).This could be related to improved properties of the media, such as water holding-capacity, porosity and organic matter content. In line with this, various organic sources and proportions improved percent germination of coffee seeds, while Taye, *et al.,(* 2008) have reported that media containing undecompensed coffee husk alone (UCH) or in combination with other ingredients, had the lowest value. This could probably be attributed to poor and undesired physical properties of the media, such as high bulk and particle densities and reduced porosity, percolation rate and hydraulic conductivity, Such physical constraints arising from compacted growth media may reduce contacts between the soil and the seed and, hence, restrict moisture imbibitions, germination and ease of emergence from the media (Pandey and Sinha, 1996).

Wootton *et al.*, (1981) have also reported that several media blends with compost were to be found best for optimum plant growth, rizosphere aeration, and moisture and nutrient retention. Vineeta *et al.,*(2005) found that soil structural stability increased with better aggregate size distribution and reduced soil disturbance due to straw addition. They have also indicated that soil organic matter acts as a reservoir for plant nutrients and prevents leaching of elements necessary for plants growth. According to Hafeez., *et al.,* (2007), application of farm yard manure, sawdust and canal silt in combinations with equal proportion improved both seed germination and growth of peach seedlings

Khandekar et al., (2006) has suggested that mixtures of rice bran, sand and sand plus rice bran are the best for maximum germination and seedling growth and vigour of nutmeg under Kerala condition in India. On the other hand, in some cases, lack of pronounced effect of growth media on germination may be associated with the fact that germination and seedling emergence are independent of soil nutrient status, but rather depend totally on the endosperm of the seed which is rich in stored food until the seedling becomes autotrophic, and the ability of the seedlings to utilize these food reserves (Dickens Dolor, 2011).

In this line, although the findings of Okunomo *et al.* (2009) indicated a higher germination percentage in top soil for *Dacryodes edulis* and *Persea Americana*,. Medagoda and Weerawardana (2007) have reported lack of media effect on seed germination of cultivars of several members of *Macadamia* species. In contrast, the findings of Sadhu (1989) showed that quartz sand comprising mainly silica is most suitable for propagation purpose. Besides, Haque *et al.* (1992) have also observed a greater seedling emergence rate of rice (*Oryza* *sativa*) in seedbeds with coarse aggregates and concluded that crop establishment was not affected by soil structure.

2.5.2. Seedbed watering frequency

Application of water on daily or every other day basis to other for seedling increased the number of leaves (Simon *et al.,* 2011) and ,hence, improves photosynthetic and transpiration area (Ritchie, 1984), increased height, survival rate and root collar diameter (RCD) of the seedling (Simon *et al*.,2011). In contrast, they have observed that limited application of water had a negative effect on seedling height, RCD and number of leaves produced.

For tree nurseries, regular watering is necessary to produce good quality seedlings at economic rate. This is because any stagnation in seedling growth or subsequent mortality may bring about huge economic loss to the grower, as seedlings take long to reach an appropriate size for grafting and transplanting or for sale (Mhango *et al.,* 2008).

Water deficit stress is one of the important factors restricting seed germination, because of low rate of imbibitions and the delay in its initiation or decrease in the final germinability (Gorai *et al.*, 2009; Mantovani and Iglesias, 2010). This phenomenon may be attributed to the increases in osmotic pressure and decreases in matrix potential caused by water deficit stress, which leads to difficulty in seed germination. If a seed is buried too deeply within the soil or the soil is waterlogged, the seed can be oxygen starved and this delay germination (Raven *et al*., 2005).

Some seeds have impermeable seed coats that prevent oxygen from entering the seed, causing a type of physical dormancy which is broken when the seed coat is worn away enough to allow gas exchange and water uptake from the environment and the fast in its initiation or increase germ in ability (Raven *et al*., 2005).

Reactive oxygen species (ROS) are accumulated during the imbibitions phase of seed germination that extend or slow the activity of seed germination (Bailly, 2004), thus, Seed germination essentially requires signaling (low levels) of ROS. Considering the role of antioxidant enzymes in controlling the ROS levels during germination, these enzymes are particularly important for the completion of germination. Although many studies have reported the effect of water stress or seed mass on germination and antioxidant enzymes in several seeds (Du and Huang, 2008).

Moisture stress affects growth and development of crop plants at different stages. Morphological characters such as leaf area, plant height and root growth are severely affected by water deficit stress in many crop plants (Blum, 1996). Therefore, by improving emergence and subsequent seedling growth of korarima through pre-sowing seed treatments and optimum watering frequency, it may be possible to shorten the time taken to raise seedlings in the nursery and reduce or minimize cost of nursery management.

Particularly for plants like coffee and associated crops growth and development are dependent on internal and external or ecophysiological and climatic factors such as water supply, temperature and soil fertility (Cambrony, 1992). In terms of importance, rainfall is the second most limiting climatic factor, after ambient temperature (Coste, 1992).

Like coffee, korarima roots cannot tolerate water logging and do not grow near permanent water tables. Roots in waterlogged soils have no root hairs and are swollen and abnormal in appearance (Coffee Hand Book (CHB), 1987). On the other hand the rate and direction of root growth are determined, mainly, by water gradient. Roots grow from areas of low water where they have low survival rate, to areas of greater water, where they have a higher survival rate (CHB, 1987). In coffee nurseries, maintaining soil moisture at optimum level by regular watering of the seedbeds once to twice a week(Tesfaye et al.,2008,2013) and a medium to low soil bulk density (Pawl and Lee, 1976) have been found to enhance healthy root and shoot growth.

2.6. Seed Germination and Emergence

Germination is a complex process that includes three phases, namely, imbibitions, plato phase and radicle protrusion (Giba *et al.,* 2004). The period of germination is one of the most sensitive life stages of a plant because this stage affects seriously seedling and crop establishment. The germination process is associated with various internal and external factors. Seed mass is positively related to germination, seedling survival, and seedling vigour (Aziz and Shaukat, 2010). Big seeds have an advantage over small seeds within a population during germination Bigger seeds require less time to germinate and achieve greater germination percentage compared to small seeds in *Castanopsis chinensis* under limited light (Du and Huang, 2008). Apart from the innate mechanisms, various environmental factors, such as soil water, temperature, and light disturb metabolic reactions and affect seed germination (Jevgenija and Gederts, 2007).

Initial growth of seedlings largely depends on stored food reserves contained in the cotyledons and also availability of soil moisture. However, after depletion of food reserves, seedlings rely on photosynthesis for their continued growth and survival (Bargali and Tewari, 2004). Water deficit stress is one of the important factors restricting seed germination because of the delay in its initiation or decrease in the final germinability (Mantovani and Iglesias, 2010). Soil moisture plays a key role in this process and also for nutrient uptake from the growing media to support plant growth (Shao *et al*., 2008). Cardamom Seeds sown immediately after harvest germinate uniformly, early and satisfactorily and seedlings are ready for transplanting at the end of 10 months.

Seed germination is influenced by many factors such as the type of substrate used, environmental factors such as oxygen, water, temperature and for some plant species, light (Hartmann *et al,* 2007). Growth medium has been believed to be the most critical factor determining seedling quality in the nursery (Baiyeri and Mbah, 2006), acting as a reservoir for nutrients and moisture (Grower, 1987). Growth medium physical properties can also have a profound effect on supply of water and air to the growing plant (Baiyeri, 2005).

Cardamom seeds and also korarima are to be sown as early as possible, preferably within 15 days after extraction, since seeds lose their viability on storage. Early sowing gives maximum germination under field conditions. Even under ideal conditions, the germination is often less than 50 % and breaking of hard seed coat through seed treatment with acid or similar chemicals improves germination. Acid scarification with 25 % nitric acid for 10 minutes to break the seed coat has been found to enhance germination in Cardamom (Spices Board, 2009).

Eyob *et al.* (2007) have reported higher contents of monoterpene from korarima seed. The inhibitory effects of high constituents of hydrocarbon monoterpenes on germination and growth of seedling have been investigated in different plants (Kordali *et al.*, 2007). Seeds of nutmeg loose viability soon after harvest (Sangakkara, 1993) and take minimum of two months for germination (Mathew, 1992),while seeds treated with 200 ppm of Gibberellic acid gave maximum seed germination (75%) (Mathew, 1992).

It is stated that loss of viability of cardamom and linked korarima seeds could be either due to the moisture content falling below a certain critical value or simply a general physiological deterioration with time (Chin *et al*., 1984). Several tropical fruit crops seeds show recalcitrant storage behavior, where seeds do not withstand drying or are unable to survive with low temperatures during storage. Thus, it is difficult to store them for longer period (Ellis, 1984). Storage of seeds results in loss of viability and delay in germination. Germination of fresh seeds has been found to be highest (59 and 50.6 %) in some varieties of Cardamom, Mysore and Malabar, respectively, and reduced when there was a delay in sowing after storing the seeds for longer periods especially in air -tight containers.

2.7 Seedling Vigor

The decline in seed quality through time is not only restricted to the reduction of viability, but also to problems in field emergence and establishment, as aged seeds generally sprout more slowly and with a considerable sensitivity to external stress (Hall and Wiesner, 1990).

Such loss of performance is revealed well before viability begins to decline, and seeds of this type are frequently stated to be low in vigor (Powell and Matthews, 1992).

According to Steiner (1990), various factors affect successful establishment and are related to seed quality and /or the prevailing field environment, the quality factors related to vigor include biochemical processes and respiration activity, rate and uniformity of germination and field growth of seedlings, and ability of seedling emergence under unfavorable environmental conditions. The earliest, but still the most common and widely used tests are the growth rate tests that comprise different methods, which could be incorporated in to the standard germination test (Steiner, 1990).

The early stages of plant development are slower when aged seeds are sown, and, hence, the rate of early seedling growth is indicated as the most consistent and sensitive measure of the level of deterioration, because it can adequately indicate the differences in vigor not revealed by the germination percentage (Steiner, 1990). These are, therefore, the most widely used methods to supplement the results obtained from the standard viability tests when evaluating vigor (Steiner, 1990). The widely used techniques of growth rate tests include the rapidity of seed germination and early seedling growth tests, the rates of seed germination and seedling emergence tests, and linear growth measurement tests, as well (Barboza and Herrera, 1990).

Growth of seedling is said to be effective measure of vigor (Thapliyal *et al*., 1991). On the other hand, as indicated by Powell and Matthews (1992), more sophisticated measures of germination rate can be made by including more frequent germination counts that could reflect the pattern of germination. According to Hall and Wiesner (1990), and Evers (1991), indices that explain the strengths or rates of seed germination and field emergence of seedlings can predict the stand producing potential of a particular seed lot effectively; hence serve as potential measures of vigor.

Seedling growth evaluations based on linear measurements were also known to indicate vigor potentials in different crop seeds (Trawatha *et al*., 1990). The use of linear measurements of plumule growth as a vigor index was first suggested for cereals and sugar beet and it has been further developed for other crops (Peri and Feder, 1982). Powell and Metthews (1992) have suggested a more accurate reflection of vigor of the seedlings themselves by calculating the vigor rating on the basis of the number of germinated seeds rather than the total number of seeds sown.. Likewise, growth measurements of korarima seedlings at their earlier stages of development, in the form of linear measurements of radicle and /or plumule have been used for determination of vigor in number of studies (Barboza and Herrera, 1990).

3. MATERIALS AND METHODS

3.1. Description of Study Area

Two experiments were executed at Jimma Agricultural Research Center (JARC) nursery site; JARC is the National Coffee Research Coordinating Center in Ethiopia and located at 365 km Southwest of Addis Ababa and 12 km from the Jimma town. It is located within tepid to cool humid highland agro-ecological zone of the country at an altitude of 1750 m.*a.s.l.,* at latitude of 7^0, 46" N, and longitude of 30^0, 50 "E in the sub humid tropical belt of south western Ethiopia. The area receive an average total annual rain fall of 1530 mm, with 66% of average relative humidity, and mean minimum and maximum temperatures of 11.6^0C and 26.3^0C, respectively. The soil of the area is characterized by reddish to reddish brown clay with pH range of 5-6. The meteorological data recorded during the experimental period is presented in appendix (Appendix 1).

3.2. Experimental Materials and Treatments

Two experiments (two sets) were carried out in the nursery from May to September 2012. Set I comprised seed pretreatments and media, while set II consisted of media and watering frequency. So far there is no released variety of korarima in the country, among, the few accessions which have been collected and maintained at Tepi and Jimma Research Centers, Jimma local landrace was used for the experiments.

3.2.1. Seed collection and processing

Fully ripened bold red capsules of local land race of korarima (Jimma) were harvested from disease free mother clumps. For uniform seed size, immature, small and abnormal capsules were excluded.

3.2.2. Seed treatment

Fresh capsules were split open and seeds were extracted from the capsules and immediately washed with tap water to remove mucilage. Then, uniform and healthy seeds were subjected to one of the following treatments: Control (un-soaked), soaked in tap water for 24 hrs, for 48 hrs, for 72 hrs; and soaked in 50% sulfuric acid (H_2SO_4) for 60 minutes (Eyob *et al.*, 2009).

3.2.3. Growth media preparation

Soil from forest land was dug up to 10 cm depth, top soil depth 15 cm was also collected from continuously cultivated land. Compost was prepared from decomposed grass, coffee pulp, top soil and cow dung, which were collected from the research center, and was air dried manually crashed and passed through 2mm sieve to remove clods and other foreign materials. The growth medium was prepared from forest soil and top soil alone and mixture of forest and top soil in 1:1 ratio, forest soil and compost in 1:1 ratio, top soil and compost in 1:1, forest soil, top soil and compost in 1:1:1 ratio , and top soil and compost in 3:1 ratio. Each medium ingredient (treatment) was filled in to black polythene bag of 16cm wide and 22cm length.

3.2.4. Watering frequency

Watering frequency treatments were involved application of water on daily, two-day, three-day and four-day intervals at field capacity level. The treatments were applied from seed sowing up to the end of the experiment. When it rains, it was covered by plastic sheet (Experiment-II).

3.3. Treatments and Experimental Design

A single experimental unit (plot) consisted of 12 pots. These were arranged in rectangle fashion (3x4) on nursery bed with 15 cm spacing between experimental units and 20cm between replications. Three seeds were sown at a depth of about one-and half cm in each pot (polythene bag) to minimize the risk of germination failure and were thinly covered with fine soil. The beds were mulched to about five cm depth with straw mulch all other routine nursery management practices, including, shading, weeding and other activities were based on nursery recommendations of Jimma Agricultural Research Center (IAR, 1996). For experiment I the seed pots were watered every other day in the conventional way until emergence. For experiment II watering was based on the treatments and water application was done during the morning hours only. The beds were constantly checked for emerging seedlings starting from the 5th day after sowing. Once emergence was observed, the mulch was removed and the seedlings were protected from direct sunlight by providing a moderate level of overhead shade, which was constructed at 1.5 m height using the elephant grass. Two months (at two leaf sage) and four months after sowing, both non-destructive and destructive parameters were measured.

3.3.1. Experiment I

This experiment involved two factors (Factor A = Soil media (seven levels) and Factor B = Seed treatment (five levels)) and their combination as described below. The media compositions were selected based on coffee and cardamom nursery media (Yakob *et al*., 1998; Spices Board of India, 2009). Seed treatments were arranged based on the experience of Eyob *et al*,.(2009) and Bhattacharya and Khuspe (2001).

Factor I -Soil media levels

1. Forest soil alone (M_1)
2. Top soil alone (M_2)
3. Forest soil and Top soil in 1: 1 ratio (M_3)
4. Forest soil and compost in 1:1 ratio (M_4)
5. Top soil and compost in 1:1 ratio (M_5)
6. Forest soil, Top soil and compost in 1: 1: 1 ratio (M_6)
7. Top soil and compost in 3: 1 ratio (control) (M_7)

Factor II-Seed treatment levels

1. Non-soaked (control) (T_1)
2. 24 hours soaking in pure water (T_2)
3. 48 hours soaking in pure water (T_3)
4. 72 hours soaking in pure water (T_4)
5. Soaking in 50% sulphuric acid (H_2SO_4) for 60 minutes (T_5)

Experimental Design, The experiment was carried out in a 7x5 factorial using RCBD with three replications. A total of 35 treatments were studied.

Table 1:-The treatment combination of soil media levels & seed treatment on Korarima of experiment I

No.	Seed Treatments	Soil Media	Treatment
1	Non-soaked (control)	Forest soil alone	Treat.1
2	Non-soaked (control)	Top soil alone	Treat.2
3	Non-soaked (control)	Forest soil and Top soil in 1 :1 ratio	Treat.3
4	Non-soaked (control)	Forest soil and compost in 1 :1 ratio	Treat.4
5	Non-soaked (control)	Top soil and compost in 1 : 1 ratio	Treat.5
6	Non-soaked (control)	Forest soil, Top soil and compost in 1 : 1 : 1 ratio	Treat.6
7	Non-soaked (control)	Top soil and compost in 3: 1 ratio (conventional)	Treat.7
8	24 hours soaking seeds in pure water	Forest soil alone	Treat.8
9	24 hours soaking seeds in pure water	Top soil alone	Treat.9
10	24 hours soaking seeds in pure water	Forest soil and Top soil in 1 :1 ratio	Treat.10
11	24 hours soaking seeds in pure water	Forest soil and compost in 1 :1 ratio	Treat.11
12	24 hours soaking seeds in pure water	Top soil and compost in 1 : 1 ratio	Treat.12
13	24 hours soaking seeds in pure water	Forest soil, Top soil and compost in 1 : 1 : 1 ratio	Treat.13
14	24 hours soaking seeds in pure water	Top soil and compost in 3: 1 ratio (conventional)	Treat.14
15	48 hours soaking seeds in pure water	Forest soil alone	Treat.15
16	48 hours soaking seeds in pure water	Top soil alone	Treat.16
17	48 hours soaking seeds in pure water	Forest soil and Top soil in 1 :1 ratio	Treat.17
18	48 hours soaking seeds in pure water	Forest soil and compost in 1 :1 ratio	Treat.18
19	48 hours soaking seeds in pure water	Top soil and compost in 1 : 1 ratio	Treat.19
20	48 hours soaking seeds in pure water	Forest soil, Top soil and compost in 1 : 1 : 1 ratio	Treat.20
21	48 hours soaking seeds in pure water	Top soil and compost in 3: 1 ratio (conventional)	Treat.21
22	72 hours soaking seeds in pure water	Forest soil alone	Treat.22
23	72 hours soaking seeds in pure water	Top soil alone	Treat.23
24	72 hours soaking seeds in pure water	Forest soil and Top soil in 1 :1 ratio	Treat.24
25	72 hours soaking seeds in pure water	Forest soil and compost in 1 :1 ratio	Treat.25
26	72 hours soaking seeds in pure water	Top soil and compost in 1 : 1 ratio	Treat.26
27	72 hours soaking seeds in pure water	Forest soil, Top soil and compost in 1 : 1 : 1 ratio	Treat.27
28	72 hours soaking seeds in pure water	Top soil and compost in 3: 1 ratios (conventional)	Treat.28
29	50% sulphuric acid soaking for 60 minutes	Forest soil alone	Treat.29
30	50% sulphuric acid soaking for 60 minutes	Top soil alone	Treat.30
31	50% sulphuric acid soaking for 60 minutes	Forest soil and Top soil in 1 :1 ratio	Treat.31
32	50% sulphuric acid soaking for 60 minutes	Forest soil and compost in 1 :1 ratio	Treat.32
33	50% sulphuric acid soaking for 60 minutes	Top soil and compost in 1 : 1 ratio	Treat.33
34	50% sulphuric acid soaking for 60 minutes	Forest soil, Top soil and compost in 1 : 1 : 1 ratio	Treat.34
35	50% sulphuric acid soaking for 60 minutes	Top soil and compost in 3: 1 ratio (conventional)	Treat.35

3.3.2. Experiment II

Experimental Design, This experiment was conducted in a split plot design, where media were assigned to the main plot and watering frequency treatments to the subplots, with three replications. A total of 28 treatments and 12 pots per plot were studied.

Two factors: Factor A = Soil media (seven levels) as indicated in experiment I
Factor B = Watering frequency (four levels)

Watering frequency levels (days)

1. Every day
2. Every two days
3. Every three days
4. Every four days

In this experiment the seeds were uniformly treated by 50% sulphuric acid (H_2SO_4) and soaked for 60 minutes as recommended by Eyob *et al*,. 2009).

Table 2: The treatment combination of the soil media levels & watering frequency on Korarima of experiment II

No.	Soil Media	Watering frequency (days)	Treatment
1	Forest soil alone	Every day	Treat.1
2	Forest soil alone	Every two days	Treat.2
3	Forest soil alone	Every three days	Treat.3
4	Forest soil alone	Every four days	Treat.4
5	Top soil alone	Every day	Treat.5
6	Top soil alone	Every two days	Treat.6
7	Top soil alone	Every three days	Treat.7
8	Top soil alone	Every four days	Treat.8
9	Forest soil and Top soil in 1 : 1 ratio	Every day	Treat.9
10	Forest soil and Top soil in 1 : 1 ratio	Every two days	Treat.10
11	Forest soil and Top soil in 1 : 1 ratio	Every three days	Treat.11
12	Forest soil and Top soil in 1 : 1 ratio	Every four days	Treat.12
13	Forest soil and compost in 1 : 1 ratio	Every day	Treat.13
14	Forest soil and compost in 1 : 1 ratio	Every two days	Treat.14
15	Forest soil and compost in 1 : 1 ratio	Every three days	Treat.15
16	Forest soil and compost in 1 : 1 ratio	Every four days	Treat.16
17	Top soil and compost in 1: 1 ratio	Every day	Treat.17
18	Top soil and compost in 1: 1 ratio	Every two days	Treat.18
19	Top soil and compost in 1: 1 ratio	Every three days	Treat.19
20	Top soil and compost in 1: 1 ratio	Every four days	Treat.20
21	Forest soil, Top soil and compost in 1 :1: 1 ratio	Every day	Treat.21
22	Forest soil, Top soil and compost in 1 :1: 1 ratio	Every two days	Treat.22
23	Forest soil, Top soil and compost in 1 :1: 1 ratio	Every three days	Treat.23
24	Forest soil, Top soil and compost in 1 :1: 1 ratio	Every four days	Treat.24
25	Top soil and compost in 3 : 1 ratio (conventional)	Every day	Treat.25
26	Top soil and compost in 3 : 1 ratio (conventional)	Every two days	Treat.26
27	Top soil and compost in 3 : 1 ratio (conventional)	Every three days	Treat.27
28	Top soil and compost in 3 : 1 ratio (conventional)	Every four days	Treat.28

3.4. Data Collection

3.4.1. Soil sampling and pre-planting soil analysis

Soil samples were collected from each medium. Five random samples making about 500 g of composite soil sample was taken from each medium and then was thoroughly mixed in to a clean plastic bag to obtain one bulk sample for each. The samples were put in clean polyethylene plastic bags and were brought to the lab for further analysis. After sun drying, the soil samples were pound into fine powder with porcelain mortar and pestle and then sieved with 500-μm size sieve. The powdered sample was kept in pre-cleaned screw capped polyethylene container till soil physical and chemical analysis. Determination of soil water was carried out for media by taking sample of the fresh and dry weight of the soils per media 5 pots from each soil media after compositing of the soil samples taken from each treatment soil media pots. The physico-chemical properties of the soil media were estimated before sowing the seeds (Appendix 2) using standard procedures (methods).

i. Soil physical variables

The texture of the media soil was determined by modified hydrometric method as described by Singh (1980). The soil sample 40g weighed soil into 600ml beaker, added 5% 50ml Calgon solution and 25ml water and was left overnight. Transferred to the cup of mechanical stirrer. Transferred the dispersed soil to a hydrometric jar and mixed with a special plunger and made up to the mark with distilled water. The hydrometer was immersed and read after 45 seconds and kept the jar undisturbed for 3 hours and took the second reading of Particle size analysis (Dewis, 1984).

Particle size analysis was determined according to the hydrometric method (Dewis, 1984). The soil sample 40g weighed into 600ml beakers and was added 50% 50ml calgon solution and 25ml water, the beaker was covered with a watch glass and left overnight, transferred to the cup of mechanical stirrer and Stirred for 5 minute and transferred the dispersed soil to a hydrometric jar Mixed with a special plunger and made up to the mark with distilled water.

Immersed the hydrometer and read after 45 seconds kept the jars undisturbed for 3 hours and took the second reading.

Bulk density was determined following the procedure of Okalebo et al. (1993) Soil samples were taken with minimum disturbance and poured into 100 ml plastic beaker with tapping to compact the medium to the field condition. on oven-dried samples soil was done at 105^{o}C for 24 hrs. The weight of each medium at the same volume was recorded and bulk density was calculated using the equation:

$$\text{Bulk Density (g/cc)} = \frac{\text{Oven−dry weight of sample}}{\text{Volume of sample}}$$

To determine water holding capacity of the field experiment, the soil samples were added into metal basins with$\cos\alpha + \cos\beta = 2\cos\frac{1}{2}(\alpha+\beta)\cos\frac{1}{2}(\alpha-\beta)$ perforated bottoms and fitted with filter paper and weighed. The basins were set in a tray of water for 24 hrs, allowed to drain for 30 minutes to remove free flowing excess water and weighed. The samples were then oven-dried and weighed. Water holding capacity, on over-dried weight basis, was calculated using the formula (Singh, 1980):

$$\underset{\text{(WHC) (\% dry wt.)}}{\text{Water Holding Capacity}} = \frac{Wt.water\ absorbed}{\text{oven−dry wt.of sample}} \text{ x } 100$$

Then, water holding capacity on percent volume basis was calculated as follows:

$$\underset{\text{(\% vol.)}}{\text{Water holding capacity}} = \underset{\text{(\% dry wt.)}}{\text{WHC}}\ x\ \underset{\text{(g/cc)}}{\text{Bulk density}}$$

ii. Soil chemical variables

Soil reaction (pH) was determined with a pH meter on 1 soil: 2.5 distilled water, after the suspension was stirred using an automatic stirrer for 30 minutes. Electrical conductivity (EC) was measured with an electrical conductivity meter in a one part potting medium to two parts water ratio (Okalebo *et al.*, 1993). Accordingly, 25 ml of distilled water was added to 10 g of soil sample and the suspensions were stirred with an automatic stirrer for 30 minutes prior to measurement. Stay for one hour until the suspension occurred and then read the sample by the help of P^H –meter which was calibrated according the nature of the soil.

The oxidation of organic matter was performed with potassium dichromate where the reaction was facilitated by the heat generated when 20ml of concentrated H_2SO_4 are mixed with 10ml of 1N $K2Cr_2O_7$ after1gm of soil in to 500ml conical flask was added exactly. In the presence of orthophosphoric acid and barium diphenylamide sulfonate indicator the solution is titrated to the end point with ferrous sulphate solution. Then organic carbon content was calculated using the formula shown below. Organic matter was then calculated by multiplying organic carbon content with the factor of 1.72.

$$\text{O.C.}(\%) = \text{N x} \frac{\text{V1} - \text{V2}}{\text{s}} \text{x 0.39 x mcf}$$

Where

a= ml of ferrous sulfate solution for Blank(v_1)
b= ml of ferrous sulfate solution for used for sample (v_2)
s= air-dry sample weight in gram
N= Normality of H_2SO_4 (0.1 N)
0.39= 3 x 10^{-3} x 100% x 1.3 (3=equivalent wt of carbon)
mcf = moisture correction factor

Total nitrogen was determined by the modified Kjeldahl method as described by Jackson (1958). Add 7 ml of concentrated H_2SO_4 was added and mixed carefully to one gram of sample passing 0.5 mm sieve plus sulphuric salicylate and potassium salt extractant mixture into which two g of catalyst mixture was added. This was digested for 3 hours and distilled with 45% NaOH. The NH3 was allowed to react with a 0.2N H_2SO_4 using methyl red as an indicator and titrated with 0.1N NaOH. A blank was run in exactly the same manner. The total nitrogen was then calculated as:

$$\% N = \frac{(a - b)}{s} \text{ x N x } 0.014 \text{ x } 100 \text{ x mcf}$$

Where

a= ml of H_2SO_4 required for titration of sample
b= ml of H_2SO_4 required for titration of blank
s= air-dry sample weight in gram
N= Normality of H_2SO_4 (0.1 N)
0.014= meq weight of nitrogen in g
mcf = moisture correction factor

From the respective organic carbon and total nitrogen values, the carbon to nitrogen ratio was calculated using the formula:

$$C/N = \frac{\text{Organic carbon content}}{\text{Total nitrogen content}}$$

Available phosphorous was determined on a two gram soil sample following the procedure of Bray II (Bray et al. 1945)(due to the soil sample in acidic range) using the NaHCO3 extracting solution. Ammonium molybdate and stannous chloride solutions were used to complete the reaction and enhance color development, respectively. A standard curve was prepared from an aliquot of dilute P solutions containing 2 to 20 ppm of P. The transmittance of the solution was measured at 660 nm with a spectrophotometer using red filter. Percent transmittance was plotted against P concentration and the results expressed as:

P (ppm or mg/kg soil) $= (a - b)\ x\ \frac{20}{2}$ x mcf = (a-b) x 10 xmcf

Where,

a= ppm P or mg/1 P in sample extract

b= ppm P or mg/1 P in sample blank

10= extraction ratio (20/2)

S= sample weight in gm (2)

20= ml of extracting solution

Available poassium was determined on a five gram soil in 100ml beaker and add 50ml of ammonium acetate (1N NH_4OAc) keep over night. Filter the soil suspension in to 250ml volumetric flask leach the soil with 30ml portion of 1N NH_4OAc 5 times. Make up the mark with distilled save the leach. Determine Na, K, Ca, and Mg with atomic absorption spectrotometer.

$$\mathbf{K}\ (\mathbf{mg\ /\ g}) = \frac{(\mathrm{a} - \mathrm{b})\mathrm{x}50\ \mathrm{x\ df}}{\mathrm{s}}\mathrm{x}\ \ \mathrm{mcf}$$

Where,

a= concentration of k measured in the sample (mg/1)

b= concentration of k measured in the blank

s =soil sample (1g)

df=dilution factor

50= ml of extraction used /sample

3.4.2. Seedling emergence evaluations

Germination under field conditions is defined as seedling emergence from the soil; radicle protrusion has already been completed sometime before emergence. For seed testing in gene banks, germination is not complete until the seedling can be judged as normal according to specific criteria for each species. This is because the intent of seed testing is to give an indication of how the seeds will perform as propagules in the field. Emergence is defined as the appearance of a normal hypocotyls following sowing in polythene bag, as described by Perry (1970). Thus, the numbers of seedlings that emerged above the soil surface and attained as the appearance of a normal hypocotyls was counted and recorded every three days till all the seeds that are capable of emerging have done so in each plot. Finally, thinning to one seedling was made in each pot after all seedlings exhaustively emerged.

The number of emerging seedlings was counted every three days. The percentages of emerged seedlings (%E) were then determined. Thus, based on the records of the emergence data, mean days to emergence (MDE), and the rate of seedling emergence (ER) of each seed sample was computed following the procedures outlined by Hartman *et al*., (2002).
The formula used to calculate these two indices were:

$$\textbf{Mean Days to Emergence}\ \text{(MDE)} = \frac{\sum(\,nT)}{\sum n}$$ (Hartman *et al*., 2002)

Where: n = number of newly emerged seeds at time t,
T = days from sowing

Rate of Emergence

The number of seeds emerged was recorded daily up to the day of final count. The speed of emergence was calculated by adopting the following formula and expressed in number (Hartman *et al*., 2002).

$$\textbf{Rate of Emergence} = \frac{\text{The number of seeds emerged}}{\text{Per day}}$$

Where: n= number of newly emerged seeds at time t, t= days from sowing

Emergency %: The number of seeds that produce a seedily from a seed population expressed as percentage or cumulative germination (%)

EP= SE/SS X 100%

WHERE SE = total number of seeds emerged

SS= total number of seeds sown (Hartman *et al*., 2002)

Two and four months after sowing, the attributes of non-destructive parameters plant height (cm), stem diameter (cm) and leaf area (cm^2) were measured by taking five seedlings from the inner most rows of each plot. Leaf and tiller numbers were counted from the sample taken. Plant height was measured from the base to the tip of the seedling using a ruler. Stem diameter was measured at the base near the medium surface using a caliper. (IP54 Damp Proof digital caliper (111-2A) Beijing, China.(http..//www.madein-China.com)

Leaf area (fully-grown green leaves) was calculated by measuring the leaf length (cm) and maximum leaf width(cm) using ruler to get the estimated leaf area; the actual leaf area constructed by tracing the leaf on square paper then calculate the area and then to get k factor divide the actual area of the leaf over estimate area of the same leaf this was to get k factor(correction factor) Yakob *et al*. (1995) for the procedure as follows:
Leaf area (cm^2) leaf length from petiole to the tip and leaf width at broadest part was measured.

E = K x L x B

Where: E = estimated leaf area

K = factor for experiment I- k=0.62, for experiment II- k=0.58

L = leaf length (cm) and

B = maximum leaf breadth (cm).

Likewise, destructive plant growth parameters such as fresh and dry weight of leaves, stems, tiller and roots; specific and mass, root: shoot ratio, root volume, total dry matter, were recorded. The largest root length, root length between the collar region and the tip of the root were measured using rulers and the mean value was recorded in cm. by uprooting four randomly selected seedlings next to the border from each plot. Each seedling sampled for measurement of non-destructive parameters was brought to the laboratory for destructive parameters. Seedlings were cut with a scissor at collar point to separate the shoot from the root. The shoot, then, was separated in to leaves and stems and fresh weight of each was weighed using sensitive balance. The polythene bag containing the roots of the seedlings was then, immersed in a bucket filled with water and roots were carefully separated from the soil still being in water. The roots were subsequently washed with clean water; surface dried with water adsorbent cloth and fresh weight was measured following the same procedures described for the shoot. Root volume was measured using graduated cylinder 500 ml filled with water and immersed the root and recorded the water displacement volume ml. Finally, the entire seedling parts were oven dried at 70°C until a constant weight as described by Adjet-Twum and Solomon (1982) and dry matter yield was determined using sensitive balance.

Seedling vigor index was calculated to determine the variation in vigorosity among seedlings of different treatments using the measurements of tap root (largest root) of the sample, girth (stem diameter) shoot length and total percentage of field emergence (%E). Attempt was made to establish some vigor indices for the seedlings at an early stage of growth following the techniques suggested by Abdul-Baki and Andeson (1973) and was expressed as pure number. The formulae used to establish a seedling vigor index (SVI) as follows;

SVI =TRL x SH x G x %E

Where; SVI= seedling vigor index

TRL= tap root (largest root)of the sample

%E = percentage field emergence.

GD = girth of stem diameter (cm) at the base

SH = stem height (cm) from the base to the shoot tip

Growth rate of seedlings was determined by measuring initial and final total dry matter yield of randomly selected plants from each plot using the formula described by (Hunt, 1990) as follows:

RGR= NAR x SLA x LWF or RGR=NAR x LAR , LAR=LWR X SLA

$NAR = \frac{1}{LA} \times \frac{TDM2-TDM1}{t2-t1}$, $LWR = \frac{LW}{TDM(W)}$, $SLA = \frac{LW}{LW}$

Where:

LAR= LA / W and known as leaf area ratio (total leaf area **:** total dry weight)

NAR (net assimilation rate, rate of increase in plant mass per unit leaf area)

SLA (Specific leaf area (leaf area **:** leaf dry weight)

LWF (leaf dry weight**:** plant dry weight)

W = Total dry weight per plant (gm)

T LA = Total Leaf Area per plant (cm^2)

LA = Leaf Area (cm^2)

LW = Total Leaf Dry Weight per plant(gm)

LWF = Leaf Weight Fraction (gm/gm)

LWR = Leaf Weight Ratio (gm/gm)

LAR = Leaf Area Ratio ($cm^{2/}$gm)

NAR = Net Assimilation Rate(gm/$cm^{2/}$gm)

SLA = Specific Leaf Area ($cm^{2/}$gm)

RGR = Relative Growth Rate (gm/gm/d)

t_1 & $t_{2} =$ in days or months

TDM1 = Total dry Matter ($^{/}$gm) of growth one -- in days (30) or month (1)

DM2= Total dry Matter of growth ($^{/}$gm) two-- in days(60) or months(2)

3.5. Data Analysis

The collected data was processed and analyzed using SAS computer software Version 9.2 (SAS, 2008). The analysis of variance (ANOVA) was employed for each parameter in order to identify the difference among the factors of seed pre-treatment, soil media and watering frequency and Significant differences among the treatments were compared using Fisher's Least Significance Difference (LSD) at < 5 % probability level.

The model

Two factor analysis of variance model with General Linear Model (GLM) Procedures of SAS Version 9.2 was used.

The model used for experiment I was:

$$Y_{ijk} = \mu + r_j + A_i + B_k + (AxB)_{ik} + \Sigma_{jik}$$

Where;

$y_{ijk=}$ The response measurement for the ijk^{th} observation

μ =is overall mean effect

$r_{j\ =}$ is effect of j^{th} replication

$A_{i=}$ is effect of the i^{th} level of seed treatment

$B_{k=}$ is effect of the k^{th} level of Soil media

$(AxB)_{ik=}$ is effect of interaction between Soil media and seed treatment

Σ_{ijk} = is a random error component for all factors

The model used for experiment II was:

$Y_{ijk} = \mu + r_j + A_i + \Sigma_{ij} + B_k + (AxB)_{ik} + \Sigma_{jik}$

where;

$y_{ijk=}$ The response measurement for the ijk^{th} observation

μ =is overall mean effect

$r_{j\ =}$ is effect of j^{th} replication

$A_{i=}$ is effect of the i^{th} level of Soil media

Σij = is the random error associated with the main plots

$B_{k=}$ is effect of the k^{th} level of watering frequency

$(AxB)_{ik=}$ is effect of interaction between soil media and watering frequency

Σ_{ijk} = is a random error associated with the subplots and interaction

4. RESULTS AND DISCUSSION

A. Experiment I

4. 1. Seedling Emergence

4. 1. 1. Mean days to seedling emergence

Days to 50% emergence was significantly affected by the interaction of seed pre-sowing treatments and soil media (Appendix Table 3). The highest days to 50% emergence (32.67) was obtained from seeds treated with 50% sulphuric acid (soaking for 60 minutes) and sown in forest soil (T_5M_1) or in forest soil and compost mixture at 1:1 ratio (T_5M_4). Seeds treated with 50% sulphuric acid and sown in forest and top soil mixture at 1:1 ratio ($T_5M_{3)}$ gave higher days to 50% emergence (32.00). The minimum days to 50% emergence were 14 days for 24 hours soaking in pure water and sowing in mixture of forest and top soil ($T2M_3$), 48 hours soaking in pure water and sowing in top soil ($T3M_2$), 72 hours soaking in pure water and sowing in mixture of forest and top soil (T4M3) or for Korarima seeds soaked for 60 minutes in 50% sulfuric acid and sown in a blend of forest soil, top soil and compost in 1:1:1 ratio (T_5M6) (Table 3). The result may be due to the growth medium physical properties can also have a profound effect on the supply of water and air to the growing seedling emergence, besides seed soaking. This is similr to the report of Taye (2008) the effect of the various organic source and proportions on percent germination of coffee seeds was highly significant.

4. 1. 2. Seedling emergence percentage (Cumulative emergence (%) over time)

The interaction of seed treatment by soil media was highly significant ($P<0.01$) for emergence percentage (Appendix Table 3). The highest value of emergence percentage was observed for seeds soaked for 24 hrs in pure water and sown in top soil and compost in 3:1 ratio (T_2M_7) and for seed soaked for 48 hrs in pure water and sown in top soil (T_3M_2) (90.67). While the lowest value (39.00) was recorded for Korarima seeds soaked for 60 minutes in 50% sulphuric acid and sown in top soil (T_5M_2) (Table 3). Reduction in emergence percentage was observed for all 72 hours soaking seeds in pure water and 50% sulphuric acid (H_2SO_4) soaking for 60 minutes combined with all soil media used. The result may be due to the presence of interaction of the pre sowing seed treatment and soil media. Based on the research result seeds soaked with water had higher value than other for all media types whereas seeds treated with H_2SO_4 had less seedling emergence percentage. This may be due to the effect of the reaction of H_2SO_4 with different media compositions. It was contrary to Eyob *et al*,.(2008) who reported that H_2SO_4 pretreatments were more effective in breaking dormancy and stimulating emergence of korarima seed and increase significant effects on emergence percentage. This may be due to difference media used, environmental factor seed material difference and the duration of sulphuric acid (H_2SO_4) in the store .

4. 1. 3 Rate of seedling emergence (number of seeds emerge per day)

Emergence rate was significantly affected by the interaction of seed pre- sowing treatments and soil media (Table 3). Korarima seeds soaked for 24 hrs in pure water and sown in top soil and compost mixture in 1:1 ratio (T_2M_5) exhibited the highest value (17.33). Seeds soaked in pure water for 72 hrs and sown in a mixture of top soil and compost in 1:1 ratio (T_4M_5) resulted in minimum emergence rate (6.33). This may be due to the soil water holding capacity was high and the seed is soaked 72 hours, that limit the rate of emergence of the seed. The highest result was observed may be due to combined effect of the soil media physical and chemical characteristics of the media mixes used and limited water soaking of the seed. It was similar with report of Hafeez-ur-Rahman *et al*.,(2007) mixed rooting media are blended to have improved structure and texture, which, in turn, increases metabolic activities in germinating seeds, leading to better seed emergence and growth of the seedling.

Table 3: Interaction effect of seed treatment by soil media on emergence of korarima seedlings

Treatments	**Days to 50 %** emergence	Emergence **rate**	Emergence **%**
T1M1	20.67^{ef}	13.33^{h-j}	75.67^{e-h}
T1M2	20.00^{f}	15.67^{c-e}	89.00^{ab}
T1M3	20.67^{ef}	13.00^{i-k}	78.67^{b-g}
T1M4	20.00^{f}	15.33^{d-f}	87.33^{a-d}
T1M5	20.67^{ef}	16.33^{bc}	89.33^{ab}
T1M6	20.00^{f}	14.67^{fg}	78.67^{b-g}
T1M7	21.33^{ef}	12.00^{lm}	66.00^{h-j}
T2M1	20.67^{ef}	16.00^{b-d}	85.33^{a-e}
T2M2	21.33^{ef}	15.33^{d-f}	87.33^{a-d}
T2M3	14.00$^{h(Early)}$	14.67^{fg}	85.67^{a-e}
T2M4	20.67^{ef}	16.67^{ab}	86.33^{a-e}
T2M5	20.67^{ef}	16.67^{ab}	87.67^{a-c}
T2M6	20.67^{ef}	14.00^{gh}	79.33^{a-f}
T2M7	20.67^{ef}	17.33^{a}	90.67^{a}
T3M1	20.00^{f}	15.00^{ef}	85.00^{a-e}
T3M2	14.00^{h}	16.33^{bc}	90. 67 ^{a}
T3M3	20.00^{f}	12.33^{kl}	68.00^{g-i}
T3M4	22.00^{e}	15.67^{c-e}	84.00^{a-e}
T3M5	20.00^{f}	13.67^{hi}	76.00^{d-h}
T3M6	20.00^{f}	15.00^{ef}	81.33^{a-e}
T3M7	20.00^{f}	13.00^{i-k}	77.00^{c-g}
T4M1	20.00^{f}	7.33^{q}	46.67^{mn}
T4M2	20.67^{fe}	12.67^{j-l}	68.67^{f-i}
T4M3	14.00^{h}	11.33^{mn}	65.33^{h-j}
T4M4	20.67^{fe}	10.67n	55.67^{j-m}
T4M5	20.00^{f}	6.33^{r}	46.67^{mn}
T4M6	30.00^{b}	8.33^{p}	53.67^{k-m}
T4M7	26.00^{c}	10.67^{n}	64.33^{i-k}
T5M1	32.67^{a}	9.00^{op}	48.00^{mn}
T5M2	17.00^{g}	6.67^{rq}	39.00^{n}
T5M3	32.00^{a}	8.33^{p}	55.67^{j-m}
T5M4	32.67^{a}	10.67^{n}	59.33^{i-l}
T5M5	24.00^{d}	8.33p	46.33^{mn}
T5M6	14.00^{h}	9.67^{o}	53.67^{k-m}
T5M7	24.00^{d}	8.33^{p}	49.67^{l-n}
CV%	3.14	4.09	8.26
LSD 5%	1.19	0.83	9.53

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$

T_1 - Non-soaked,(T_{2}-: 24 hrs ,T_{3}-: 48 hrs T_4 -72hrs) soaking seeds in pure water) , T_{5}-:50% sulphuric acid soaking for 60 minutes, M_{1}- Forest soil , M_{2}- Top soil , M_{3}- Forest & Top soil (1:1), M_{4}- Forest & compost (1:1), M_{5}-: Top & compost (1:1), M_{6}- Forest l, Top & compost (1:1: 1), M_{7}: Top & compost (3:1)

4. 2. Vegetative Growth

4. 2. 1 Shoot height

The interaction of seed treatment by soil media was highly significant ($P<0.01$) for Shoot Length (Appendix Table 3). The highest mean values of Shoot Length 10.88cm were recorded for Korarima seeds soaked 24 hrs in pure water and sown in top soil and compost in 1:1 ratio (T_2M_5) at four months of growth stage after sowing (Table 4). The lowest value recorded for Shoot Length was 5.23cm for seeds soaked 48 hrs in pure water and sown in forest soil media (T_3M_1). The vigorous and fast growth of seedlings may be attributed to better water holding capacity and availability of nutrients for plant growth in top soil and compost. While poor growth in Forest soil alone may be due to low nutritional status for plant growth offered by the media. Similar results were reported by Conover *et al*. (1981) who reported better plant height in mixes and lowest in bark in considering single factor, the various proportion of organic source mixed with the same amount of top soil significantly affected shoot length Taye (2002),but with tow factor interaction the result may not similar.

4.2.2 Root length

The highest mean value of root length at the growth stage of four months after sowing the maximum value of root length (18.44cm) was recorded for Korarima seeds not pre treated and sown in mixed forest and top soil media of ratio 1:1 (T_1M_3) (Table 4). Wheras the lowest root length were recorded for Korarima seeds soaked for 72 hrs in pure water and sown in forest soil, top soil and compost in 1:1:1 ratio (T_4M_6) (8.71cm) at four months of growth stage after sowing. The results indicate that the seeds soaked not significant for root length as soil media, and media has different soil nutrient for seedling root length growth.. The highest root length root growth of korarima seedlings grown on those potting media containing of forest and top soil media at four months growth stage of seedling after sowing. This could be attributed largely to the improved physical conditions and promoted the penetration with profound growth and development of the root system. The lowest value observed may be due to low combination ratio of the nutrient soil medium This finding corroborates those of Taye Kufa , 1998. Hale and Orcut (1987), who found stunted root growths and thus, reduced nutrient uptake under similar nutrient deficient conditions.

4.2.3. Stem girth

The interaction of seed treatment by soil media was highly significant ($P<0.01$) for seedling stem girth (Appendix Table 3). The highest mean values of seedling girth 0.67cm was recorded for korarima seeds soaked 24 hrs in pure water and sown in soil media of top and compost ratio of 1:1 (T_2 M_5) at four months of growth stages after sowing (Table 4). The lowest value recorded for plant girth at four months of growth stage after sowing was 0.37cm for Korarima seeds soaked for 24 hrs in pure water and sown in forest soil alone (T_2M_1). The best performance of treatments might be attributed to its richer nutritional status specially nitrogen and phosphorus nutrient which enhanced increasing seedling girth growth. The adverse effect of sulphuric acid treated seeds and the limited nutrient content of medium might be restricting the girth growth. This result coincide with the finding of Henley, (1974) who reported girth growth affected pre sowing seed treatment and soil media type.

4. 2. 4. Mean leaf area per leaf

The response of Leaf area (cm^2) to seed treatment by soil media was highly significant ($p<0.01$) (Appendix Table 3). The leaf area of seeds soaked 24 hrs and sown in mixed forest and Top soil media in 1:1 ratio (T_2M_3) was found the highest during four months of growth stage after sowing, (Table 4) and their values was 15.03 cm^2. Korarima seeds soaked for 24 hrs in pure water and sown in forest soil, top soil and compost in 1:1:1 ratios (T_2M_6) (14.78) also seeds not treated and sown in forest soil and compost soil media in 1:1 ratio (T1M4) (14.37 cm^2) shown higher Leaf area at the four months of growth stage. On the other hand, the least leaf area was observed from seeds soaked for 72 hrs in pure water and sown in forest and compost soil media in 1:1 ratios (T_4M_4) (8.7cm^2)at four months of growth stages. The influence of the different proportions of media on leaf area at growth stage showed highly significant response. There were also non-significant leaf area growth variations within the proportions of each media source and seed pre treatment. However, the lowest value of leaf area was noted from those seedlings grown on the different proportions of media and seed pre treatment. This may be due to the age or early stage of seedling not used more compost blended of the media improve the soil condition in physical and nutrient availability. This contrary with the findings of Wosen et al., (2010) who reported growth parameters of leaf area has also increase with increasing soaking time.

Table 4: Interaction **e**ffect of seed treatment by media on shoot height, root length, girth and leaf area of Korarima

Treatment	Shoot height (cm)	Root length(cm)	Girth(cm)	Leaf area(cm^2)
T1M1	7.61^{h-k}	15.91^{b-d}	0.46^{d-h}	11.50^{m-o}
T1M2	9.24^{c-e}	15.76^{b-e}	0.49^{c-h}	12.17^{j-m}
T1M3	7.78^{g-jk}	18.44^{a}	0.42^{hi}	10.73^{pq}
T1M4	9.43^{b-e}	16.57^{a-c}	0.59^{b}	14.37^{a-c}
T1M5	10.48^{ab}	13.74^{d-l}	0.57bc	10.54^{q}
T1M6	9.71^{b-d}	15.46^{b-f}	0.49^{c-h}	13.22^{e-g}
T1M7	9.07^{c-f}	12.48^{g-n}	0.46^{d-h}	13.07^{e-h}
T2M1	8.68^{d-h}	14.60^{c-j}	0.37^{i}	13.44^{de}
T2M2	7.94^{f-j}	15.92^{b-d}	0.51^{b-h}	12.05^{k-n}
T2M3	8.58d-i	15.25^{b-f}	0.49^{c-h}	15.03^{a}
T2M4	9.94a-c	15.55^{b-f}	0.54^{b-d}	10.22^{q}
T2M5	10.88^{a}	13.34^{d-m}	0.67^{a}	12.6^{f-k}
T2M6	8.98^{c-g}	12.18^{i-n}	0.54^{b-e}	14.78^{ab}
T2M7	8.38^{e-i}	17.57^{ab}	0.53^{b-f}	10.95^{o-q}
T3M1	5.23^{l}	11.00^{m-p}	0.48^{h-g}	13.45^{de}
T3M2	7.56^{h-k}	13.15^{e-m}	0.48^{c-h}	11.35^{n-p}
T3M3	8.91^{c-g}	15.12^{b-g}	0.45^{d-i}	12.49^{g-k}
T3M4	8.43^{e-i}	13.73^{d-l}	0.53^{b-e}	12.27^{i-m}
T3M5	8.85^{c-g}	13.68^{d-l}	0.49^{c-h}	13.01^{e-i}
T3M6	9.39^{b-e}	11.95^{j-n}	0.54^{b-e}	13.27^{e-g}
T3M7	8.56^{d-i}	14.25^{c-k}	0.46^{d-i}	10.40^{q}
T4M1	6.94^{jk}	14.79^{c-i}	0.47d-i	14.14^{b-d}
T4M2	7.60^{h-k}	11.67^{k-o}	0.44f-i	10.64^{pq}
T4M3	7.56^{i-k}	10.47^{n-p}	0.48^{c-h}	11.87^{k-n}
T4M4	7.44^{i-k}	9.34^{op}	0.53b-e	8.70^{r}
T4M5	8.73^{d-h}	9.23^{op}	0.59^{b}	14.16^{b-d}
T4M6	6.72^{k}	8.71^{p}	0.52^{b-g}	10.43^{q}
T4M7	7.64^{h-k}	13.07^{f-n}	0.45^{e-i}	10.63^{pq}
T5M1	7.44^{i-k}	14.78^{c-i}	0.53^{b-e}	13.72^{c-e}
T5M2	8.39^{e-i}	12.38^{h-n}	0.47^{c-h}	11.66^{lo}
T5M3	7.56^{h-k}	15.00^{b-h}	0.43^{g-i}	12.39^{h-l}
T5M4	7.53^{h-k}	11.35^{l-o}	0.46^{d-i}	12.97^{e-j}
T5M5	8.66^{d-i}	11.67^{k-o}	0.52^{b-g}	13.33^{f}
T5M6	9.20^{c-e}	13.82^{d-l}	0.47^{d-h}	13.10^{e-h}
T5M7	8.74^{d-h}	15.68^{b-f}	0.54^{b-e}	13.48^{de}
Cv%	7.32	9.94	9.56	3.47
LSD 5%	1.00	2.21	0.08	0.70

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$
T_1 - Non-soaked,(T_2-: 24 hrs ,T_3-: 48 hrs T_4 -72hrs) soaking seeds in pure water) , T_5-:50% sulphuric acid soaking for 60 minutes, M_1- Forest soil , M_2- Top soil , M_3- Forest & Top soil (1:1), M_4- Forest & compost (1:1), M_5-: Top & compost (1:1), M_6- Forest l, Top & compost (1:1: 1), M_7: Top & compost (3:1)

4. 2. 5. Total leaf area

Total Leaf Area (cm^2) was significantly ($P<0.01$) affected by the interaction of seed treatment and media (Appendix Table 3). The highest value 201.09 $cm^2$was observed for seeds soaked for 60 minutes in 50% sulfuric acid and sown in forest and top soil in 1:1 ratio (T_5M_3), while the smallest values (73.09) for seeds soaked 72 hrs in pure water and sown in forest soil alone (T_4M_1) was recorded four months of seedling growth stages after sowing (Table 5).This is because of combined effect of the media seed treatment provide more nutrients than single media for increasing specific leaf area. This is consistent with the findings of Ahmadi et al., (2007) who reported pre sowing seed treatment in concentrated sulfuric acid increase imbibitions and improve growth characteristics parameters such as total leaf area.

4.2.6. Leaf number

The interaction of seed treatment by soil media was highly significant ($P<0.01$) for leaf number (Appendix Table 3). The highest Leaf number (8.17) was recorded for seeds soaked 24 hrs in pure water and sown in media ratio of 1:1 forest soil and top soil (T_2M_3) and seeds soaked for 60 minutes in 50% sulphuric acid sown in forest soil and compost in 1:1 ratio (T_5M_4). Even if T_2M_3 and T_5M_4 had higher values statically there were no different for most treatments (Table 5). The lowest value of leaf number (6.50) was recorded for seeds soaked for 48 hrs in pure water sown in top soil with compost ratio of 3:1 (T_3M_7) (Table 5). Different results recorded in leaf number may be due to the water holding capacity which is needed for plant growth that may be affected by seed treatment. Different seeds need seed treatments for germination as well as for growth. The increase in leaf number due to supplied of more nutrient from the media and this could be attributed to more number of leaves.

4.2.7. Largest root length

Even though korarima have fibrous roots the longest root was considered as tap root for this research. The highest largest root length was obtained from seeds not soaked and sown in top soil media (T_1M_2), seeds not soaked and sown in top soil and compost in1:1 ratios (T_1M_5), seeds soaked for 24 hrs in pure water and sown in forest soil media(T_2M_1), seeds soaked for 24 hrs in pure water and sown in top soil media(T_2M_2), seeds soaked for 48 hrs in pure water and sown in Top soil and compost media in 1:1:1atios (T_3M_5) and seeds soaked for 60 minutes in 50% sulfuric acid and sown in forest soil media (T_5M_1),its values were 30.60, 30.77, 30.37, 30.23, 30.8 and 30.40 cm at transplanting stage, respectively. The minimum value of largest root length (22.27 cm) was recorded when un soaked seeds sown in media composition of top soil and compost in 3:1 ratio (T_1M_7), at similar stage of transplanting (Table 5). This was due to the application of soil media favor nutrient and water in most of the treatments for the growth of largest root length. Synergistic combination of both the factors in improving the physical conditions of the media and nutritional factors better plant seedling growth of largest root observed (Sahni *et al.,* 2008).

4.2.8. Root number

The highest mean values of root number 30.00 per plant was recorded for seeds soaked 48 hrs in pure water and sown in soil media ratio of 1:1 top soil and compost (T_3M_5) .Where as the lowest value (7.67) recorded for root number for seeds soaked 24 hrs in pure water and sown in media ratio of 3:1 top soil and compost (T_2M7). The lowest values recorded for root number was maybe caused due to unbalanced composition of nutrients and availability of moisture of the soil and less water soaking of the seed. This may occurred for the reason of availability of nutrient phosphorus in soil media develop of healthy root systems and cell division.

4.2.9. Tiller number

The result showed that number of tillers was highly significantly ($P<0.01$) affected by the interaction between seed treatment and media (Appendix Table 3). The maximum mean value of number of tillers (1.97) was recorded for seeds soaked 24 hrs in pure water and sown in top soil and compost mixture in 3:1 ratio (T_2M7) at four months growth stage duration and the lowest value (0.33) was achieved for seeds not soaked and sown in forest soil media (T_1M_1), seeds not soaked and sown in top soil media (T_1M_2), seeds soaked for 24 hrs in pure water and sown in forest soil media(T_2M_1) and seeds soaked for 24 hrs in pure water and sown in top soil media (T_2M_2) (Table 5). The highest value observed may be due to the combination of the media of the soil supplied good nutrient and compost improves soil physical structure on for water holding and air.

Table 5: Interaction **e**ffects of seed treatment and media on total leaf area, longest root length, leaf number, root number and tiller number of Korarima

Treatment	Total Leaf Area(cm^2)	Largest root length (cm)	Leaf number	Root number	Tiller number
T1M1	144.21^{f-j}	25.60^{hi}	7.00^{b-d}	13.33^{kl}	0.33^{j}
T1M2	142.26^{g-j}	30.60^{a}	7.17^{b-d}	15.00^{hi}	0.33^{j}
T1M3	121.59^{jk}	29.33^{b}	6.83^{cd}	9.00^{p}	0.67^{g-j}
T1M4	139.49^{g-j}	29.40^{b}	7.67^{a-c}	13.67^{jkl}	1.33^{b-e}
T1M5	138.09^{g-j}	30.77^{a}	7.500^{a-c}	21.33^{d}	1.67^{a-c}
T1M6	125.75^{i-k}	25.63^{hi}	7.33^{a-d}	26.00^{b}	1.00^{e-h}
T1M7	147.81^{e-i}	22.27^{m}	7.500^{a-c}	16.33^{g}	0.78^{f-j}
T2M1	121.09^{jk}	30.37^{a}	7.67^{a-c}	12.17^{n}	0.33^{j}
T2M2	136.33^{g-j}	30.23^{a}	7.17^{b-d}	18.33^{f}	0.33^{j}
T2M3	118.73^{jk}	23.47^{l}	8.17^{a}	15.33^{h}	1.00^{e-h}
T2M4	173.88^{bd}	26.70^{fg}	7.17^{b-d}	19.33^{e}	1.67^{a-c}
T2M5	147.04^{e-i}	29.23^{bc}	7.50^{a-c}	12.33^{mn}	1.22^{c-f}
T2M6	158.34^{c-g}	25.27^{ij}	7.67^{a-c}	11.67n	1.22^{c-f}
T2M7	157.87^{c-g}	27.43^{ef}	7.17^{b-d}	7.67^{q}	1.97^{a}
T3M1	169.19^{b-e}	28.37^{d}	7.50^{a-c}	15.00^{hi}	1.80^{ab}
T3M2	154.67^{d-h}	27.20^{ef}	7.50^{a-c}	10.00^{o}	0.55^{h-j}
T3M3	183.87^{ab}	27.63^{e}	7.83^{ab}	9.00^{p}	1.50^{a-d}
T3M4	138.31^{g-j}	23.37^{l}	7.50^{a-c}	15.67^{gh}	0.57^{h-j}
T3M5	168.30^{b-f}	30.80^{a}	7.33^{a-d}	30.00^{a}	0.78^{f-j}
T3M6	105.3^{kl}	26.43^{g}	7.50^{a-c}	15.00^{hi}	0.99^{e-h}
T3M7	185.3^{ab}	27.30^{ef}	6.50^{d}	13.00^{lm}	1.11^{d-g}
T4M1	73.09^{m}	28.57^{cd}	7.17^{b-d}	12.33^{mn}	1.50^{a-d}
T4M2	123.67^{i-k}	24.47^{k}	7.17^{b-d}	19.00^{ef}	1.00^{e-h}
T4M3	181.65^{a-c}	25.47^{ij}	7.83^{ab}	15.00^{hi}	0.44^{ij}
T4M4	119.34^{jk}	26.27^{gh}	6.83^{cd}	16.33^{g}	0.44^{ij}
T4M5	177.55^{a-d}	24.77^{jk}	7.67^{a-c}	18.33^{f}	1.22^{c-f}
T4M6	156.99^{c-g}	24.37k	7.50^{a-c}	13.00^{lm}	1.78^{ab}
T4M7	86.55^{lm}	24.83jk	7.00^{b-d}	15.00^{hi}	1.44^{b-e}
T5M1	90.66^{lm}	30.40a	7.50^{a-c}	13.33^{kl}	1.61^{a-c}
T5M2	187.18^{ab}	28.47d	7.50^{a-c}	8.00^{q}	1.67^{a-c}
T5M3	201.09^{a}	27.47ef	7.50^{a-c}	12.00^{n}	0.86^{f-i}
T5M4	108.00^{kl}	27.40ef	8.17^{a}	14.33^{ij}	0.67^{g-j}
T5M5	138.97^{g-j}	29.33b	7.00^{b-d}	15.67^{gh}	1.33^{b-e}
T5M6	130.05^{h-k}	26.23gh	7.00^{b-d}	23.00^{c}	1.68^{a-c}
T5M7	179.33^{a-d}	28.47^{d}	7.50^{a-c}	14.00^{jk}	1.44^{b-e}
Cv%	9.04	1.56	6.47	2.68	22.24
LSD 5%	21.16	0.69	0.78	0.66	0.4

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$
T_{1} - Non-soaked,(T_{2}-: 24 hrs ,T_{3}-: 48 hrs T_{4} -72hrs) soaking seeds in pure water) , T_{5}-:50% sulphuric acid soaking for 60 minutes, M_{1}- Forest soil , M_{2}- Top soil , M_{3}- Forest & Top soil (1:1), M_{4}- Forest & compost (1:1), M_{5}-: Top & compost (1:1), M_{6}- Forest l, Top & compost (1:1: 1), M_{7}: Top & compost (3:1)

4. 3. Dry Matter Production

4.3. 1. Leaf dry weight

The interaction of seed treatment by soil media was highly significant ($p<0.01$) for leaf dry weight (Appendix Table 3). The highest mean values of leaf weight (g) 0.786 and 0.787 were recorded for seeds not soaked and sown in forest soil and compost in 1:1 ratio (T_1M_4) and seeds soaked for 24hrs in pure water and sown in mixed forest and compost soil media in 1:1 ratios (T_2M_4) at four months of growth stages after sowing,respectively (Table 6). The lowest value 0.373g and 0.376g were recorded for seeds soaked for 48 hrs in pure water sown in top soil (T_3M_2), and seeds soaked for 60 minutes in 50% suluric acid sown in top soil (T_3M_2), respectively. In respect to leaf dry weight, it was significantly influenced by the various seed treated and ratios of soil media with highly significant effects by sources and proportion including their interactions (Table 6). As a result, the value for leaf dry weights ranged from 0.0039g to 0.786g was observed at different growth stage. In general, leaf growth responses indicate the influences of wide C: N ratio in the media and hence inadequate nitrogen nutrition due to limited mineralization. This supports the findings of Franco and Munns (1982), who demonstrated the temporary shortage of nitrogen under a similar setting. This support the combined of the media of forest and compost soil combination Vineeta *et al* (2005) reported that soil structural stability increased due to straw addition with better aggregate size distribution and reduction in soil disturbance. He further added that soil organic matter acts as a reservoir for plant nutrients and prevents leaching of elements, necessary for seedling growth.

4.3.2. Stem dry weight

The highest mean values of stem weight (g) 0.513 were recorded seeds not soaked and sown in mixed forest and compost soil media in 1:1 ratio (T_1M_4) at four months of growth stages after sowing (Table 6). The lowest value recorded for stem weight(g) was 0.170, for seeds soaked for 24 hrs in pure water and sown in top soil and compost in 3:1 ratio (T_2M7). The result indicate un soaked seed (wihout seedtreatment) and the equal combination of soil media improve the soil physical stracture and media nutrient, and this give high dry stem weight.On the other hand, less compost combination of the soil give less weight of stem dry weight(g).

4. 3. 3 Root dry weight

Interaction of seed treatment by soil media on root dry weight was highly significant ($p< 0.01$) (Appendix Table 3). Among the treatments tested, highest root weight per plant was recorded from seeds soaked for 24hrs in pure water and sown in mixed forest and compost soil media in 1:1 ratios (T_2M_4) treatments, which was 0.511 g at four months of growth stages. On the other hand, the seeds soaked for 48 hrs in pure water and sown in top soil media (T_3M_2) gave the lowest root weight during the growth stages four months and the values was 0.124 g (Table 6).This is may be due to combined effect of the soil improve the soil water holding capacity and nutrient uptake for growth. Hafeez-ur-Rahman *et al*., (2007) reported that mixed soil media improve soil structure and texture, which, in turn, increases metabolic activity in germinating seeds, leading to better germination of seed and growth of seedling.

4.3.4. Total dry weight

Interaction of seed treatment and media on weight total dry matter per plant showed highly significant ($p< 0.01$) (Appendix Table 3). The highest total dry weight per plant of 2.386g and 2.219g were obtained from seeds soaked for 24hrs in pure water and sown in mixed forest and compost soil media in 1:1 ratio (T_2M_4) and seeds soaked for 60 minutes in 50% sulphuric acid and sown in top soil and compost in 1:1 ratio soil media (T_5M_5), respectively, followed by seeds not soaked and sown in forest soil and compost in 1:1 ratio (T_1M_4) (2.033g). On the other hand, seeds soaked for 48 hrs in pure water and sown in top soil media (T_3M_2) (0.846g) and seeds soaked for 60 minutes in 50% sulfuric acid and sown in top soil media (T_5M_2) (0.845g) showed the lowest values at the four after sowing months seedling growth stage (Table 6).Dry matter production in any crop depends upon the leaf area index (LAI), the structure of the canopy, photosynthetic rate per unit of leaf area, and the strength of the metabolic sinks in attracting assimilates, which is may be enhanced by seed treatment and blended media combination and this particularly important in sin seedling growth. This result is in agreement with previos finding of Wooton *et al*.,(1981)as reported that media blends with compost were to found be best for optimum seedling growth.

Table 6: Interaction **e**ffects of seed treatment and media on dry weight of leaf, stem, root and total dry weight of Korarima

Treatment	Leaf weight (g)	stem weight (g)	Root wt(g)	Total Dry weight (g)
T1M1	0.586^{e-h}	0.383^{c-g}	0.342^{c-f}	1.470^{gh}
T1M2	0.569^{f-j}	0.290^{j-n}	0.292^{d-h}	1.254^{i-k}
T1M3	0.600^{d-h}	0.324^{g-l}	0.296^{d-h}	1.618^{e-g}
T1M4	0.786^{a}	0.513^{a}	0.411^{bC}	2.033^{b}
T1M5	0.665^{b-f}	0.412^{b-f}	0.290^{e-i}	1.856^{b-d}
T1M6	0.701^{a-d}	0.366^{d-i}	0.358^{c-e}	1.675^{d-f}
T1M7	0.476^{i-n}	0.307^{h-m}	0.245^{g-k}	1.293^{h-k}
T2M1	0.600^{d-h}	0.371^{d-h}	0.371^{cd}	1.482^{gh}
T2M2	0.573^{f-i}	0.335^{g-k}	0.337^{c-f}	1.332^{h-j}
T2M3	0.527^{h-m}	0.324^{g-l}	0.298^{d-g}	1.297^{h-k}
T2M4	0.787^{a}	0.443^{bc}	0.511^{a}	2.386^{a}
T2M5	0.436^{mn}	0.422^{bcd}	0.286^{e-i}	1.576^{fg}
T2M6	0.422^{mn}	0.416^{b-e}	0.380^{bc}	1.680^{d-f}
T2M7	0.552^{g-l}	0.170^{q}	0.397^{bc}	1.282^{h-k}
T3M1	0.454^{k-n}	0.185^{pq}	0.280^{e-i}	1.035^{l-n}
T3M2	0.373^{n}	0.255^{l-o}	0.124^{n}	0.846^{n}
T3M3	0.496^{hm}	0.335^{g-k}	0.249^{g-j}	1.306^{h-j}
T3M4	0.560^{f-k}	0.345^{f-j}	0.286^{e-i}	1.441^{g-i}
T3M5	0.764^{ab}	0.372^{d-h}	0.449^{ab}	1.978^{bc}
T3M6	0.736^{a-c}	0.349^{e-j}	0.412^{bc}	1.810^{c-e}
T3M7	0.553^{g-k}	0.352^{e-j}	0.220^{g-m}	1.198^{j-l}
T4M1	0.463^{j-n}	0.199^{o-q}	0.180^{j-n}	1.004^{l-n}
T4M2	0.596^{d-h}	0.308^{h-m}	0.265^{f-i}	1.315^{h-j}
T4M3	0.446^{l-n}	0.268^{kl-n}	0.147^{mn}	0.994^{mn}
T4M4	0.467^{i-n}	0.250^{m-p}	0.222^{g-m}	1.101^{k-m}
T4M5	0.689^{a-e}	0.343^{f-ij}	0.215^{h-m}	1.593^{fg}
T4M6	0.433^{mn}	0.299^{i-m}	0.234^{g-l}	1.012^{l-n}
T4M7	0.549^{g-l}	0.343^{f-j}	0.209^{i-m}	1.375^{h-j}
T5M1	0.460^{k-n}	0.242^{m-p}	0.218^{g-m}	1.056^{lm}
T5M2	0.376^{n}	0.227^{n-q}	0.166^{k-n}	0.845^{n}
T5M3	0.426^{mn}	0.256^{l-o}	0.160^{l-n}	0.929^{mn}
T5M4	0.518^{h-l}	0.266^{k-o}	0.273^{f-i}	1.282^{h-k}
T5M5	0.653^{c-g}	0.479^{ab}	0.356^{c-e}	2.219^{a}
T5M6	0.643^{c-g}	0.366^{d-i}	0.225^{g-m}	1.697^{d-f}
T5M7	0.666^{b-f}	0.424^{b-d}	0.333^{c-f}	1.965^{bc}
Cv%	9.83	11.07	14.55	7.39
LSD 5%	0.09	0.06	0.07	0.17

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$

T_{1} - Non-soaked,(T_{2}-: 24 hrs ,T_{3}-: 48 hrs T_{4} -72hrs) soaking seeds in pure water) , T_{5}-:50% sulphuric acid soaking for 60 minutes, M_{1}- Forest soil , M_{2}- Top soil , M_{3}- Forest & Top soil (1:1), M_{4}- Forest & compost (1:1), M_{5}-: Top & compost (1:1), M_{6}- Forest l, Top & compost (1:1: 1), M_{7}: Top & compost (3:1)

4.3.5. Shoot dry weight

The highest shoot weight(g) were recorded from seeds soaked 24 hrs in pure water and sown in a blend of forest soil : compost in 1:1 ratio (T_2M_4) and seeds soaked for 60 minutes in 50% sulphuric acid and sown in top soil and compost in 1:1 ratios (T_5M_5) at four months of growth stage 1.875 &1.863g, respectively. The least value from seeds soaked for 60 minutes in 50% sulphuric acid and sown in top soil media(T_5M_2) and their respective values 0.679 g was obtained (Table 7). This is in line with the reports of (Taye kufa, 1998), who indicated that the growth responses to the various potting media blends were consistently highly significant highest shoot dry weights (g) were from seedlings grown on Organic manure: top soil ratio, while the lowest shoot dry weight was obtained from the top soil alone treatment.

4.3. 6. Root to shoot ratio dry weight

Interaction of seed treatment and media on **r**oot to shoot ratio dry weight per plant showed highly significant ($p< 0.01$) (Appendix Table 3). Korarima seeds soaked for 24 hrs in pure water and sown in mixed top soil and compost in 3:1 ratio (T_2M7) gave the highest root to shoot ratio per plant 0.45g at four months of growth stage after sowing. On the other hand, the seeds soaked for 60 minutes in 50% sulphuric acid and sown in mixed forest soil, top soil and compost in 1:1:1 ratios (T_5M_6) gave the lowest root to shoot ratio per plant at growth stage of four months growth stages with their respective values of 0.15 (Table 7).Generally, The treatments of Korarima seeds not soaked and sown in mixed forest soil, top soil and compost in 1:1:1 ratios (T_1M_6), seeds soaked for 24 hrs in pure water and sown in forest soil, top soil and compost in 1:1:1 ratios (T_2M_6), seeds soaked for 24hrs in pure water and sown in mixed forest and compost soil media in1:1 ratios (T_2M_4) significantly improved the seedling root weight (Table7). Increasing the water soaking for 72 hrs and seed treatment by Soaking in 50% sulfuric acid (H_2SO_4) for 60 minutes reduced the seedling growth. seeds not treated(soaked) and sown in forest soil , top soil and compost in 1:1:1 ratios (T_1M_6), Korarima seeds soaked for 24 hrs in pure water and sown in forest soil, top soil and compost in 1:1:1 ratios (T_2M_6), Korarima seeds soaked for 24hrs in pure water and sown in mixed forest and compost soil media in 1:1 ratios (T_2M_4) significantly enhanced root weight (o.511 g) compared to other treatments at this growth stage. The result is similar with the report of Lamant,(1992) the importance of vigorous rooting of seedling in water relationship, nutrient uptake and subsequent growth, reduced root to shoot ratio may decrease the rate of survivaland vegetative growth of seedling especially under nutrient and moisture supplies.

4.3. 7. Tiller dry weight

The response of tillers weight for interaction of seed treatment by media was highly significant ($p < 0.01$) (Appendix Table 3). Interaction of seed treatment and media on tillers dry weight was highly significant different ($p < 0.01$) (Table 7). The result indicated that some had the same response to interaction of seed treatment and media in dry matter accumulation in their tillers. At four months growth stage, relatively maximum tiller dry weight per plant was recorded from seeds soaked for 60 minutes in 50% sulphuric acid and sown in top soil and compost in 1:1 ratio soil media (T_5M_5) with respective value of 0.731 g, and minimum from seeds soaked for 72 hrs in pure water and sown in a blend of forest soil, top soil and compost in 1:1:1 ratio (T_4M_6) (0.046 g). This may be due to high equal combination of the soil media the highest weight was observed and the least weight value was due to less proportionality of the media and more seed soaking time.

4.3. 8. Root volume

Interaction of seed treatment by soil media on root volume (mm) showed highly significant ($p < 0.01$) variations in their root volume, (Appendix Table 3). The highest root volume were obtained from seeds not soaked and sown in top soil and compost in 1:1 ratio (T_1M_5), seeds soaked for 24 hrs in pure water and sown in top soil and compost in 3:1 ratio (T_2M7), seeds soaked for 48hrs in pure water and sown in Top soil and compost media in 1:1 ratio(T_3M_5), seeds soaked for 48 hrs in pure water and sown in forest soil, top soil and compost in 1:1:1 ratio (T_3M_6), its values were 4.00ml for all, and also the minimum root volume was recorded from seeds soaked for 60 minutes in 50% sulphuric acid and sown in top soil (T_5M_2),its value was 0.67 ml at four growth stage (Table 7). This due to combined application of soil media in most of the treatments showed significant effect on volume. The less root volume may be due to the soil media moisture status and less nutrient availability reduce the root volume. Synergistic combination of both the factors in improving physical conditions of the media and nutritional factors better plant seedling growth observed (Sahni *et al.*, 2008).The present study confirmed.

4.4. Seedling Vigor Index

The interaction of seed treatment and soil media was highly significant ($P<0.01$) in respect of SVI (Appendix Table 3). The highest score for seeds soaked for 24 hrs in pure water and sown in Top soil and compost media in 1:1 ratio (T_2M5) (185.73) at four months stage duration after sowing. While the lowest values (43.68), (46.43), (43.95) & (49.71) were recorded for seeds soaked for 72 hrs in pure water and sowing in forest soil media (T_4M_1) or forest soil, top soil and compost in 1:1:1 ratios (T_4M_6), seeds soaked for 60 minutes in 50% sulphuric acid and sown in top soil media(T_5M_2) or Forest and Top soil mixture 1:1 ratio, respectively at four months stage after sowing (Table 7). Reduction in seedling vigor index (SVI) was observed for interaction of seed treatment (72hrs water soaking and 60 minutes in 50% sulfuric acid) with soil media. The highest mean values of seed emrrgence percentge, seed rate emergence,shoot length and girth of seedling were recorded for korarima seeds soaked 24 hrs in pure water and sown in soil media of top and compost ratios of 1:1 (T_2 M_5) at four months of growth stages after sowing and this result confirm also the same treatment effect on the SVI. This result is not similar to that of Wosene *et al.* (2010) who reported that increase of time of water soaking presents significant effects on SVI. In addition, combined application of compost and top soil in equal ratio soil in the treatments showed significant SVI, which helped in better nutrient availability to the growing parts and enhanced seedling growth compared to the other treatments.

Table 7: Interaction **e**ffects of seed treatment and media on shoot weight, root to shoot ratio, tiller dry weight, root volume and seedling vigor index

Treatment	Shoot wt(g)	Root to Shoot	Tillers wt(g)	Root Vol.(ml)	Seedling vigor index
T1M1	1.128^{h-j}	0.30^{cd}	0.154^{kl}	3.33^{a-c}	68.24^{j-o}
T1M2	0.962^{k-n}	0.30^{cd}	0.103^{l-q}	2.67^{c-f}	123.43^{cd}
T1M3	1.323^{ef}	0.22^{g-l}	0.399^{ef}	1.67^{g-i}	75.20^{i-n}
T1M4	1.623^{b}	0.26^{d-i}	0.323^{gh}	3.67^{ab}	141.88^{c}
T1M5	1.565^{bc}	0.19^{j-n}	0.488^{d}	4.00^{a}	163.59^{b}
T1M6	1.318^{f}	0.27^{d-g}	0.251^{j}	2.33^{e-g}	97.2^{e-i}
T1M7	1.048^{h-k}	0.23^{f-k}	0.265^{ij}	1.33^{ij}	61.74^{k-o}
T2M1	1.111^{h-k}	0.34^{bc}	0.140^{k-n}	2.33^{fg}	83.70^{g-l}
T2M2	0.995^{j-m}	0.34^{bc}	0.0867^{n-q}	3.17^{b-d}	107.4^{d-g}
T2M3	0.999^{i-m}	0.30^{cd}	0.147^{k-m}	1.67^{g-i}	84.52^{g-k}
T2M4	1.875^{a}	0.27^{d-g}	0.645^{b}	2.67^{c-f}	123.23^{cd}
T2M5	1.291^{fg}	0.22^{g-l}	0.433^{de}	2.33^{e-g}	185.73^{a}
T2M6	1.300^{fg}	0.29^{c-f}	0.462^{d}	2.17^{f-h}	96.46^{e-i}
T2M7	0.885^{l-o}	0.45^{a}	0.163^{k}	4.00^{a}	114.42^{de}
T3M1	0.755^{o-q}	0.37^{b}	0.116^{k-p}	3.00^{b-d}	54.27^{no}
T3M2	0.722^{pq}	0.17^{l-n}	0.095^{m-q}	1.33^{ij}	89.09^{f-i}
T3M3	1.058^{h-k}	0.23^{f-k}	0.227^{j}	1.67^{h-j}	75.79^{i-n}
T3M4	1.155^{g-i}	0.25^{d-i}	0.251^{j}	3.17^{b-d}	88.06^{f-j}
T3M5	1.529^{b-d}	0.29^{c-e}	0.393^{ef}	4.00^{a}	100.28^{d-h}
T3M6	1.398^{df}	0.30^{c-e}	0.313^{ghi}	4.00^{a}	109.67^{d-f}
T3M7	0.978^{j-n}	0.23^{g-k}	0.072^{pq}	1.33^{ij}	82.6^{h-m}
T4M1	0.824^{n-q}	0.22^{g-l}	0.161^{kl}	1.50^{hi}	43.68^{o}
T4M2	1.049^{h-k}	0.2^{d-i}	0.145^{k-n}	1.50^{hi}	55.9^{no}
T4M3	0.847^{m-p}	0.18^{k-n}	0.134^{k-o}	2.33^{e-g}	60.46^{k-o}
T4M4	0.880^{l-p}	0.26^{d-i}	0.162^{kl}	2.17^{f-h}	58.18^{m-o}
T4M5	1.378^{ef}	0.16^{mn}	0.347^{fg}	2.00^{f-hi}	59.39^{l-o}
T4M6	0.777^{o-q}	0.30^{cd}	0.046^{q}	2.67^{c-f}	46.43^{o}
T4M7	1.165^{gh}	0.18^{k-n}	0.273^{h-j}	2.33^{e-g}	54.58^{no}
T5M1	0.838^{n-p}	0.26^{d-h}	0.136^{k-n}	1.33^{ji}	58.29^{m-o}
T5M2	0.679^{q}	0.24^{e-j}	0.076^{o-q}	0.67^{j}	43.95^{o}
T5M3	0.768^{o-q}	0.21^{i-m}	0.0867^{n-q}	2.33^{e-g}	49.71^{o}
T5M4	1.009^{h-l}	0.27^{d-g}	0.226^{j}	2.00^{f-i}	56.43^{no}
T5M5	1.863^{a}	0.19^{j-n}	0.731^{a}	2.50^{de}	61.58^{k-o}
T5M6	1.471^{c-e}	0.15^{n}	0.462^{d}	3.00^{b-d}	60.61^{k-o}
T5M7	1.632^{b}	0.20^{i-n}	0.542^{c}	2.67^{c-f}	66.12^{j-o}
Cv%	7.32	14.06	12.07	16.72	15.39
LSD 5%	0.14	0.06	0.05	0.66	20.78

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$

T_{1-} Non-soaked,(T_{2-}: 24 hrs ,T_{3-}: 48 hrs T_{4-}72hrs) soaking seeds in pure water) , T_{5-}:50% sulphuric acid soaking for 60 minutes, M_{1-} Forest soil , M_{2-} Top soil , M_{3-} Forest & Top soil (1:1), M_{4-} Forest & compost (1:1), M_{5-}: Top & compost (1:1), M_{6-} Forest l, Top & compost (1:1: 1), M_7: Top & compost (3:1)

4.5. Correlation Studies

The Pearson correlation matrix for the data set is shown in Table 8. In this study, the association among growth parameters and relationship with each other was discussed. Shoot height in cm was positively but not significantly correlated with root length, root volume, root number, root length and leaf area. However, it was highly significant (p<0.01) correlated with girth(r = 0.43), SVI(r = 0.72), total dry matte(r = 0.61), root weight(r = 0.43) and shoot weight(r = 0.62).

Root length (cm) was negatively but not significantly correlated with girth and root number and also positively but not significantly correlated with the rest of the parameters leaf area, total dry matter, root volume root weight and shoot weight.

Girth was observed positively and not significantly correlated among the parameters of root volume, root number, tap root length , leaf area. total dry matter, root weight and shoot weight.

. Root number was positively and highly significant (p<0.01) correlated with total dry matter(r = 0.45) and shoot weight (r=0.46). However, positively but not significantly correlated with root volume, root weight, leaf area (cm^2) .

Leaf area cm was positively but not significantly correlated with the the parameters of root volume, , tap root length , total dry matter, root weight and shoot weight

Root weight was positively and highly significant (P<0.01) correlated with total dry weight (r=0.77), root volume (r = 0.61) and shoot weight (r=0.64) and positively but not significantly correlated with tap root length.

Total dry weight was positively and highly significant (P<0.01) correlated with root volume (r = 0.50) and shoot weight (r=0.98) and and positively but not significantly correlated with tap root length (cm).

Root volume was positively and highly significant (P<0.01) correlated with shoot weight (r = 0.43).Tap root length (cm) was positively but not significantly correlated with root volume and shoot weight (gm).

Table 8: Correlation coefficients (r) among growth parameters of effect of seed treatment and soil media on korarima

Growth characteristic	shoot length(cm)	Root length(cm)	Girth (cm)	Root No.	Leaf Area(cm^2)	Root wt(gm)	Total dry wt(gm)	Tap Root length (cm)	Root vol.(ml)	shoot wt(gm)
shoot length (cm)	1.00									
Root lengh (cm)	0.24	1.00								
girth (cm)	0.43**	-0.08	1.00							
root number	0.26	-0.13	0.09	1.00						
Leaf Area (cm^2)	0.11	0.09	0.06	0.06	1.00					
Root wt (gm)	0.43**	0.34	0.21	0.30	0.15	1.00				
Total dry wt (gm)	0.61**	0.21	0.32	0.45**	0.18	0.77**	1.00			
Tap Root length (cm)	0.14	0.35	0.03	-0.02	0.04	0.21	0.17	1.00		
Root vol.(mm)	0.24	0.16	0.27	0.36	0.01	0.61**	0.50**	0.21	1.00	
shoot wt (gm)	0.62**	0.16	0.32	0.46**	0.17	0.64**	0.98**	0.15	0.43**	1.00

**Highly Significant different at $P < 0.01$

4. 6. Growth Rate Components

The interaction of seeds pre sowing treatment and soil media showed highly significant $P<0.01$) difference in Relative Growth Rate (RGR), Net Assimilate Rate(NAR), Leaf Area Ratio(LAR), Specific Leaf Area(SLA) and Leaf Weight Ratio(LWR) (Appendix 4). The data showed that different interaction of seeds pre sowing treatment and soil media had highly significant ($P<0.01$) effect on seedling relative growth rate (RGR) (Appendix 4). Mean values given in table 9 showed that the highest RGR (0.296g/g/d) was recorded in seeds soaked for 48 hrs in pure water and sowing in mixture of top soil and compost in 3:1 ratios (T3M7). A minimum value for seedling relative growth rate (RGR) (0.085 g/g/d) was observed in seeds soaked for 72 hrs in pure water and sown in forest soil (T_4M_1). The best performance of top soil and its combination with compost might be attributed to its richer nutritional status which enhanced photosynthetic activity resulted in more plant stored material, thereby increasing seedling relative growth rate. Similarly, minimum seedling relative growth rate in forest soil alone may be due to less soil nutrition than the combination soil media with compost which restricted plant growth.

NAR-Korarima seeds soaked for 24 hrs in pure water and sown in mixed Forest soil and compost in 1:1 ratio (T_2M4) gave the highest NAR 0.0039 g/cm^2/day,1.86,respectively at four months of growth stages after sowing. The seeds soaked for 60 minutes in 50% sulfuric acid and sown in top soil media(T_5M_2) and seeds soaked for 72 hrs in pure water and sown in Forest soil (T4M1) gave the lowest Net Assimilate Rate at growth stages of four months after sowing with their respective values of 0.0012 g/cm^2/day (Table 9).

LAR- The interaction of seed treatment by soil media was highly significant ($P<0.01$) for leaf area ratio. The highest value of LAR was observed for seed soaked for 60 minutes in 50% sulfuric acid and sown in top soil (T_5M_2) and for seeds soaked for 60 minutes in 50% sulfuric acid and sown in mixture of forest and top soil in equal ratio (T_5M_3) 220.31 and 218.55cm^2/g. While the lowest value (58.3 cm^2/g) was recorded for Korarima seeds soaked for 48 hrs in pure water and sown in blended forest, top soil and compost in 1:1:1 ratio (T_3M_6).

Specific Leaf area was significantly affected by the interaction of seed pre-sowing treatments and soil media . The highest SLA(507.87 cm^2/g) was obtained from seeds treated with 50% sulfuric acid (soaking for 60 minutes) and sown in top soil (T5M1). The minimum SLA was 143.43 cm^2/g for 48 hours soaking in pure water and sowing in mixture of forest, top soil and compost (T3M6) (Table 9).

Leaf weight ratio was significantly affected by the interaction of seed pre-sowing treatments and soil media. The highest LWR (0.46g/g) was obtained from seeds treated with 50% sulfuric acid (soaking for 60 minutes) and sown in mixture of forest and top soil (T5M3) , 48 hours soaking in pure water and sowing in blended top soil & compost 3:1 ratio(T3M7) and 72 hours soaking in pure water and sowing in forest soil (T4M1) or forest soil and compost mixture at 1:1 ratio (T5M4). The minimum LWR were 0.28 and 0.25g/g for 24 hours soaking in pure water and sowing in mixture of top & compost soil (T2M5) or sown in a blend of forest soil, top soil and compost in 1:1:1 ratio (T2M6) (Table 9)

The importance of a high RGR for a plant could be a high plant mass after a certain period of growth stages. The result is in agreement with that of Rafael. et al., (1998), who reported that the rate of increase in biomass per unit biomass have been identified due to cause of variation in RGR between growth stages can be associated with variation in LAR (total leaf area : total dry weight) or rate of increase in plant mass per unit leaf area(SLA). Likewise, the best shoot growth and development (i.e. shoot length, leaf number, leaf and shoot fresh and dry mass) were recorded from those seedling grown on a mixture of soil blended media. However, poor growth was observed on those seedling grown on pure soil media. The number of leaves is considered a measure of photosynthetic and transpiration area (Ritchie, 1984).

Table 9: Interaction of seed treatment and soil media on on growth component of Korarima seedling at four months after sowing

Treatment	RGRII	NAR	LAR	SLA	LWR
T1M1	0.208^{g-j}	0.0021^{d-g}	98.72^{e-j}	248.82^{g-j}	0.40^{d-i}
T1M2	0.193^{h-k}	0.0017^{j-m}	113.62^{ef}	251^{g-j}	0.45^{ab}
T1M3	0.188^{i-l}	0.0025^{c}	75.3^{j-m}	202.98^{i-l}	0.37^{g-k}
T1M4	0.161^{k-o}	0.0023^{cd}	68.77^{k-m}	180.81^{j-l}	0.39^{e-j}
T1M5	0.217^{e-i}	0.0029^{b}	74.72^{j-m}	208.91^{i-l}	0.36^{j-k}
T1M6	0.158^{l-o}	0.0021^{d-g}	75.21^{j-m}	180.05^{j-l}	0.42^{a-g}
T1M7	0.187^{i-l}	0.0016^{k-m}	114.51^{ef}	315.46^{e-g}	0.37^{h-k}
T2M1	0.149^{m-o}	0.0018^{h-l}	81.73^{i-m}	202.12^{i-l}	0.41^{b-h}
T2M2	0.187^{i-l}	0.0018^{h-l}	103.6^{e-i}	240.75^{h-j}	0.43^{a-e}
T2M3	0.131^{op}	0.0015^{m-o}	91.62^{f-k}	227.3^{h-k}	0.41^{a-e}
T2M4	0.282^{ab}	0.0039^{a}	73.03^{j-m}	221.97^{h-k}	0.33^{kl}
T2M5	0.193^{h-k}	0.0020^{e-h}	93.52^{f-l}	339.81^{d-f}	0.28^{m}
T2M6	0.177^{j-m}	0.0019^{f-j}	94.28^{f-l}	375.00^{c-e}	0.25^{m}
T2M7	0.238^{c-g}	0.0019^{f-i}	123.06^{de}	285.92^{f-h}	0.43^{a-e}
T3M1	0.208^{g-j}	0.0013^{op}	163.7^{bc}	374.17^{c-e}	0.44^{a-d}
T3M2	0.225^{d-h}	0.0013^{op}	184.2^{b}	415.14^{bc}	0.44^{a-d}
T3M3	0.244^{c-f}	0.0017^{i-m}	142.22^{cd}	378.78^{c-e}	0.38^{f-j}
T3M4	0.187^{i-l}	0.0020^{f-h}	96.17^{f-j}	250.05^{g-j}	0.39^{e-j}
T3M5	0.215^{f-i}	0.0025^{c}	85.15^{h-l}	220.68^{h-k}	0.39^{e-j}
T3M6	0.132^{op}	0.0023^{cd}	58.3^{m}	143.43^{l}	0.41^{b-h}
T3M7	0.296^{a}	0.0019^{f-j}	155.04^{c}	336.56^{ef}	0.46^{a}
T4M1	0.085^{q}	0.0012^{p}	73.12^{j-m}	158.5^{kl}	0.46^{a}
T4M2	0.192^{h-k}	0.0020^{e-h}	95.25^{f-j}	209.03^{i-k}	0.45^{ab}
T4M3	0.253^{b-d}	0.0014^{n-p}	184.88^{b}	411.66^{b-d}	0.45^{ab}
T4M4	0.227^{d-g}	0.0021^{d-g}	110.16^{e-h}	256.6^{g-i}	0.43^{a-e}
T4M5	0.208^{g-j}	0.0019^{g-k}	111.59^{e-g}	257.74^{g-i}	0.43^{a-e}
T4M6	0.248^{c-e}	0.0016^{l-n}	155.77^{c}	365.66^{c-e}	0.43^{a-e}
T4M7	0.135^{n-p}	0.0021^{d-f}	62.77l^{m}	158.22^{kl}	0.40^{d-i}
T5M1	0.109^{pq}	0.0013^{op}	85.83^{g-l}	197.19^{i-l}	0.44^{a-d}
T5M2	0.264^{a-c}	0.0012^{p}	220.31^{a}	507.87^{a}	0.45^{ab}
T5M3	0.268^{a-c}	0.0012^{op}	218.55^{a}	474.14^{ab}	0.46^{a}
T5M4	0.140^{n-p}	0.0016^{k-m}	84.53^{h-m}	211.64^{i-l}	0.40^{d-i}
T5M5	0.173^{k-l}	0.0028^{b}	62.64l^{m}	213.37^{h-l}	0.29l^{m}
T5M6	0.165^{k-n}	0.0021^{d-f}	76.89^{j-m}	202.63^{i-l}	0.38^{f-j}
T5M7	0.221^{d-h}	0.0024^{c}	91.58^{f-k}	269.79^{f-i}	0.34^{k-l}
Cv%	10.24	8.16	14.84	16.55	7.24
LSD 5%	0.0329	0.0003	26.26	73.11	0.05

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$

T_{1-} Non-soaked,(T_{2-}: 24 hrs ,T_{3-}: 48 hrs T_{4-}72hrs) soaking seeds in pure water) , T_{5-}:50% sulphuric acid soaking for 60 minutes, M_{1-} Forest soil , M_{2-} Top soil , M_{3-} Forest & Top soil (1:1), M_{4-} Forest & compost (1:1), M_{5-}: Top & compost (1:1), M_{6-} Forest l, Top & compost (1:1: 1), M_7: Top & compost (3:1)

RGR - relative growth rate(gm/gm/d) , NAR-net assimilate rate (gm/cm^2/d), SLA-specific leaf area(cm^2/gm) , LWR- Leaf weight ratio(gm/gm), LAR- leaf area ratio(cm^2/gm)

B. Experiment II

4. 7. Seedling Emergence

4. 7. 1. Mean days to seedling emergence

The interaction of soil media and watering frequency were highly significant ($P<0.01$) for mean days to emergence, emergence rate and emergence **%** (Appendix Table 5). The highest mean values of mean days to emergence 28.67 was recorded for seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every four days (M_7WF_4) (Table 5). The result indicate late emergence percentage which indicate more time and cost. while seeds sown in mixture of forest and top soil or top and compost soil mixture at equal ratio with watering frequency every days gave minimum days(15) or shown early emergence treatments. This may be less water for softening of seed coat and breaking of dormancy due to watering frequency gap and the soil mixture was not equal ratio to hold enough the water. On the other hand, daily water application increased the number of mean days emergence (Table 10). This result similar with result obtained by (Mhango *et al.,* 2008) regular watering is necessary to produce good quality seedlings at economic rate. This is because any stagnation in seedling growth or subsequent mortality may bring about huge economic loss to the grower, as seedlings take long to reach an appropriate size for grafting and transplanting or for sale.

4. 7. 2. Seedling emergence

The interaction of soil media and watering frequency was highly significant ($P<0.01$) for emergence percentage (Appendix Table 5). The highest value of emergence percentage for seeds sown in forest soil and watering frequency every two days (M_1WF_2) (85.77) and seeds sown in forest and top soil mixture in 1:1 ratio and watering frequency every day (M_3WF_1) (85.63). While the lowest value (60.23) was observed for seeds sown in mixture of forest and top soil and watering frequency every four days (M_3WF_4) or for seeds sown in forest soil and compost mixture in 1:1 ratio and watering frequency every four days (M_4WF_4) . With regard to emergence behavior as these media were got watering frequency every day or two days and in addition the media may have suitable physical properties and good water holding capacity that supports the emergence of seeds. In general, the data shown that the highest emergence percentage (85.77%) was obtained in 3 weeks period after sowing (Table 10). The lowest emergence percentage was observed may be due to the soil combination media was not hold moisture for consequent days without applying the moisture daily for initiating of the processing of seedling emergence. This result similar with work of Simon *et al*., (2011) application of water on daily or every other day basis to other for increased seedling emergence..

4.7. 3 Rate of seedling emergence

The data showed that different interaction of soil media and watering frequency had highly significant ($P<0.01$) on rate of emergence (Appendix 5). Mean values observed in table 10 showed that the highest rate of emergence (10.67) was recorded for seeds sown in forest soil and watering frequency every two days (M_1WF_2), seeds sown in forest soil and top soil mixture in 1:1 ratio and watering frequency every day (M_3WF_1), seeds sown in top soil and compost mixture at 1:1 ratio and watering frequency every day (M_3WF_1) and seeds sowing in mixture of top and compost soil in 3:1 ratios and watering frequency every days (M_7WF_1). A minimum value for rate of emergence (4.67) was observed for seeds sown in forest and top soil mixture in 1:1 ratio and watering frequency every four days (M_3WF_4). The treatment forest soil and watering frequency every two days (M_1WF_2) was found to be the best this is because of the interaction effect of the factors media and watering frequency may have suitable physical properties and good water holding capacity that supports the emergence rate of seeds. Minimum value for rate of emergence may be due to less frequency of day of water treatments not enough to soften hard seed coat that delays emergence of seeds as a result of physical barrier against imbibitions of water by seeds. The work is similar with report of Gorai *et al.,(* 2009); Mantovani and Iglesias,(2010) water deficit stress is one of the important factors restricting seed germination, because of low rate of imbibitions and the delay in its initiation or decrease in the final emergence

Table 10: Interaction effect of soil media and watering frequency on emergence of korarima seedlings

Treatments	Mean days to Emergence	Emergence rate	emergence %
M1WF1	19.00^{bc}	8.67^{a-d}	66.63^{b-e}
M1WF2	18.00^{bc}	10.67^{a}	85.77^{a}
M1WF3	20.00^{bc}	10.33^{ab}	77.03^{a-c}
M1WF4	25.33^{ab}	8.00^{b-d}	66.63^{b-e}
M2WF1	19.00^{bc}	10.33^{ba}	79.47^{ab}
M2WF2	20.00^{bc}	8.33^{a-d}	65.07^{b-e}
M2WF3	19.33^{bc}	7.33^{cd}	62.93^{b-e}
M2WF4	18.00^{bc}	8.67^{a-d}	66.63^{b-e}
M3WF1	15.00^{c}	10.67^{a}	85.63^{a}
M3WF2	20.33^{bc}	9.00^{a-d}	69.20^{a-e}
M3WF3	19.33^{bc}	9.00^{a-d}	70.23^{a-e}
M3WF4	19.00^{bc}	4.67^{e}	60.23^{c-e}
M4WF1	16.00^{c}	9.67^{a-c}	72.93^{a-d}
M4WF2	18.67^{bc}	9.67^{a-c}	74.33^{a-c}
M4WF3	16.67^{c}	9.00^{a-d}	66.63^{b-e}
M4WF4	19.00^{bc}	7.33^{cd}	60.23^{c-e}
M5WF1	15.00^{c}	10.67^{a}	77.03^{a-c}
M5WF2	18.67^{bc}	9.67^{a-c}	76.27^{a-c}
M5WF3	17.67^{bc}	7.00^{d}	72.03^{a-e}
M5WF4	18.0^{bc}	8.00^{b-d}	66.63^{b-e}
M6WF1	22.33^{a-c}	9.67^{a-c}	74.33^{a-c}
M6WF2	21.67^{a-c}	9.33^{a-d}	72.93^{a-d}
M6WF3	16.67^{c}	10.33^{ab}	79.73^{ab}
M6WF4	19.00^{bc}	7.67^{cd}	62.93^{b-e}
M7WF1	18.67^{bc}	10.67^{a}	77.03^{a-c}
M7WF2	18.33^{bc}	9.00^{a-d}	70.23^{a-e}
M7WF3	20.67^{bc}	8.67^{a-d}	66.63^{b-e}
M7WF4	28.67^{a}	8.00^{b-d}	66.63^{b-e}
Cv%	20.77	13.83	12.3
LSD 5%	6.53	2.02	13.94

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$

M_1 - Forest soil , M_{2-} Top soil , M- Forest & Top soil (1:1 , M_{4-} Forest & Compost(1:1) , M_{5-} Top & Compost(1:1 ratios) , M_{6-} Forest , Top and Compost(1:1:1) , Top and Compost 3:1 (control), WF_{1-} Watering Frequency Every day , WF_{2-} Watering Frequency Every 2 days, WF_{3-} Watering Frequency Every 3 days ,WF_4: Watering Frequency Every 4 days

4. 8. Vegetative Growth

4. 8. 1. Shoot height

The interaction of soil media and watering frequency was highly significant ($P<0.01$) for Shoot height (Appendix Table 5). The highest mean values of Shoot height 21.33cm was recorded for seeds sown in top soil and compost mixture at 1:1 ratio and watering frequency every day (M_5WF_1) or watering frequency every four days (M_5WF_4) at four months of growth stages after sowing (Table 11). The lowest value recorded for shoot height at four months of growth stages after sowing were 13.25cm and 12.58 cm for seeds sown in a blend of forest soil, top soil and compost in 1:1:1 ratio and watering frequency every four days (M_6WF_4) and seeds sown in mixture of top soil and compost in 3:1 ratio and watering frequency every three days(M_7WF_3), respectively (Table 11).

The growth rate in terms of shoot height was, however, not consistent with the growth stages order. The highest mean values of shoot height 3.47was recorded for seeds sown top soil and watering frequency every day(M_2WF_1) at two months of growth tage after sowing.where as seeds sown in top soil and compost mixture in 1:1 ratio and watering frequency every day (M_5WF_1) and seeds sown in top soil and compost mixture in 1:1 ratios and watering frequency every four days (M_5WF_4) exihibit the highest growth rate at four months of growth stages after sowing.From the result indicated in the table 12 after two months of growth stage enrich nutrient soil and watering holding capacity media needed as growth of seedling increase to escape from the stress to get tolerant and high number of transplanting seedling. This suggested that M_5WF4 (seeds sown in top soil and compost mixture in 1:1 ratio and watering frequency every four days) was tolerant to in terms of shoot height. The shoot height increased due to the media has got frequently water. This result similar with work of Mohammed .(2004) the rate of vegetative growth of shoot height is enhanced by increases in available soil water content in the root zone, reduction in shoot height was observed due to less frequency of water for soil medium.

4. 8. 2 Root length

Root length significantly affected by interaction of soil media watering frequency (Appendix Table 5).The highest mean values of root length 17.71cm was exhibited for seeds sown in top soil and watering frequency every day(M_2WF_1) at four months of growth stages of seedling after sowing. Similarly, higher values were recorded 16.81cm for seeds sown in forest soil media and watering frequency every three days (M_1WF_3) ,17.17cm seeds sown in a blend of forest soil, top soil and compost in 1:1:1 ratio and watering frequency every day (M_6WF_1) and 16.61 cm seeds sown in top soil and compost mixture in 3:1 ratio and watering frequency every two days (M_7WF_2) at four months of growth stages of seedling after sowing .The lowest value recorded for root length was 10.55cm, for seeds sown in top soil and compost mixture in 1:1 ratio and watering frequency every four days (M_5WF_4) (Table 11).

The responses of korarima seed to growth media types watering frequency could be associated with the variations in physical and chemical characteristics of the media mixes used in this experiment. In the present study, although the highest longest roots were recorded from the top soil medium, root development in terms of, root number and fresh and dry masses of roots were less in Top medium than the rest media. This may be associated with the differences in water holding capacity of the stated media types. The observed variations hence indicate the intolerance of korarima seed to moisture stress and confirm their requirement for a growth medium possessing a relatively higher water holding capacity. root growth are determined, principally, by soil water gradient; roots grow from areas of low water to areas of high water present and unable to grow through zones of dry soil. Soil water level also has a pronounced effect on the uptake of plant nutrients by frequency water.

4.8.3. Stem girth

Highly significant ($P<0.01$) interaction differences were also noted in factors of soil media and watering frequency on girth(cm) and Root No (Appendix Table5). The highest mean value of Girth diameter in cm 0.70 for seeds sowing in mixture of top soil and compost in 3:1 ratio and watering frequency every two days(M_7WF_2) at four months of growth stages after sowing (Table 11). While seeds sown in top soil and compost mixed at 3:1 ratio and watering frequency every three days (M_7WF_3) showed the minimum values of girth (0.45cm). Stem diameter increase is due to increasing of in available soil water content of the combination of the soil , conversely, reduction of stem girth due to decreasing water frequency and less uptake of nutrient. The adverse effect of moisture stress on leaf growth and leaf area has been observed in korarima seedling due to less frequent of water, this revealed that in addition to leaf enlargement, stem diameter and plant height also decreases with the development of the gap of water frequency .

4. 8. 4. Mean leaf area per leaf

The response of Leaf area (cm^2) to soil media and watering frequency were highly significant ($p<0.01$) (Appendix 5). The leaf area of seeds sown in top soil and compost mixture in 1:1 ratio and watering frequency every day (M_5WF_1) was found highest value 24.89 cm^2 at four months of growth stages after sowing (Table 11). Similarly, seeds sown in top soil media and watering frequency every day(M_2WF_1) and seeds sown in a blend of forest soil, top soil and compost in 1:1:1 ratios and watering frequency every two days(M_6WF_2) exhibited higher mean values (24.78 cm^2) and (24.26 cm^2) at four months of growth stage and lowest leaf area values (13.96 cm^2), (13.27 cm^2) for seeds sown in forest soil media and watering frequency every four days(M_1WF_4) and seeds sown in top soil and compost soil media in 3:1 ratios and watering frequency every three days(M_7WF_3) were recorded.

Contrary to shoot height and girth, which showed rapid increase two months after emergence, rapid leaf area growth was observed a month later i.e. four months after emergence. This could explain that assimilates were available primarily for root development and later on for shoot growth during the period of two months after emergence. In general the growth of above ground parts of korarima seedlings between two months after emergence was very slow but it was rapid after two months after emergence. Such a growth trend indicated that growth of korarima seedlings in the first 2 months after emergence is probably the period of root development and the growth of the above ground plant parts become rapid only when root system is well established. The result coincide with the reports of Tesfaye (2005) more frequent of irrigation resulted in higher rate of shoot growth with greater leaf area and other parts of the seedling, Blum(1996) moisture shortage affects growth and development of crop plants at different stages morphological characters such as leaf area. plant height and root growth are several affected by less water frequent in many crop plants.

Table 11: Interaction effect of soil media and watering frequency on shoot height, root length, girth and leaf area of Korarima

Treatment	Shoot height(cm)	Root length (cm)	Girth(cm)	Leaf area(cm^2)
M1WF1	15.4^{fg}	13.59^{g-i}	0.57^{fg}	19.40^{kl}
M1WF2	16.56^{e}	15.50^{c-f}	0.57^{fg}	22.14^{fgh}
M1WF3	18.33^{cd}	16.81^{ab}	0.64^{bcd}	16.94^{m}
M1WF4	14.43^{h}	14.41^{f-h}	0.61^{def}	13.96^{n}
M2WF1	19.66^{b}	17.71^{a}	0.66^{bcd}	23.00^{d-f}
M2WF2	17.50^{de}	15.41^{d-f}	0.56^{g}	24.78^{ab}
M2WF3	15.28^{f-h}	16.43^{b-e}	0.65^{b-d}	22.88^{d-f}
M2WF4	19.72^{b}	14.96^{f}	0.63^{cd}	21.32^{hi}
M3WF1	19.38^{b}	15.10^{f}	0.55^{g}	20.67^{ij}
M3WF2	17.33^{e}	15.32^{ef}	0.64^{bcd}	23.77^{b-d}
M3WF3	15.45^{fg}	14.58^{fg}	0.61^{def}	19.05^{kl}
M3WF4	15.40^{fg}	14.80^{f}	0.68^{ab}	16.61^{m}
M4WF1	17.39^{e}	13.28^{hi}	0.62^{de}	22.59^{e-g}
M4WF2	18.89^{bc}	13.33^{hi}	0.64^{b-d}	23.43^{c-e}
M4WF3	15.63^{f}	11.19^{kl}	0.65^{b-d}	22.99^{d-f}
M4WF4	15.22^{f-h}	12.70^{ij}	0.68^{a-c}	20.06^{jk}
M5WF1	21.33^{a}	15.61^{c-f}	0.65^{b-d}	24.89^{a}
M5WF2	19.50^{b}	12.54^{ij}	0.57^{fg}	21.65^{g-i}
M5WF3	14.58^{gh}	13.01^{i}	0.58^{e-g}	23.01^{d-f}
M5WF4	21.33^{a}	10.55^{l}	0.62^{de}	22.18^{f-h}
M6WF1	16.68^{e}	17.17^{ab}	0.63^{cd}	18.77^{l}
M6WF2	18.38^{cd}	13.41^{hi}	0.65^{b-d}	24.26^{a-c}
M6WF3	19.68^{b}	14.56^{fg}	0.65^{b-d}	21.01^{ij}
M6WF4	13.25^{i}	12.68^{ij}	0.623^{de}	19.31^{kl}
M7WF1	15.56^{f}	16.48^{b-d}	0.64^{b-d}	23.00^{d-f}
M7WF2	18.40^{cd}	16.61^{a-c}	0.70^{a}	23.04^{d-f}
M7WF3	12.58^{i}	13.04^{i}	0.45^{h}	13.27^{n}
M7WF4	16.56^{e}	11.71^{jk}	0.57^{fg}	16.32^{m}
Cv%	3.04	4.36	4.04	2.92
LSD 5%	0.85	1.02	0.04	1.00

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$
M_1 - Forest soil , M_{2-} Top soil , M- Forest & Top soil (1:1 , M_{4-} Forest & Compost(1:1) , M_{5-} Top & Compost(1:1 ratios) , M_{6-} Forest , Top and Compost(1:1:1) , Top and Compost 3:1 (control), WF_{1-} Watering Frequency Every day , WF_{2-} Watering Frequency Every 2 days, WF_{3-} Watering Frequency Every 3 days ,WF_4: Watering Frequency Every 4 days

4. 8. 5. Total leaf area

The interaction of soil media and watering frequency was significantly (P<0.01) affected Total Leaf Area (cm^2) (Appendix Table 5). The highest record was 284.33 cm^2 for seeds sown in a blend of forest soil, top soil and compost in 1:1:1 ratio and watering frequency every two days (M_6WF_2)

were recorded for four months of seedling growth stages. while the smallest value (139.84) for seeds sown in a blend of forest soil, top soil and compost soil media in 1:1:1 ratios and watering frequency every four days (M_6WF_4) and seed sown in forest soil media and watering frequency every 4 days (M1WF4)(139.46 cm^2) was recorded for four months (Table12). The reason for better frequent water application could be attributed to the established fact that increase leaf area expansion and thus photosynthetic activity, rooting volume and efficiency which all contributed to better growth and development. It has been reported that the rate of extension growth of the shoot and total leaf area of seedlings increased as the available soil water increased (Meinzer et al., 1992) and also with available soil media nutrient.

4.8.6 Largest root length

There were highly significant ($P<0.01$) interaction among the levels of soil media and watering frequency on largest root length (cm). The highest values for seeds sown in forest soil media and watering frequency every two days (M_1WF_2) (34.33 cm), seeds sown in forest soil media and watering frequency every four days (M_1WF_4) (35.00), seeds sown in top soil and watering frequency every two days(M_2WF_2) (35.00) and seeds sown in forest and top soil mixed at 1:1 ratio and watering frequency every day(M_3WF_1) (34.67) were recorded at four months of seedling growth stage after sowing. While the lowest value (16.50) was observed for seeds sowing in mixture of top soil and compost in 1:1 ratio and watering frequency every four days (M_5WF_4) (Table 12). The increase of largest root length may be because of growth root to the sites where nutrients and moisture are located as the root systems develop. The result observed may be due to optimum soil water levels and a medium to low soil bulk density are necessary to enhance healthy root and shoot growth .

4.8.7. Leaf number

Interaction of soil media and watering frequency were significant different ($p< 0.05$) on Leaf number (Appendix 5). During four months of seedling growth stage, maximum leaf number were recorded from seeds sown in top soil media and watering frequency every day

(M_2WF_1)(11.33), seeds sown in mixture of forest and top soil in 1:1 ratio and watering frequency every day (M_3WF_1) (11.17), seeds sown in forest soil and compost mixture at 1:1 ratio and watering frequency every day (M_4WF_1) (11.17), seeds sown in top soil and compost mixture at 1:1 ratio and watering frequency every day(M_5WF_1)(11.33) and seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every day(M_7WF_1) (11.17), followed by (10.67) (Leaf number) were recorded for seeds sown in top soil media and watering frequency every two days(M_2WF_2), seeds sown in top soil and compost mixture at 1:1 ratio and watering frequency every two days(M_5WF_2) and seeds sown in top soil and compost mixture at 1:1 ratio and watering frequency every four days (M_5WF_4),and minimum from seeds sown in forest soil and compost mixture at 1:1 ratio and watering frequency every three days (M_4WF_3)(8.5) at four months of seedling growth stage, respectively (Table12).

The result indicate frequent watering and most media are convenient for increasing of leaf number. The present finding is in line with that of Simon *et al*., (2011) application of water on daily or every other day basis to other for seedling increased the number of leaves, increased height, survival rate and root collar diameter (RCD) of the seedling. In contrast, they have observed that limited application of water had a negative effect on seedling height, RCD and number of leaves produced.

4.8.8. Root number

Root number significantly ($p< 0.01$) affected by the interaction of soil media and watering frequency. The highest mean values of root number 20.67 was recorded for seeds sowing in mixture of top soil and compost in 1:1 ratio and watering frequency every day (M_5WF_1) at four months of growth stages of seedling after sowing. while seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every three days(M_7WF_3) was the minimum value of root number (7.00)(Table 12). In the current study, korarima seed revealed strong response to media differences with respect to several root and shoot development parameters. The observed result was due to more water frequency and blended soil media for nutrient content and water holding capacity increase root number and growth of the root. Type of growth media is one of the most important factors that influence the success in rooting (Leakey *et al*., 1990).

4.8.9. Tiller number

Interaction of soil media with watering frequency was highly significant ($P<0.01$) for number of tillers (Appendix Table 5). The highest number of tillers (2) was recorded when seeds sown in equal mixture of forest soil, top soil and compost in1:1:1 ratio for watering frequency every two days (M_6WF_2) at four months of growth stages of seedling after sowing.The lowest value (0.37) was achieved for seeds sown in top soil and compost mixture at 1:1 ratio when watering every three days of frequency (M_7WF_3) (Table 12). The tiller development was duo to enrich soil media for more nutrient content and frequency of water by one day interval and media of the soil water holding capacity. The present finding is in line with that of Carvalho and schank (1989) seedling produced less leaf and more tillers and root may be more favored under water deficit conditions than those with more leaf and less stem and root .

Table 12: Interaction effect of soil media and watering frequency on total leaf area, longest root length, leaf number, root number and tiller number of Korarima

Treatment	Total Leaf Area(cm^2)	Largest Root Length(cm)	Leaf No.	Root No.	No. Tillers
M1WF1	183.84^{jk}	28.67^{bc}	10.33^{bc}	12.00^{ijk}	1.4^{a-f}
M1WF2	215.74^{i}	34.33^{a}	10.00^{b-d}	17.67^{c}	0.9^{e-g}
M1WF3	174.43^{k}	26.17^{def}	9.50^{c-e}	11.00^{jkl}	0.8^{fg}
M1WF4	139.46^{l}	35.00^{a}	9.00^{ef}	11.67^{ijk}	1.33^{b-f}
M2WF1	254.21^{c-e}	25.50^{ef}	11.33^{a}	18.00^{c}	1.53^{a-e}
M2WF2	250.59^{c-f}	35.00^{a}	10.67^{ab}	12.67^{g-i}	1.3^{b-f}
M2WF3	243.09^{e-g}	25.90^{ef}	9.50^{c-e}	14.33^{ef}	1.3^{b-f}
M2WF4	240.62^{e-g}	25.57^{ef}	10.33^{bc}	15.00^{ef}	1.67^{a-d}
M3WF1	226.11^{gh}	34.67^{a}	11.17^{a}	16.67^{cd}	1.07^{d-f}
M3WF2	271.189^{ab}	26.60^{c-f}	10.17^{b-d}	9.00^{m}	1.63^{a-d}
M3WF3	193.97^{j}	22.13^{g}	9.67^{cde}	19.33^{b}	1.53^{a-e}
M3WF4	151.06^{l}	22.20^{g}	10.00^{b-d}	11.33^{i-k}	1.67^{a-d}
M4WF1	266.71^{bc}	26.00^{ef}	11.17^{a}	17.00^{cd}	1.53^{a-e}
M4WF2	238.85^{e-g}	25.17^{ef}	10.17^{b-d}	17.67^{c}	1.70^{a-d}
M4WF3	251.99^{c-e}	24.50^{f}	8.50^{f}	14.00^{fg}	1.60^{a-d}
M4WF4	190.75^{jk}	25.17^{ef}	10.00^{b-d}	13.67^{f-h}	1.67^{a-d}
M5WF1	252.02^{c--}	28.77^{bc}	11.33^{a}	20.67^{a}	1.90^{ab}
M5WF2	248.17^{def}	27.30^{c-e}	10.67^{ab}	12.33^{h-j}	1.90^{ab}
M5WF3	234.13^{f-h}	28.23^{b-d}	10.00^{b-d}	14.33^{ef}	1.63^{a-d}
M5WF4	252.23^{c-e}	16.50^{h}	10.67^{ab}	11.00^{jkl}	1.63^{a-d}
M6WF1	194.60^{j}	22.13^{g}	10.33^{bc}	12.00^{ijk}	1.80^{a-c}
M6WF2	284.33^{a}	25.23^{ef}	9.33d^{e}	15.67^{de}	2.00^{a}
M6WF3	220.59^{hi}	24.67f	10.17^{b-d}	9.67^{lm}	1.43^{a-e}
M6WF4	139.84^{l}	25.50^{ef}	9.33^{de}	10.67^{kl}	1.60^{a-d}
M7WF1	246.50^{d-f}	30.17^{b}	11.17^{a}	17.67^{c}	1.20^{c-f}
M7WF2	263.58^{b-d}	28.33^{b-d}	9.67^{c-e}	10.67^{kl}	1.73^{a-c}
M7WF3	237.02^{e-g}	25.27^{ef}	9.00^{ef}	7.00^{n}	0.37^{g}
M7WF4	183.47^{jk}	24.83^{f}	9.17^{ef}	8.33^{m}	1.47^{a-e}
Cv%	4.13	4.49	4.23	5.73	22.28
LSD 5%	15.07	1.97	0.7	1.27	0.56

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$

M_1 - Forest soil , M_2- Top soil , M- Forest & Top soil (1:1 , M_4- Forest & Compost(1:1) , M_5- Top & Compost(1:1 ratios) , M_6- Forest , Top and Compost(1:1:1) , Top and Compost 3:1 (control), WF_1- Watering Frequency Every day , WF_2- Watering Frequency Every 2 days, WF_3- Watering Frequency Every 3 days ,WF_4: Watering Frequency Every 4 days

4. 9. Dry Matter Production

4.9. 1. Leaf dry weight

Interaction of soil media and watering frequency on leaf dry weight was highly significant different ($p< 0.01$) (Appendix 5). The response indicating that some had the same response to interaction **e**ffects of soil media and watering frequency in dry matter accumulation in their leaf weight (g) for seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every two days (M_7WF_2) (1.590) maximum dry weight per plant was recorded at four months growth of seedling stage. Similarly, seeds sown in forest soil media and watering frequency every two days (M_1WF_2), seeds sown in top soil media and watering frequency every three days (M_2WF_3) and seeds sown in top soil and compost mixture at 1:1 ratio and watering frequency every three days (M_5WF_3) exhibited higher mean values (1.303g),(1.283g)and(1.403g) at four months growth of seedling stage, while seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every four days (M_7WF_4) showed the minimum value of (0.527g) (Table 13). The minimum value observed was because of the soil less frequent irrigated and also physical and chemical character of the soil medium support the watering frequency of one and two days interval. While at growth stage increase the frequency of the water may decrease at normal condition. The finding similar with work of Tesfaye et al., (2005) frequent watering resulted in higher rate of shoot growth with greater leaf area, stem diameter, leaf and stem dry weight and height of seedlings.

4.9. 2. Stem dry weight

Interaction of soil media and watering frequency on stem dry weight (g) were highly significant different ($p< 0.01$) observed and relatively maximum stem dry weight per plant were recorded from seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every two days(M_7WF_2) 0.827g ,and minimum values from seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every four days (M_7WF_4) (0.230 g) (Table 13). This finding is observed due to forest soil media alone with applying daily watering frequency up to two months increase the weight of leaf and stem but after this stage the media not increase the weight even though the frequency as it is, this may be due to nutrient content of the media. On the other hand, media with compost soil combination shown weight increase. This finding similar with work of (Simon A *et al*., 2011) Considering water availability, labor costs and time involved and based on the present results, nursery to irrigate *korarima* seedlings every two days or three days interval with compost soil combination under the prevailing conditions. This is because seedlings under different environmental conditions may have different water requirement. The result coincide with finds of report Naples et al., (1990) dry matter accumulation in the stem and leaves were consistently reduced as the supply of water to the seedlings decreased

4.9. 3. Root dry weight

Interaction of soil media and watering frequency on root dry weight was differed significantly ($p < 0.01$) (Appendix 5). Among the treatments tested, highest root weight per seedling were recorded from seeds sown in forest soil and compost mixture at 1:1 ratio and watering frequency every two days (M_4WF_2) and seeds sown in a blend of forest soil, top soil and compost in 1:1:1 ratio and watering frequency every two days (M_6WF_2) treatments, which were 0.633g and 0.600g at four months of growth stages. On the other hand, the seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every four days (M_7WF_4) gave the lowest root weight during the growth stages of four months and the value was 0.093 g (Table 13). From the result obtained with blended soil media due to watering frequency increase the dry matter of the root was increased with less watering frequency the root dry weight decreased..The result similar with work of Mohammed (2004) growth and the distribution of the root of coffee seedling expressed as root length and root density and root weight were further enhanced by water frequency of water but decreased with limited supply. The adverse effect of water stress and nutrient supply on root growth and dry weight of roots has also been observed on different crops (Naples et al.,1990).

4.9.4. Total dry weight

The interaction of soil media and watering frequency on weight (g) of total dry weight per seedling showed highly significant ($P<0.01$) variations (Appendix 5). The highest mean value of total dry weight (g) (3.47) was recorded for seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every two days (M_7WF_2). The lowest value recorded was 1.07(g) for seeds sown in top soil and compost mixture at 3:1 ratios and watering frequency every four days (M_7WF_4) at four months after sowing. In general, all the treatments showed an increase in total dry matter accumulation during the fourth month's period with unequal increasing rate among the treatments observed. The total dry matter increment after two months period was highest (more than 3 g) for the M_7WF_2 (seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every two days) except for M_7WF_4 (seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every four days), which showed total dry weight gm per plant increment of 3.47 and 1.07g. The results are in agreement with those of Cannel (1985) who reported that total dry weight (g) increment of coffee was greater during the rainy season as well as of Guridi et al. (1987) who observed higher total dry matter production at around 80 to 100% field capacity than at lower soil water contents. However, the observations made by Tilahun and Schubert (2001) for haricot bean and chickpea, and by Zenebe (2000) for cowpea are contrary to the results of this investigation.

Table 13: Interaction effects of soil media and watering frequency on dry wt of leaf, stem root and total dry wt. of Korarima

Treatment	Leaf dry wt(g)	stem dry wt(g)	Root dry wt(g)	Total dry wt(g)
M1WF1	1.000^{c-g}	0.417^{f-i}	0.453^{b-d}	1.94^{f-l}
M1WF2	1.303^{a-c}	0.713^{bc}	0.470^{bc}	2.74^{bc}
M1WF3	0.870^{e-i}	0.443^{e-g}	0.320^{f-h}	1.72^{i-n}
M1WF4	0.710^{g-j}	0.263^{jk}	0.290^{g-i}	1.40^{m-o}
M2WF1	1.003^{c-g}	0.463^{e-g}	0.367^{d-g}	1.95^{e-l}
M2WF2	0.983^{c-g}	0.433^{e-h}	0.437^{b-e}	2.00^{e-l}
M2WF3	1.283^{a-d}	0.633^{cd}	0.313^{f-i}	2.45^{b-e}
M2WF4	1.157^{b-e}	0.477^{ef}	0.300^{g-i}	2.05^{e-i}
M3WF1	0.950^{d-h}	0.517^{e}	0.283^{g-i}	1.86^{g-m}
M3WF2	1.147^{b-f}	0.500^{ef}	0.493^{b}	2.39^{c-f}
M3WF3	0.75^{g-j}	0.343^{h-j}	0.350^{e-g}	1.59^{j-n}
M3WF4	0.630^{h-j}	0.333^{ij}	0.220^{ij}	1.31^{no}
M4WF1	1.193^{b-e}	0.493^{ef}	0.337^{f-h}	2.13^{e-i}
M4WF2	0.777^{g-j}	0.610^{d}	0.633^{a}	2.66^{b-d}
M4WF3	0.747^{g-j}	0.450^{e-g}	0.243^{hi}	1.64^{i-n}
M4WF4	0.813^{f-j}	0.420^{e-i}	0.347^{e-g}	1.72^{i-n}
M5WF1	1.137^{b-f}	0.640^{cd}	0.490^{b}	2.71^{bc}
M5WF2	1.180^{b-e}	0.767^{ab}	0.413^{b-f}	2.92^{b}
M5WF3	1.403^{ab}	0.477^{ef}	0.283^{g-i}	2.30^{c-g}
M5WF4	1.040^{e-g}	0.377^{g-i}	0.350^{e-g}	1.98^{e-k}
M6WF1	0.697^{g-j}	0.347^{h-j}	0.347^{e-g}	1.53^{k-b}
M6WF2	1.24^{b-d}	0.737^{b}	0.600^{a}	2.75^{bc}
M6WF3	1.267^{b-d}	0.463^{e-g}	0.303^{g-i}	2.20^{d-h}
M6WF4	0.737^{g-j}	0.270^{jk}	0.35^{e-g}	1.47^{l-o}
M7WF1	1.220^{b-d}	0.463^{e-g}	0.380^{c-g}	2.40^{c-f}
M7WF2	1.590^{a}	0.827^{a}	0.477^{b}	3.47^{a}
M7WF3	0.557^{ij}	0.473^{ef}	0.093^{k}	1.26^{no}
M7WF4	0.527^{j}	0.230^{k}	0.147^{jk}	1.07^{o}
Cv%	17.67	10.28	14.38	12.68
LSD 5%	0.29	0.18	0.08	0.8

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$
M_1 - Forest soil , M_{2-} Top soil , M- Forest & Top soil (1:1 , M_{4-} Forest & Compost(1:1) , M_{5-} Top & Compost(1:1 ratios) , M_{6-} Forest , Top and Compost(1:1:1) , Top and Compost 3:1 (control), WF_{1-} Watering Frequency Every day , WF_{2-} Watering Frequency Every 2 days, WF_{3-} Watering Frequency Every 3 days ,WF_4: Watering Frequency Every 4 days

4.9.5. Shoot dry weight

The highest shoot dry weight(g) were recorded from seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every two days(M_7WF_2) (2.92 g) at four months of seedling growth stage after sowing. On the other hand, the least shoot weight (g) was observed from seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every four days

(M_7WF_4)(0.93 g) at four months of growth stages or periods after sowing (Table 14). This might be because of the interaction of the two factors enough to bring a significant difference on growth of Leaf area (cm^2) and stem weight (g) response to soil media mixture at nutrient supplying and physical structure improving water holding capacity and aeration, the media has good OM% and phosphorus nutrient content. Likewise, the best shoot growth and development (i.e. shoot length, leaf number, leaf and shoot fresh and dry mass) were recorded from those seedlings grown on a 1:1 mixture of media and watering frequency every two days. However, poor growth was observed mostly on those pure media and watering frequency every four days. The result is not similar with report of Garside et al., (1992) an increase watering frequency interval progressively enhanced shoot dry weight.

4.9. 6 Root to shoot ratio dry weight

Among the **i**nteraction **e**ffects of soil media and watering frequency on Root to shoot ratio of treatments tested, the highest root to shoot ratio per plant was recorded from seeds sown in forest soil and compost mixture at 1:1 ratio and watering frequency every two days (M_4WF_2), seeds sown in a blend of forest soil, top soil and compost in 1:1:1 ratio and watering frequency every four days(M_6WF_4) treatments, which were, 0.3142 and 0.3129 at growth stages of four months after sowing. On the other hand, the seeds sown in top soil and compost mixture at 3:1 ratio and watering frequency every three days (M_7WF_3) gave the lowest root to shoot ratio values of 0.0798 per seedling (Table 14). The result observed was may be due to the combination of the soil ability can conceive water and supply nutrient that enhanced growth of root and shoot, and that increased the ratio of dry weight . It was also shown that the amount of root growth and shoot were also influenced by the amount of nutrients in the soils and it has also been indicated that the root system seems and its effectiveness in obtaining water and nutrients from the soil. Furthermore, the porosity and pore size distribution can give important on soil structure as pores determine the various soil physical properties important to plant growth In addition a nutrient deficient soil media resulted low root to shoot ratio at this stage . It can be, therefore, suggested that watering frequency should consider media composition and growth stages of seedlings so as to produce high quality seedlings with right proportion of shoot and root growth that can ensure maximum field establishments. The result similar with report of Taye *et al.*, (2008) shoot, root and total dry matter yield were significantly influenced by watering treatment where maximum values were measured at a watering interval of days and reduced results were noticed with more delayed watering. This was more evidenced on the above ground shoot growth as compared with roots. Consequently, decreased shoot to root ratio was observed with reduced watering intervals, on the other hand, in several crops including korarima seedling, both shoot and root dry matter decrease as result of less frequent water (Naples et al.,1990).

4.9. 7. Tiller dry weight

The interaction of soil media and watering frequency showed highly significant ($P<0.01$) difference in dry weight of Tillers (Appendix 5).The data in indicated highest value of dry weight(g) tillers (0.643g) was due to the interaction **e**ffects of soil media and watering frequency treated with seeds sown in forest soil and compost mixture at 1:1 ratio and watering frequency every two days (M_4WF_2) at four months of seedling growth stage and the lowest value (0.0733g) was achieved for seeds sown in forest soil media and watering frequency every days (M_1WF_1). The difference may be observed due to mixture of soil media has balanced nutrient and soil improved physically structure and this caused the seedling that received water every 2 days had significantly maximum responses as compared with those seedling receiving more frequent and delayed water.

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4.9. 8. Root volume

Two way interaction effects of soil media and watering frequency application resulted in highly significant ($P<0.01$) response of root volume (ml); besides, the main effects of both soil media and watering frequency were significant ($p>0.05$) on root volume (ml) .The highest record for seeds sown in top soil media and watering frequency every two days(M_2WF_2) (9.67ml), seeds sowing in mixture of forest and top soil in 1:1 ratio and watering frequency every day(M_3WF_1) (10.33ml) and seeds sown in top soil and compost mixture at 1:1 ratio and watering frequency every day(M_5WF_1)(10.00ml). Similarly, seeds sown in top soil and compost mixture at 1:1 ratio and watering frequency every two days (M_5WF_2) exhibited higher mean values (9.33ml) were recorded at four months seedling growth stage after sowing. While the lowest value (2.33ml) was observed for seeds sown in forest soil and compost mixture at 1:1 ratio and watering frequency every four days (M_4WF_4) and seeds sown in a blend of forest soil, top soil and compost in 1:1:1 ratio and watering frequency every three days (Table 14). In general, highly significant differences in root development, root number, root volume, root length, as well as fresh and dry mass of roots were observed or raised not only on different media types also watering frequency considered in this study. From this study the lowest value observed due to less days of watering frequency factor than soil media factor This is consistent with the finding of Simon et al.,(2011) application of water frequencyevery day or every two days increase hight, survival rate and root volume of the seedling.In contrast, limited application of water had negative effection seedling height,root volume and number of leaves produced.

4.10. Seedling Vigor Index

The interaction effect of soil media and watering frequency was highly significant ($P<0.01$) in respect of SVI (Appendix Table 5). The highest score for Korarima seeds sown in forest soil and top soil media in 1:1 ratios and watering frequency every day (M_3WF_1) (316.69) and Korarima seeds sown in top soil and compost soil media in 1:1 ratio and watering frequency every day (M_5WF_1) (307.14).Similarly, Korarima seeds sown in forest soil media and watering frequency every two days (M_1WF_2)(278.82) were recorded at transplanting stage duration. While the lowest values (88.21)and (96.24) were attained for Korarima seeds have sown in forest and top soil media in 1:1 ratio and watering frequency every four days (M_3WF_4) and seeds have sown in top soil and compost soil media in 3:1ratio and watering frequency every three days (M_7WF_3) at transplanting stage duration(Table 14). The result observed due to seedling vigor parameter was significantly influenced by various media composition and watering treatment. The seedling vigor index (SVI) also synchronized with the emergence performance of seedlings. Accordingly, Korarima seeds sown in forest soil and top soil media in 1:1 ratio and watering frequency every day (M_3WF_1) and Korarima seeds sown in top soil and compost soil media in 1:1 ratios and watering frequency every day (M_5WF_1) that showed better performance in emergence throughout the emergence period were also found to be vigorous than Korarima seeds have sown in top soil and compost soil media ratio and watering frequency every three or four days. In other words, korarima seedlings that emerged earlier were vigorous than those seedlings that emerged later. The finding is similar to the result obtained with coffee (Tesfaye et al., 2008) frequent watering during early growth stages may be considered advantageous for raising successful stand with vigorous shoot growth.

Table 14: Interaction of soil media and watering frequency on dry weight of shoot and tiller, root volume and root to shoot ratio dry weight and seedling vigor index of Korarima

Treatment	Shoot wt(g)	Tillers wt(g)	Root Vol.ml	Root to Shoot Ratio	Seedling vigor index
M1WF1	1.49^{g-k}	0.0733^{k}	6.33^{e-h}	0.3062^{ab}	166.47^{hi}
M1WF2	2.27^{bc}	0.253^{e}	3.00^{l-n}	0.2081^{e-i}	278.82^{ab}
M1WF3	1.40^{h-k}	0.080^{jk}	2.67^{mn}	0.2303^{d-f}	235.19^{b-e}
M1WF4	1.11^{kl}	0.130^{ijk}	5.33^{g-j}	0.2616^{b-d}	172.92^{g-i}
M2WF1	1.5867^{g-j}	0.127^{ijk}	9.67^{a}	0.2309^{d-f}	261.09^{bc}
M2WF2	1.56^{g-j}	0.147^{g-k}	8.33^{bc}	0.2786^{a-c}	218.99^{c-f}
M2WF3	2.14^{b-e}	0.223^{ef}	7.33^{c-}f	0.1485^{k}	162.65^{h-j}
M2WF4	1.75^{e-h}	0.117^{i-k}	4.00^{j-m}	0.1718^{h-k}	212.29^{d-g}
M3WF1	1.58^{g-j}	0.113^{i-k}	10.33^{a}	0.1761^{g-k}	316.69^{a}
M3WF2	1.89^{c-g}	0.247^{e}	6.33^{e-h}	0.2599^{b-d}	197.21^{e-h}
M3WF3	1.24^{i-l}	0.150^{g-j}	6.00^{f-h}	0.2879^{a-c}	144.89^{ij}
M3WF4	1.08^{kl}	0.120^{i-k}	3.67^{k-n}	0.2061^{e-j}	88.21^{k}
M4WF1	1.80^{d-h}	0.110^{i-k}	4.00^{j-m}	0.1886^{f-k}	185.67^{f-i}
M4WF2	2.03^{c-f}	0.643^{a}	4.33^{g-j}	0.3142^{a}	225.15^{c-f}
M4WF3	1.4^{h-k}	0.203^{e-h}	5.33^{g-j}	0.1767^{g-k}	160.83^{h-j}
M4WF4	1.37^{h-k}	0.137^{h-k}	2.33^{n}	0.2526^{c-e}	156.94^{h-i}
M5WF1	2.22^{b-d}	0.447^{c}	10.00^{a}	0.2205^{d-g}	307.14^{a}
M5WF2	2.51^{b}	0.560^{b}	9.33^{ab}	0.1653^{i-k}	228.91^{c-f}
M5WF3	2.02^{c-f}	0.143^{g-k}	5.67^{g-i}	0.1448^{k}	173.08^{g-i}
M5WF4	1.63^{f-i}	0.210^{e-g}	3.67^{k-n}	0.2148^{d-h}	144.85^{ij}
M6WF1	1.19^{j-l}	0.143^{g-k}	8.00^{cd}	0.2912^{a-c}	172.67^{g-i}
M6WF2	2.15^{b-e}	0.177^{f-i}	7.67^{c-e}	0.2776^{a-c}	219.85^{c-f}
M6WF3	1.90^{c-g}	0.163^{f-j}	2.33^{n}	0.1600^{i-k}	249.86^{b-d}
M6WF4	1.12^{kl}	0.117^{i-k}	6.33^{e-h}	0.3129^{a}	118.9^{jk}
M7WF1	2.02^{c-f}	0.337^{d}	5.00^{h-k}	0.1888^{f-k}	230.88^{c-e}
M7WF2	2.92^{a}	0.503^{bc}	4.33^{i-l}	0.1619^{i-k}	256.92^{bc}
M7WF3	1.17^{j-l}	0.14^{g-k}	6.67^{d-g}	0.0798^{l}	96.24^{k}
M7WF4	0.93^{l}	0.163^{f-i}	3.33^{l-n}	0.1587^{jk}	153.91^{h-j}
Cv%	13.46	17.36	13.12	11.56	13.55
LSD 5%	0.66	0.07	1.24	0.05	43.83

Mean values followed by the same letter(s) with in a column are not significantly different at P < 0.05
M_1 - Forest soil , M_{2-} Top soil , M- Forest & Top soil (1:1 , M_{4-} Forest & Compost(1:1) , M_{5-} Top & Compost(1:1 ratios) , M_{6-} Forest , Top and Compost(1:1:1) , Top and Compost 3:1 (control), WF_{1-} Watering Frequency Every day , WF_{2-} Watering Frequency Every 2 days, WF_{3-} Watering Frequency Every 3 days ,WF_4: Watering Frequency Every 4 days

4.11. Correlation Studies

The Pearson correlation matrix for the data set is shown in Table 15. In this study, the association among growth parameters and relationship with each other was discussed. Shoot height was positively and highly significant (*p*<0.01) correlated with shoot weight (r = 0.44), total dry weight(r = 0.46) and leaf area (r=0.51) and also was positively and but not significantly correlated with girth, Stem weight, root weight, root volume, leaf weight, root length tiller number and tiller weight.

Root length was negatively but not significantly correlated with tiller number and also positively but not significantly correlated with the rest of the parameters. A highly significant (p<0.01) and positive association (r = 0.45) was also obtained from girth and number of tillers and negatively correlated with root volume and also positively but not significantly correlated with the rest of the parameters. A highly significant (p<0.01) positive correlation (r = 0.51), (r=0.46) were observed between root number and leaf area, , respectively.

Leaf area was positively and highly significant (p<0.01) correlated with, leaf wt (r=0.63), stem wt (r=0.57), root wt (r=0.64), tillers wt (r=0.43) and shoot wt (r=0.67) and also positively but not significantly correlated with total dry weight, number of tillers and root volume.

A positive and highly significant (p<0.01) association (r = 0.67) were observed among leaf wt and stem weight, root wt (r=0.46), total dry weight (r=0.86),and shoot wt (r=0.89) and a positively and non significant correlation was found between leaf wt, root volume, tiller wt and number of tillers.

Stem wt was correlated (r = 0.57) positively and highly significant (p<0.01) with root wt, tiller wt (r = 0.64), total dry weight (r = 0.88) and shoot wt (r= 0.89) and also positively but not significantly correlated with number of tillers and root volume.

Root weight was positively and highly significant (P<0.01) correlated with tillers wt (r= 0.55), total dry weight (r= 0.73), number of tillers (r=0.44), and shoot (r = 0.61) and positively but not significantly correlated with root volume.

A positive and highly significant ($p<0.01$) association (r = 0.70), (r = 0.68) was observed between tillers wt and total dry weight and shoot wt, respectively and also positively but not significantly correlated with root volume.

Total dry weight was correlated (r = 0.99) positively and highly significant ($p<0.01$) with shoot wt and also positively but not significantly correlated with number of tillers and root volume. Number of tillers positively but not significantly correlated with shoot wt and root volume. A positive and not significant association was observed between root volume and shoot wt.

Table 15: Correlation coefficients (r) among growth parameters of soil media and watering frequency of korarima

	SL cm	RL Cm	Gi cm	R No.	LA cm^2	LW gm	SW gm	RW gm	TW gm	TDW gm	T No.	RV ml	SHW gm
SLcm	1.00												
RLcm	0.15	1.00											
Gi cm	0.28	0.25	1.00										
RNo.	0.28	0.25	0.21	1.00									
LAcm^2	0.51**	0.12	0.36	0.51**	1.00								
LW gm	0.36	0.25	0.24	0.25	0.63**	1.00							
SW gm	0.40	0.20	0.14	0.30	0.57**	0.67**	1.00						
RW gm	0.40	0.19	0.35	0.41	0.64**	0.46**	0.57**	1.00					
TW gm	0.37	0.01	0.18	0.23	0.43**	0.33	0.64**	0.55**	1.00				
TDW gm	0.46**	0.22	0.28	0.35	0.71	0.86**	0.88**	0.73**	0.70**	1.00			
T No.	0.28	-0.11	0.45**	0.18	0.39	0.29	0.17	0.44**	0.31	0.36	1.00		
RV ml	0.15	0.23	-0.21	0.28	0.26	0.08	0.23	0.19	0.13	0.18	0.17	1.00	
SHW gm	0.44**	0.21	0.24	0.31	0.67**	0.89**	0.89**	0.61**	0.68**	0.99**	0.31	0.16	1.00

**Highly significantl different at $P < 0.01$

SLcm-Shoot Length cm, RLcm-Root Length cm, Gi cm-Girth, RNo.-Root Number ,LAcm^2-leaf Area , LWgm-Leaf weight gm, SW gm- Stem Weight gm, RWgm-Root Weight gm , TWgm-Tiller Weight gm, TDW gm-Total Dry Weight gm, , TNo.-Tiller Number, RV ml-Root Volume ml. SHWgm-Shoot Weight gm

4. 12. Growth Rate Components

The interaction of soil media and watering frequency showed highly significant P<0.01) difference in Relative Growth Rate (RGR), Net Assimilate Rate(NAR), Leaf Area Ratio(LAR), Specific Leaf Area(SLA) and Leaf Weight Ratio(LWR) (Appendix Table 6). The data showed that different interaction of soil media and watering frequency had highly significant (P<0.01) effect on seedling relative growth rate (RGR). Mean values given in table 16 showed that the highest RGR (0.29g/g/d) was recorded in soil mixture of top and compost (3:1) and watering frequency every three days (M7WF3). A minimum value for seedling relative growth rate (RGR) (0.119 g/g/d) was observed in soil mixture of forest, top and compost soil and watering frequency every four days (1:1:1) (M_6WF_4).

NAR- Korarima seeds sown in soil mixture of top and compost (3:1) and watering frequency every two days (M_7WF_2) gave the highest NAR 0.0024 g/cm^2/day, at four months of growth stages after sowing. Korarima seeds sown in top soil and compost in 3:1 ratios and watering frequency every four days (M_7WF_4).gave the lowest Net Assimilate Rate during the growth stages of four months growth stages with their respective values of 0.0011 g/cm^2/day (Table 16).

LAR-The interaction of soil media and watering frequency was highly significant (P<0.01) for leaf area ratio. The highest value (190.85 cm^2/g) of LAR was observed for for Korarima seeds sown in top soil and compost in 3:1 ratio and watering frequency every three days (M_7WF_3). While the lowest value (79.17 &77.86 cm^2/g) was recorded for for Korarima seeds sown in forest soil and watering frequency every two days (M_1WF_2) and Korarima seeds sown in top soil and compost in 3:1 ratio and watering frequency every two days (M_7WF_2), respectively.

SLA-Specific Leaf area was significantly affected by the interaction of soil media and watering frequency (Table 16). The highest SLA(446.45 cm^2/g) was obtained from for Korarima seeds sown in top soil and compost in 3:1 ratios and watering frequency every three days (M_7WF_3). The minimum SLA was 166.72 & 166.32 cm^2/g for Korarima seeds sown in top soil and compost in 3:1 ratios and watering frequency every two days (M_4WF_2).and for Korarima seeds sown in forest soil and watering frequency every two days (M_1WF_2), respectively (Table16).

Leaf weight ratio was significantly affected by the interaction of soil media and watering frequency. The highest LWR (0.60g/g) was obtained for Korarima seeds sown in top soil and compost in 1:1 ratios and watering frequency every three days (M_5WF_3). The minimum LWR were 0.29 g/g for Korarima seeds sown in forest soil and compost in 1:1 ratios and watering frequency every two days (M_4WF_2 (Table 16).

Generally, the result observed may be due to soil media mixed with compost that improve the physical and chemical properties of the media with appropriated frequency of water. On the other hand, reduction in total leaf area and the proportion of biomass that portioned to leaves resulted in reduced LAR & LWR, respectively, and the reduced LAR was associated with lower SLA(thicker leaves), and RGR in less frequent irrigated seedling. The finding is similar to the result of (Tesfaye, 2005; Tesfaye et al., 2008, 2013) watering nursery grown coffee seedlings once or twice a week resulted in higher growth of both root and shoot parts and total dry matter yield than did both more and less fragment applications. Similarly, yield and crop quality of coffee orchards significantly imported by optimum rate of irrigation application and with limited water supply AGR and SLA significantly decreased. The specific leaf mass, SLM is the reciprocal of SLA. Accordingly, the dry matter accumulation in leaves per unit leaf area (SLM) continuously increased with an increasing rate as soil water stress and stress recovery periods increased. This may be accounted for growth reduction due to its inverse relationship to relative growth rate. The increase in SLM during the stress periods may also be due to increase in leaf thickness and reduction of leaf area extension.

Table 16: Interaction of media and watering frequency on growth component of Korarima seedling at four months after sowing

Treatment	RGR	NAR	LAR	SLA	LWR
M1WF1	0.154^{ij}	0.0016^{d-h}	94.57^{e-i}	183.9^{ef}	0.51^{b-e}
M1WF2	0.160^{g-j}	0.0020^{cb}	79.17^{i}	166.32^{f}	0.48^{d-g}
M1WF3	0.168^{e-i}	0.0016^{d-h}	102.29^{c-i}	201.7^{ef}	0.51^{b-e}
M1WF4	0.164^{f-j}	0.0016^{d-h}	100.12^{c-i}	196.02^{ef}	0.51^{b-e}
M2WF1	0.180^{b-f}	0.0014^{g-k}	130.5^{c}	255.07^{d-f}	0.51^{b-e}
M2WF2	0.166^{e-j}	0.0013^{h-l}	125.52^{c-e}	254.85^{d-f}	0.49^{c-g}
M2WF3	0.174^{c-h}	0.0017^{c-f}	101.24^{c-i}	196.85^{ef}	0.52^{b-d}
M2WF4	0.186^{b-d}	0.0016^{e-i}	118.94^{c-g}	213.27^{d-f}	0.56^{a-c}
M3WF1	0.178^{b-g}	0.0015^{f-k}	122.24^{c-f}	237.78^{d-f}	0.51^{b-e}
M3WF2	0.187^{b-d}	0.0016^{d-h}	114.27^{c-h}	237.66^{d-f}	0.48^{d-g}
M3WF3	0.166^{e-j}	0.0014^{h-l}	125.58^{c-e}	271.43^{d-f}	0.47^{d-h}
M3WF4	0.149^{j}	0.0013^{i-l}	117.28^{c-g}	247.33^{d-f}	0.48^{d-g}
M4WF1	0.193^{b}	0.0015^{e-j}	125.2^{c-e}	223.93^{d-f}	0.56^{a-c}
M4WF2	0.167^{e-i}	0.0019^{b-d}	89.91^{g-i}	317.33^{b-d}	0.29^{i}
M4WF3	0.179^{b-g}	0.0012^{kl}	158.72^{b}	372.72^{a-c}	0.44^{e-h}
M4WF4	0.156^{h-j}	0.0014^{g-k}	111.07^{c-h}	234.09^{d-f}	0.48^{d-g}
M5WF1	0.166^{e-j}	0.0018^{c-e}	92.94^{f-i}	222.28^{d-f}	0.42^{gh}
M5WF2	0.188^{bc}	0.0022^{ab}	85.3^{hi}	212.63^{d-f}	0.40^{h}
M5WF3	0.167^{e-i}	0.0016^{d-h}	103.93^{c-i}	174.93^{ef}	0.60^{a}
M5WF4	0.187^{b-d}	0.0014^{f-k}	128.21^{cd}	245.38^{e-f}	0.52^{b-d}
M6WF1	0.169^{d-i}	0.0013^{h-l}	128.26^{cd}	282.21^{c-e}	0.46^{d-h}
M6WF2	0.193^{b}	0.0019^{b-d}	103.71^{c-i}	229.32^{d-f}	0.45^{d-h}
M6WF3	0.173^{c-h}	0.0017^{d-g}	101.44^{c-i}	177.3^{ef}	0.57^{ab}
M6WF4	0.119^{k}	0.0012^{j-l}	96.91^{d-i}	198.99^{ef}	0.50^{b-f}
M7WF1	0.176^{b-g}	0.0017^{d-g}	103.58^{c-i}	204.99^{ef}	0.50^{b-f}
M7WF2	0.188^{bc}	0.0024^{a}	77.86^{i}	166.72^{f}	0.47^{d-h}
M7WF3	0.29^{a}	0.0016^{e-i}	190.85^{a}	446.45^{a}	0.44^{f-h}
M7WF4	0.183^{b-e}	0.0011^{l}	180.83^{ab}	388.78^{ab}	0.48^{d-g}
Cv%	5.36	12.44	13.98	22.73	7.70
LSD 5%	0.02	0.0003	26.23	89.70	0.06

Mean values followed by the same letter(s) with in a column are not significantly different at $P < 0.05$

M_1 - Forest soil , M_{2-} Top soil , M- Forest & Top soil (1:1 , M_{4-} Forest & Compost(1:1) , M_{5-} Top & Compost(1:1 ratios) , M_{6-} Forest , Top and Compost(1:1:1) , Top and Compost 3:1 (control), WF_{1-} Watering Frequency Every day , WF_{2-} Watering Frequency Every 2 days, WF_{3-} Watering Frequency Every 3 days ,WF_4: Watering Frequency Every 4 days

RGR - relative growth rate(gm/gm/d) **,** , NAR-net assimilate rate (gm/cm^2/d), SLA-specific leaf area(cm^2/gm) **,** LWR- Leaf weight ratio(gm/gm), LAR- leaf area ratio(cm^2/gm)

5. SUMMARY AND CONCLUSION

The ANOVA indicated that there was a significant variation among the different growth media, seed treatment and watering frequency of *Afframomum korarima seed regarding emergence and seedling growth*. Highly significant (p<0.01) variation was obtained among the treatments in terms of plant height, root length, stem girth seedling vigour index, leaf area ,leaf number, leaf weight, root weight stem weight, root to shoot ratio, total dry weight, root volume, relative growth rate . The interaction effect of seed treatment by soil media was highly significant (P<0.01) in respect of emergence percentage, mean days to emergence, The highest score of emergence percentage and early mean days to emergence for Korarima seeds soaked for 24 hrs in pure water and sown in top soil and compost in 3:1ratios and Korarima seeds soaked for 48 hrs in pure water and sown in top soil media (90.67)(14,20),respectively. While the lowest value (39.00) was attained for Korarima seeds soaked for 60 minutes in sulphuric acid and sown in top soil media, the highest mean days to emergence (32.67) was obtained from Seed treated with sulphuric acid and sown in forest soil. The highest value score of total dry weight (2.386g), seedling vigor index (185.73), total leaf area (201.09cm^2) and relative growth rate (15.73) were obtained from Korarima seeds soaked for 24hrs and 48hrs, in pure water and 60 minutes in sulphuric acid and sown in soil media of forest and compost, top and compost, forest and top and top and compost (3:1), respectively.

The interaction effect of soil media and watering frequency were highly significant (p<0.01) for mean days to emergence and emergence %. Korarima seeds sown in mixed forest and top soil and also top soil and compost soil media combination in equal ratio with watering frequency every days gave days(15) or shown early emergence treatments. Watering frequency every four days shown late emergence days and low percentage mean values in all media (28.67) days (60.23%), respectively.

The highest score of emergence percentage for Korarima seeds has sown in forest soil or forest soil and top and watering frequency every two days (85.77) and every day (85.63), respectively. The present findings of the interaction effect of soil media and watering frequency was highly significant ($P<0.01$) in respect of seedling growth at four months of growth stage of almost all the variables tested. According to the results obtained Korarima seeds sown in mixed top and compost soil media and watering frequency every two days enhanced early seedling growth. The correlation analysis of experiments also indicated that most of the parameters were positively but not significantly correlated. However, there were strong positive highly significant ($p<0.01$) correlation with the rest of parameters observed that attribute to the seedling growth. Plant height was positively and highly significant ($p<0.01$) correlated with shoot weight ($r = 0.44$), total dry weight($r = 0.46$), and leaf area ($r=0.51$) and also was positively and but not significantly correlated with girth, Stem weight, root weight, root volume, leaf weight, root length tiller number and tiller weight. Leaf area was positively and highly significant ($p<0.01$) correlated with leaf wt ($r=0.63$), stem wt ($r=0.57$), root wt ($r=0.64$), tillers wt ($r=0.43$) and shoot wt ($r=0.67$) and also positively but not significantly correlated with total dry weight, number of tillers and root volume.

According to the results obtained Korarima seeds sown in mixed forest soil and top soil media in 1:1 ratios and watering frequency every day are advised to be used for early and high percentage of emergence and also Korarima seeds sown in mixed top and compost soil media and watering frequency every two days enhanced early seedling growth.

From the present results of this study it can be concluded that pre-sowing seed treatment and media applied by Korarima seeds soaked for 24 hrs in pure water and sown in top soil and compost in 3:1 ratios (T_2M_7) combinations improved both seed emergence and growth of korarima seedlings. Hence the above pre-sowing seed treatment and media mixed in combinations are recommended for korarima nursery growers as soil media. Considering water availability, labor costs and time involved and based on the present results, it would be advisable for nursery operators to irrigate *korarima* seedlings every two days or three days interval with compost soil combination under the prevailing conditions. This is because seedlings under different environmental conditions may have different water requirement.

6. FUTURES LINE OF WORK

The experiments conducted so far in this area are not sufficient to draw a reliable conclusion. Since, the present study was done for the first time under Jimma conditions and further experiment needs to be conducted for korarima seed at different environmental conditions and agronomic practice techniques of seed treatment, sowing date, media, watering frequency and rate, mulch thickness, transplanting stage, viability, ranges of seed initial moisture content and storage temperatures.

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8. APPENDIX

Appendix Table 1: Monthly meteorological data for the experimental duration (2012) of Jimma Agricultural Research Center and experimental sites

month	RF, NRD, and T and RH in the site experiment I						T and RH in the site experiment II			
	RF (mm)	NRD	T (^{O}C) 2012			RH(%)	T (^{O}C) 2012			RH(%)
	2012	2012	Max.	Min.	Mean	Mean	Max.	Min.	Mean	Mean
May	96.4	17	23.8	10.2	17	60	26.72	17.26	21.99	77
June	190.2	19	24.9	10.1	17.5	61	26	15.86	20.93	78
July	188.7	16	24.6	9.9	17.3	77	27.67	14.93	21.3	79
August	223.8	20	24.5	9.5	17	65	28.5	15.4	21.95	80
Septe.	131.3	15	24.7	9.8	17.2	60	27	14	20.5	80
Total	830.4	87	122.5	49.5	86	323	135.89	77.45	106.67	394
Mean	166.08	17.4	24.5	9.9	17.2	64.6	27.178	15.49	21.334	78.8

RF-Rainfall, NRD-Number of Rainy Days , T- Temperature, Max. –Maximum, Min.-Minimum
RH- Relative humidity, Septe.-September

Appendix table 2: Pre sowing soil analysis

Soil characteristics	Soil media						
	F	*T*	*F : T* (1:1)	*F : C* (1:1)	*T : C* (1:1)	*F: T :C* (1:1: 1)	*T : C* (3:1)
P^{H}	5.62	4.36	5.64	5.52	5.52	5.03	5.31
ppm P	25.74	1.89	71.28	5.40	151.92	66.33	60.03
% OC	4.57	4.38	4.91	3.78	6.64	5.57	5.25
%OM	7.87	7.55	8.47	6.51	11.44	9.60	9.05
%N	0.22	0.32	0.25	0.18	0.49	0.36	0.33
Available K	3.71	1.41	6.65	6.13	6.90	3.45	3.58
C:N	21:1	14:1	21:1	21:1	14:1	15:1	16:1
Particle % & Texture							
% Clay	30	27.5	17.5	40	17.5	20	20
% Silt	13.75	23.75	16.25	13.75	18.75	13.75	8.75
% Sand	56.25	48.75	66.25	46.25	63.75	66.25	71.25
Soil Type	*S,C,L*	*S,C,L*	*S,L*	*S,C*	*S,L*	*S,L*	*S,L*
WHC %	62	65	56	65	72	73	69
B.D(g/cm^{3})	1.38	1.38	1.48	1.32	1.47	1.46	1.47

B.D-Bulk Density S,C,L-Sand Clay Loam S,L- Sand Loam S,C- Sand Clay OC-Organic Carbon OM-Organic Matter N- Nitrogen F- Forest soil T- Top soil C- Compost F :T –Forest ratio toTop soil F :C –Fores soil ratio to Compost T:C- Top soil ratio to Compost F:T:C- Fores soil, Top soil and compost ratio W.H.O.- Water holding capacity

Appendix Table 3: Mean squares for Seed treatments and media of korarima emergence and seedling growth (at four month growth stage)

Variables	Factors			CV%
	Seed treatment(T)	Soil Media(M)	Tx M	
DF	4	6	24	
Emergence Rate	213.319**	7.327**	7.930**	4.087
Emergence percentage	5435.729**	108.241**	174.912**	8.268
Mean Days of Emergence	113.610**	39.775**	63.410**	3.138
Shoot length cm	9.01**	7.73**	1.79**	6.74
Root length cm	62.79**	15.18**	8.82**	9.66
Stem girth cm	0.004*	0.026**	0.007**	8.18
No. Root	21.70**	111.35**	64.82**	2.68
Seedling Vigor Index (SVI)	15412**	4450.6**	3504.50**	15.39
Total Leaf area cm^2	2195.15**	3038.85**	1283.3**	8.80
Leaf area cm^2	6.37**	6.99**	6.60**	3.47
Leaf wt g	0.035**	0.053**	0.038**	9.88
stem wt g	0.023**	0.034**	0.015**	11.09
Root wt g	0.080**	0.027**	0.014**	14.23
Tillers wt g	0.077**	0.241**	0.055**	12.09
Total dray wt g	0.560**	1.067**	0.288**	7.45
No. Leaf	0.18^{ns}	0.35^{ns}	0.43*	6.51
Tap root length cm	22.04**	26.94**	12.83**	1.49
No. Tiller	0.55**	0.78**	0.77**	20.48
Root vol.ml	2.20**	2.83**	2.19**	15.82
shoot wt g	0.271**	0.799**	0.201**	7.41
Root to shoot ratio	0.03315952**	0.01211746**	0.00872897**	14.06

Appendix Table 4:- Mean squares for Seed treatment and media on growth component of Korarima seedling at four months after sowing

	Factors			CV%
	Seed treatment(T)	Soil Media(M)	Tx M	
DF	**4**	**6**	**24**	10.19
RGR	0.002497**	0.008655**	0.007349**	10.24
NAR	0.00000082**	0.00000201**	0.00000094**	8.16
LAR	5608.51**	9293.42**	5646.9**	14.85
SLA	19635.50**	29381.70**	25832.7**	16.55
LMR	0.01601**	0.01604**	0.00828**	7.24

RGR - relative growth rate , NAR-net assimilate rate, SLA-specific leaf area ,

- LWR-Leaf weight ratio ,LAR- leaf area ratio

Appendix Table 5:-Mean squares for media and watering frequency of Korarima emergence and seedling growth (four)

Variables	Factors			
	Soil Media(M)	watering frequency(WF)	M X WF	CV%
DF	**6**	**3**	**18**	
Emergence Rate	1.595238^{ns}	25.063492**	3.970899**	13.33
Emergence percentage	98.846627^{ns}	1130.113452**	208.629378**	11.05
Mean Days of Emergence	29.662698*	37.888889*	19.583333**	17.6
Shoot length cm	15.991**	22.945**	14.948**	2.98
Root length cm	18.13007**	21.44027**	5.844913**	4.37
Stem girth cm	0.005307**	0.002417**	0.009412**	3.94
No. Root	34.24206**	81.05952**	30.96693**	5.41
Leaf area cm^2	45.77422**	91.65607**	13.55726**	2.95
Leaf wt g	0.160232**	0.494919**	0.202442**	16.62
stem wt g	0.027426**	0.301141**	0.036814**	21.37
Root wt g	0.023147**	0.23835**	0.017368**	13.6
Tillers wt g	0.079252**	0.206404**	0.03449**	19.44
Total dray wt g	0.889037**	5.209648**	0.983194**	17.25
No. Leaf	1.03373^{ns}	3.114087*	0.500661**	7.62
Seedling Vigor Index (SVI)	2685.9^{ns}	37603**	10173**	13.55
Tap root length cm	61.24151**	79.28393**	46.01828**	4.5
No. Tiller	0.81873**	0.647421**	0.145661**	27.24
Root vol.ml	22.45635**	47.55556**	10.10185**	12.49
shoot wt g	0.803266**	3.271811**	0.862172**	17.02
Root to shoot ratio	0.004785**	0.01848**	0.006874**	12.3
Total Leaf Area cm^2	7502.289**	16882.43**	1963.443**	4.04

Appendix Table 6:- Mean squares for media and watering frequency on growth component of Korarima seedling at four months after sowing

	Factors			
	Soil Media(M)	WF	M X WF	CV%
DF	**6**	**3**	**18**	
RGR	0.003048**	0.002239**	0.002243**	5.31
NAR	0.000000202**	0.00000112**	0.000000283**	11.49
LAR	2536.116**	3619.508**	2171.54**	13.48
SLA	20004.46**	5928.958^{ns}	13785.65**	22.10
LMR	0.007407**	0.022901**	0.010653**	7.57

RGR - relative growth rate , NAR-net assimilate rate, SLA-specific leaf area ,

LWR- Leaf weight ratio, LAR- leaf area ratio

Appendix Figure 1. Korarima Seedling

Appendix Figure 2. korarima plant

Appendix Figure 3: Green korarima fruit **Appendix Figure 4:** Matured red korarima fruit

Appendix Figure 5: Dried korarima fruits

Appendix Figure 6: korarima Seed