

# ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE STUDIES

## **Influence of Propagation Medium on the Growth and Development of Seedlings of Avocado (*Persea Americana* Mill.), Papaya (*Carica papaya* L.) and Guava (*Psidium Guajava* L.).**

By  
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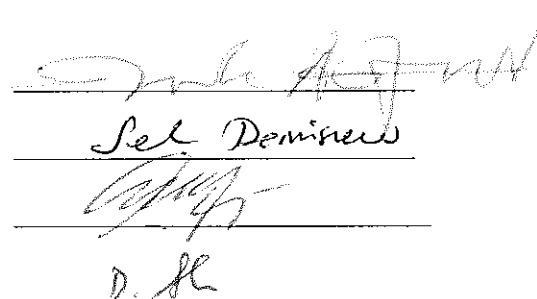
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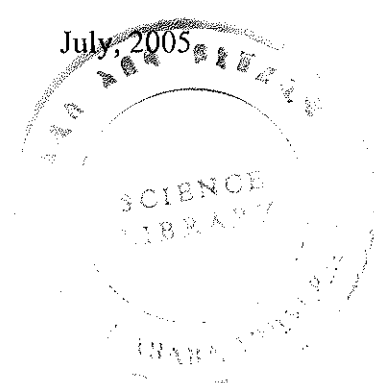
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## **DEDICATION**

This work is dedicated to my family

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## ABSTRACT

The experiment was conducted to evaluate the influence of different mixes of growth media on the growth and development of avocado, papaya and guava seedlings. It was undertaken in the nursery site of the Center for Indigenous Trees Propagation and Biodiversity Development. The study focused on addition of cattle manure and sand to topsoil. Six media mixes were prepared. The ratio of these media mixes, as treatment was determined on volume bases using flowerpot. Thus, treatments were: topsoil (T1); topsoil, cattle manure & sand, 3:1:1(T2); topsoil, cattle manure & sand, 2:1:1(T3); topsoil, cattle manure & sand, 1:1:1(T4); topsoil & sand, 1:1(T5); and topsoil and cattle manure, 1:1 (T6) and studied in a complete randomized design with three replications separately for avocado (*Persea americana*), papaya (*Carica papaya*) and guava (*Psidium guajava*). The data on total shoot height and numbers of fully expanded leaves per plant were collected starting from 7 weeks after germination up to 15 weeks of growth in the nursery at two weeks interval. Sample leaves were collected at the termination of the former two parameters for the determination of leaf fresh and dry biomass. The data taken at the termination of the measurement was used for analyses. The different media mixes did not significantly influence on any parameter of avocado; while leaf number and leaf dry weight of papaya; and the leaf fresh weight of guava seedlings were significantly influenced ( $p < 0.05$ ). Therefore growth medium 3 (topsoil + cattle manure + sand, 2:1:1) v/v] gave significantly higher leaf number and leaf dry weight than growth medium 6 (topsoil + cattle manure in equal ratio) on papaya seedlings. Growth medium 5 (topsoil + sand in equal ratio) had significant influence on leaf fresh biomass of guava seedlings than growth media 1 (topsoil). Media mixes influenced at least one growth character of the seedling of papaya and guava. Generally the presence of sand in any proportion in all the three seedling species gave better performance than the media mixes without sand mixture. All the seedling types were in a well growth performance till the termination of data collection and had reached the plantable size except for some seedlings of papaya and guava. Thus, it is concluded that avocado, papaya and guava seedlings can grow in the vicinities of Tulu-Korma. However it deserves detailed investigation on their further growth up to yield.

## 1. INTRODUCTION

Plant propagation has been started as a fundamental occupation of mankind, when ancient man learned to grow plants to fulfill nutritional needs for himself and his animals. With the continuation of the practice plants were also grown to utilize as a source of fibers, medicine, recreational opportunity and beauty (Hartmann and Kestler, 1997). Before the development of methods for plant propagation, plant cultivators must have learnt a great deal about regeneration by observing nature's methods and by trying to imitate them, for example when suckers or shoots were noticed arising naturally from the roots of such plants (Wright and Titchmarsh, 1987; Kirk, 1996). The fundamental objectives of plant propagation are to increase the number of plants and preserve the useful characteristics of the plant (Youdewei, 1994); and also to improve the quality and quantity of products (Legesse Negash, 2002). The propagation of plants is of great importance in perennial crops. When new kinds of plants have to be conserved or propagated or exploited, there is a need to develop knowledge and technique to propagate them. An appropriate propagation technology can be selected for each kind of plant based on its growth, physiology, flowering and phenology (Reddy, 1990).

Fruit crops unlike most cereals and many vegetables, are not sown directly in the field where they grow. Instead they are commonly propagated in nurseries and are then transplanted to the field when they are large enough to survive the relatively harsh conditions in the orchard (Moura-Costa, 1996). Thus, the success or failure of an orchard depends on how well the propagating and growing of fruit trees has been done in the nursery.

The propagation of fruit crops is achieved either sexually or asexually. Asexual propagation involves the vegetative parts of a plant in which a single parent plant is made to regenerate itself into a new plant, which is genetically identical to the parent plant (Sadhu, 1986). In contrast sexual propagation involves the seed which is a unit of propagation that transmits genetic material from generation to generation. A seed consists of a tiny embryonic plant in the resting stage that is provided with food and is protected by the hard seed covering (Doijode, 2002). The viable seed is a source of new plant, a beginning based on inherited parental characteristics. Seeds contain genetic material in compact form that is well protected from extraneous factors. Seeds are used for raising rootstocks and also in breeding programs and are viable tools for long-term conservation of genetic diversity because they are easier to handle, practicable, inexpensive, and capable of maintaining genetic stability on storage (Rose and Mitra, 1990).

Fruits have excellent nutritional usefulness in the tropics and subtropics due to their carbohydrate and vitamin contribution to the diet (Quebedeaux and Eisa, 1990). This is especially true if no fat, or sugar has been added in the processing. Most fruits contain fiber and some contain potassium, and magnesium (Quebedeaux and Bliss, 1987). Fruits also contain large quantities of sugar and minerals and are high in vitamins such as vitamins A and C that are usually not adequate in the staple food of many warm areas (Wargovich, 2000). Fruits in the daily diet have been strongly associated with reduced risk for some forms of cancer, heart disease, stroke, and other chronic diseases (Southon, 2000). In addition, since fruits are normally eaten fresh rather than cooked, the vitamin content is not diminished in preparation. Thus, fruits are important components of an adequate diet (Quebedeaux and Bliss, 1987).

In addition to providing variety to the diet, fruits are good choices to help keep weight under control. They are generally low in calories, yet they provide vitamins and minerals and do not contain cholesterol; and with few exceptions such as avocados, they are low in fat. Therefore these qualities are recognized in the dietary where fruits are specified as components of an adequate diet. In addition to nutrient contribution is the eating pleasure of fruits that provided to the consumers because of their colour, texture and flavour (Quebedeaux and Bliss, 1987). Further, since fruits are palatable, they are often consumed in large quantities thus contributing markedly to nutrient intake. They may also be economically important since they can produce large yields in small areas and yet sell for high prices if post harvest loss is minimized (Mitra, 1997). For some countries they represent significant means of earning valuable foreign exchange, while for others they help diversify the economics (Buchanan, 1993).

The market for tropical fruit is increasing rapidly in many countries because of increasing tourism, incomes and trend towards healthy eating. The rapid growth in air travel and tourism in the past years has made customers to become familiar with tropical fruits (Abbot, 1970). This combination of high yield and high price means that in heavily populated areas, farmers can make good incomes even from small farms. The production of high-quality fruits which provide all the benefits described above occurs only if the producers start with healthy plants of cultivars which are adapted to the environment in which they are to be grown and are genetically capable of producing quality fruits.

The adoption of intensive animal husbandry production has been contributing toward the production of large volumes of organic wastes and is creating a serious disposal problem and a

major source of environmental (Inbar *et al.*, 1993). These can be rarely applied directly to the soil since they might damage soil fertility severely (Senesi, 1989) and result in structural incompatibility, nitrogen immobilization and phytotoxicity (Inbar *et al.*, 1993). However, by composting these animal wastes can be used as a growth medium without detrimental effects on crop growth (Terrance *et al.*, 2004). Livestock manure is often rich in plant nutrients. It consists of a wide range of nutrients, including N, P, K and trace elements, and enriches humus materials, which will improve soil structure, thereby increasing aeration, water intake, and stability of soil aggregates (Azevedo and Stout, 1974). Thus, the manure compost product can be used as a good soil conditioner by enhancing clumping and, therefore, improving texture and permeability of soil to air and water, and most importantly promoting recycling and utilization of valuable resources in the organic wastes (Bertoldi *et al.*, 1983). Organic material such as cattle manure has long been known to aid in horticultural endeavors of which compost is a wonderful in the garden, when growing plants in containers (McGinnis *et al.*, 2004).

The starting point in a farmer's quest for high production of quality fruits produce is the selection of the right planting material-seed or seedling. The planting material must be of the variety ecologically suited to the farmer's geographical area, be high yielding, and be free from diseases and pest. Once these requirements are met, the farmer can be regarded as having set the right foundation to operate profitability as a business (Kenya Business Development Services, 2003).

However, fruit crops are hardly seen around Tulu-Korma (some 63 Km West of Addis Ababa) indicating the need for familiarizing the local farmers with such fruit trees. However the access for healthy and the quality seedlings is an important issue in fruit production. This is possible

with using suitable variety; best growing media and the suitable climatic conditions. Type of growing media should be seen in terms of economic viability and should obtain suitable chemical and physical characteristics. The mixture of growing media can be changed according to the fruit species and growing region to match the growth medium to the natural root development of the seedlings. It was therefore important that the rooting medium that gives better performance of avocado, papaya and guava seedlings under the prevailing climatic conditions are determined as soon as possible. In view of the increasing role played by fruit crops in the food security endeavors of Ethiopia, it is believed that this study will contribute greatly towards efficient propagation of fruit trees.

## **2. OBJECTIVES**

### **2.1. General objectives**

The present study was conducted with an aim to determining the best rooting medium appropriate for raising seedlings of Avocado, Papaya, and Guava fruit crops under the nursery and climatic conditions of Tulu-Korma

### **2.2. Specific objectives**

The specific purpose of the study was:

- (i) To evaluate the growth performance of the seedlings in the nursery on different mixtures of growth media; and
- (ii) To examine the time required for the seedlings to reach planting size under the existing conditions of the site.

### 3. LITERATURE REVIEW

#### 3.1. Biology and General Description of the Study Plants

##### *Avocado (Persea americana Mill.)*

The genus *Persea* belongs to the laurel family (Lauraceae). This family is composed of about 47 genera with about 2000 - 2500 species. The genus that mostly consists of evergreen trees and shrubs, occasionally aromatic is mostly well known for the fruit avocado, *Persea americana* Mill. *Persea americana* bears large fruits that are watery, fibrous and pleasant in flavour (Nakasone and Paull, 1999). The avocado tree is variable in shape: ranging from tall, upright trees to widely spreading forms with multiple branches. The tree can attain heights of 15-18m, with manageable heights being controlled by pruning. Although classified as an evergreen, some cultivars shed leaves during flowering and juvenile leaves from terminal shoot rapidly replace the leaves. Others shed their leaves gradually, and so are never without leaves. The dark green leaves are spirally arranged and variable in size from 10-13 cm by 20 - 25 cm long, entire or ovate to lanceolate. New growth occurs in flashes of shoot. Flushes of shoot and root tend to alternate on a 30-60 day cycle (Ploetz *et al.*, 1991). Root growth continues throughout the year, even at a low rate between the flushes, while shoot growth may stop. The period between flushes varies with location and cultivars. Growth flushes in summer tend to be asynchronous, with only a portion of a tree canopy being involved. (Kaiser and Wolstenhome, 1994). The juvenile period in avocado can be from 5 to 15 years (Lavi *et al.*, 1992)

### **Papaya (*Carica papaya* L.)**

Cultivated papaya is a fast-growing tree-like herbaceous plant in the family Caricaceae (Nakasone and Paull, 1998). The Caricaceae are a small family of dicotyledonous plants with four genera. Papaya is the most important economic species of the 31 species in *Carica*. *Carica* species are dioecious with some exceptions, and normally grow as single-stemmed trees with a crown of large palmate leaves emerging from the apex of the trunk. The cluster leaves at the apex and along the upper stem make up the foliage of the tree. New leaves are constantly formed at the apex and old leaves senesce and fall. Leaves are palmately lobed, with prominent venation and can measure 40-50cm or more in diameter and have an individual leaf area of 1625cm<sup>2</sup>, with 15 mature leaves per plant (Villegas, 1997).

The monoaxial stem normally grows without branching, unless the growing point is injured or the plants become older (Malo and Campbell, 1994). Under optimal conditions, trees can reach 8-10 m in height but in cultivation, they are usually destroyed when they reach heights that make harvesting of fruits difficult (Villegas, 1997). Natural growth of axillary branches develops when the trees are 5-10 years old. The stem is semi-woody and hollow. The bark is smooth, grayish in colour, with large, prominent leaf scars. When the stem is wounded, a thin milky sap oozes from the wound (Nakasone and Paull, 1998). After transplanting, shoot growth is initially slow, although considerable root growth is taking place, extending well beyond the canopy line. Stem growth is then rapid up to 2mm per day. Growth rate peaks at flowering and then declines as the tree starts bearing. Root growth declines dramatically as flower initiation occurs, continuing at a very slow rate during flowering and fruiting. These findings suggest that the need for continued stem growth, as well as new leaf and flower formation that decides final yield (Nakasone and Paull, 1999).

### **Guava (*Psidium guajava* L.)**

Guava belongs to the family Myrtaceae. The family has more than 80 genera and 3000 species (Nakasone and Paull, 1999). It is an evergreen shrub but, under high moisture conditions, grows to 6-9m high with spread in branches. The trunk diameter at breast height can be 30cm or more. The trunk is short, freely branching from the base but under cultivation a single trunk tree (Morton, 1987). Branches are pliable and hence are rarely broken by winds. The leaves arranged in pairs, are oblong or oval, 10-18cm in length, smooth on the upper surface, finely pubescent on the undersurface and prominent veined (Nakasone and Paull, 1998). Flowers are bisexual, with four or five calyx lobes, separated or united at the base, four or five petal and numerous stamens; the ovary is usually inferior, with one to three or more cells; the fruit is berry capsule, rarely a drupe or nut-like; and seeds are few to many (Nakasone and Paull, 1999).

## **3.2 Origin and Distribution**

### **Avocado**

There is a general agreement that the center for origin of the genus *Persea*, including the avocado, is in the high lands of central and east Mexico and in the adjacent high land areas of Guatemala. Early European travelers during the sixteenth century found avocado in cultivation and distributed it throughout Central America and northern South America (Nakasone and Paull, 1999). This is evidenced by the native names given to avocado in many languages and by archeological findings. Carbon datings indicate the Mexican avocados were used as food as early as 9000-10,000 years ago (Williams, 1976). Distribution to Africa occurred during the 17<sup>th</sup> and 18<sup>th</sup> centuries. Now it is widely distributed throughout the tropics and subtropics but the use of the fruit differs in different areas (Nakasone and Paull, 1999). The report by Edossa (1998) shows

that the first small-scale avocado orchard in Ethiopia was planted around 1930 by foreigners at *Wondo Genet* and then the practice got spread to other areas.

### **Papaya**

Although opinions differ on the origin of *C. papaya* in tropical America (Garrett, 1995), it is likely that *C. papaya* originated from the low lands of eastern Central America from Mexico to Panama (Nakasone and Paull, 1998). The greatest diversity exists in the area of Central America, with the wild population having greater diversity than domesticated population (Morshidi, 1996). Botanists indicated that seeds of papaya were taken from the Caribbean to Malacca and on to India (Storey, 1941). Then distribution continued throughout Asia and to the south pacific region. Papaya is now grown in all tropical countries and in many subtropical regions of the world. Early distribution over wide regions was enhanced by a bundance of seed in the fruit and their long viability period (Nakasone and Paull, 1998).

### **Guava**

Guava is native to American tropics but the extent of dissemination in the pre-Columbian period is ambiguous (Nakasone and Paull, 1999). It was spread easily and rapidly throughout the tropics because of the abundance of seeds with long viability period and became naturalized to the extent that people in different countries considered the guava to be indigenous to their own region (Malo and Campbell, 1994). Now it grows in nearly every tropical and frost-free subtropical country, and is naturalized in most of these countries (Howard, 1989). The hardness of guava has led to be considered as a pest in pastureland (Nakasone and Paull, 1999).

### **3.3. Ecology**

#### **3.3.1. Soils**

##### **Avocado**

Ecological requirements of avocado should be looked in terms of the area of geographical origin. It is generally considered to be a subtropical plant. Regardless of origin, the avocado has shown adaptability to a wide range of ecological conditions, from the tropics to approximate latitude of 30° north and south. This wide distribution is due to the broad genetic difference of the three horticultural races (Nakasone and Paull, 1999). Avocado tree grow well on many soil types provided the soil is well drained (Chia and Evans, 1997), but does not tolerate poorly drained conditions. Deep soils of volcanic origin, sandy loam soils, calcareous and other soil types have supported good growth. Soil pH may range from 5 to around 7; and has little tolerance for saline conditions (Nakasone and Paull, 1999)

##### **Papaya**

Major commercial production of papaya is found primarily between 23°N and South latitude. Papaya grows in a variety of soil types, with the most essential requirement being drainage; poor drainage leads to the development of root rot. A porous loam or sandy loam soil is preferred (Nakasone and Paull, 1999). It grows well in a soil pH between 5 and 7 (Awada *et al.*, 1975). At pH levels below 5 seedlings growth is poor and mortality is high. Papaya has been ranked from extremely sensitive to moderately tolerant to salt stress, germination and early seedling growth being the most sensitive stage.

## **Guava**

Guava grows on soils of all textures derived from most parent materials (Morton, 1987). Trees thrive on shallow, infertile soils, although growth and production are poor. However, it responds well to soils with good drainage and high organic matter having a pH range from 5 to 7. Cultivation in soil with a pH less than 5 or higher than 7 has been also observed (Nakasone and Paull, 1999).

### **3.3.2 Climate**

#### **Avocado**

Most cultivars are sensitive to water stress and to excess moisture caused by poor drainage. Generally, a moderate rainfall ranging between 1250 mm and 1750 per annum with good distribution is desirable (Nakasone and Paull, 1999). Relatively dry conditions are preferred during flowering. Avocado roots are shallow and prolonged dry conditions during the critical periods of flowering and fruit set cause flower and young-fruit drop. The West Indian race is best adapted to a humid, warm climate with optimum temperatures around 25-28°C. However, higher temperatures depress photosynthesis, thus lowering yield. Mature trees of Mexican cultivars have been observed to tolerate temperature as low as -4 to -5 without damage to the foliage and wood, although flowers are damaged. The Guatemalan race is adapted to a cool tropical climate but is less tolerant of low temperatures (McKellar *et al.*, 1992). Generally, growing temperature of 25-30°C during the day and night temperature of 15-20°C are considered optimum (Whiley, 1984). High humidity, exceeding 50% is desirable, especially during flowering and early fruit set. The Mexican race has shown wider temperature tolerance to cold than those the Guatemalan races (Nakasone and Paull, 1999).

## **Papaya**

Papayas grow well and produce substantial yield with out supplementary irrigation if there is a minimum monthly precipitation of approximately 100 mm. The minimum relative humidity of 66% has been reported for papaya's optimum growth (Marler, 1994). However, drought leads to the rapid shedding of older leaves and poor fruit set. On the other hand flooding frequently leads to plant death due to root rot disease. Optimum temperature for growth is between 21 and 33°C. At a temperature above 35°C, there is a tendency of bisexual cultivars to form functional male flowers with poor developed and non-functional female parts. Net photosynthetic rate also rapidly declines above 30°C (Nakasone and Paull, 1999).

## **Guava**

The guava plant does best with abundant moisture but 1000-2000mm is optimal for growth. Drought and very low humidity during flowering can dramatically reduce fruit set but generally it withstands drought very well (Morton, 1987). However, low moisture conditions during fruit enlargement reduce fruit size due to shrinkage of the inner pulp, which separate from the inner. It also does best in warm areas with abundant moisture and it is grown from sea level to elevation exceeding 1 500m (Maggs, 1984). The optimum temperature is reported to be between 23 and 28°C. However, with temperature lower than 23°C and higher than 27°C during flowering reduces fruit set (Malo and Campbell, 1968).

### 3.4. Utilization

#### Avocado

The avocado is considered a nutrient-dense food (Rainey *et al.*, 1994). It has the highest fibre content of any fruit and is a source of food antioxidants (Bergh, 1990a). Avocado has high oil content. Major fatty acids are the monounsaturated oleic acid, followed by palmitic and linoleic acid (Bergh, 1990b). Palmitoleic acid is found to approximate percentages of linoleic acid values are slightly higher or lower depending upon the cultivar.

The nutrient values of the different ecological races also vary, but in general, it is a fair to good source of vitamin A, riboflavin and niacin. The protein content of 1-2 % is considered to be greater than in any other fresh fruits (Bergh, 1990a). It also increases the diet's content of antioxidant, foliates and fibre (Rainey *et al.*, 1994). Avocado is mainly used fresh in salads and has high fat content. Avocado may be used to supply the fat content of frozen desserts, such as ice cream. However, deterioration of flavour and enzymatic discolouration serious problems in the commercial processing of avocado (Ahmed and Barmore, 1980).

Avocado oil has a composition closely resembling olive oil and can be directly substituted for it in a healthful cuisine. The oil has very desirable qualities as food oil, while there may well be constituents not yet explored. The oil is very rich in monounsaturated fatty acids and extremely low in saturated fat and also contains no cholesterol (Eyres *et al.*, 2001).

As a medicinal use, the fruit skin is antibiotic and thus is employed as a vermifuge and remedy for dysentery. The leaves are chewed as a remedy for pyorrhea. Leaf poultices are applied on

wounds. Heated leaves are applied on the forehead to relieve neuralgia and the leaf juice has antibiotic activity. The aqueous extract of the leaves has a prolonged hypertensive effect. The leaf decoction is also taken as a remedy for diarrhea, sore throat and hemorrhage; it allegedly stimulates and regulates menstruation. It is also drunk as a stomachic. A decoction of the new shoots is a cough remedy. This is when leaves or shoots of the purple-skinned type, are boiled to serve the decoction as an abortifacient. The seed is also cut in pieces, roasted and pulverized and given to overcome diarrhea and dysentery. The powdered seed is believed to cure dandruff. A piece of the seed, or a bit of the decoction, put into a tooth cavity may also relieve toothache. An ointment made of the pulverized seed is rubbed on the face as a rubefacient to redden the cheeks. Oil extracted from the seed has been applied on skin eruptions. Avocado fruit may also help to protect the liver from damage, according to new research from Japan (Mercola, 2005).

### **Papaya**

Nutritionally, the papaya is a good source of calcium and is an excellent source of vitamin A and ascorbic acid. Papayas are consumed fresh as dessert or in salads. They can also be processed into various forms such as dehydrated slices, chunks and slices for tropical fruit salad and cocktails, or processed for juices and nectar base, usually frozen and as canned nectar, mixed drink and jams (Villegas, 1997). Green fruits, leaves and flowers may also be used as a cooked vegetable (Watson, 1997). Papaya has a proteolytic enzyme that digests proteins and is used as meat tenderizer, as digestive medicine in the pharmaceutical industry, in the brewing and tanning industries and in the manufacture of chewing gum (Nakasone and Paull, 1998). Biochemically, its leaves and fruits are complex, producing several proteins and alkaloids with important pharmaceutical and industrial application (El Moussaoui *et al.*, 2001). Of these, however, papain

is a practically important proteolytic enzyme that is produced in the milky latex of green, unripe papaya fruits (Nakasone and Paull, 1998). Commercially, however, papain has varied industrial uses in the beverage, food and pharmaceutical industries including in the drug preparation for various digestive ailments and treatment of gangrenous wounds. Papain has also been used in the textiles industry, for degumming silk and for softening wool; and in the cosmetics industry, in soaps and shampoo (Villegas, 1997). The seed-oil content of 33% on a dry mass basis is considered high when compared with seeds of other fruits. The protein content of 29% on a dry-weight basis is also comparable to that of soybean with 35%. Papaya-seed meal, with 40% crude protein and 50% crude fibers appears to be a potentially rich animal feed (Nakasone and Paull, 1999). Papaya seed extracts might also become the first plant-based suitable oral contraceptives for males (Lohiya, 2001).

### **Guava**

Guava is either consumed fresh or processed. It is an excellent source of ascorbic acid, dietary fiber, vitamin A and Ca. The ascorbic acid is mainly located in the skin of the fruit and a slightly lower concentration is found in the flesh, the concentration ranges being from 0.6 -6g kg<sup>-1</sup> edible flesh. The flesh is high in pectin, making it useful for jams and jelly (Nakasone and Paull, 1999). On the other hand, guava helps to protect the soil and can be a major participant in reforestation on disturbed areas and abandoned pastures. It furnishes food and cover for wild life. The wood is used for tool handles, carving, and fuel (Advisory Committee on Technology Innovation, 1983). It has also been shown that guava leaves are used to control blood sugar diabetics in Japan. It has been effective *in vitro*, in mice and in human volunteers (Deguchi *et al.*, 1998). The basis for herbal treatment of diarrhea was demonstrated by inhibition of eight bacteria species and amoebas, and antispasmodic activity (Tona *et al.*, 1999).



Guava improves heart health by helping to control blood pressure and cholesterol. This ability to lower blood pressure could be the result of potassium, which is an electrolyte that is essential to electrical reactions in the body. It also keeps heartbeat steady, and it assists kidneys in removing waste from your body. The leaves of guava have been used as medicine for digestive problems, particularly diarrhea. Crushed leaves are also put on wounds and chew the leaves to relieve toothaches ([www.bellybytes.com/bytes/index.shtml](http://www.bellybytes.com/bytes/index.shtml)). The seeds also consist of high amount of lignocellulosic materials used to carbonize or pyrolyse the material to form a porous carbon that is suitable to be used as adsorbent (Rahman and Saad, 2003).

### **3.5. Seed Orchard**

For highest economic return, the grower needs optimal plant standards. Poor quality seed will eventually lead to sales losses by the seedling producers (Cantliffe, 1998). The fruit industry relies on the availability of high quality planting material mainly in the form of seeds. Hence, to remain competitive, fruit producers must have access to an array of seeds for as many varieties of crops as required by the market. Thus making available to the public high quality seeds and seedlings of genetically distinct fruit crop varieties is important (Bradford, 2004). A seed orchard is an area where seeds of particularly valuable genotypes are produced to obtain seed as quickly and economically as possible. Seed orchards are plantations with known family identity that are managed for maximum seed production. They consist of a population of naturally pollinated families of selected trees. Typically, they result from the process of removing those trees with less desirable genetic potential. An ideal site will have good soil structure, drainage, and fertility, with protection from high winds. Seed orchards require gently sloping terrain with easy access

and good security. They should be located near the nursery or farm offices so that equipment and personnel are readily available. The distance between the orchard and contaminating should also be kept as great a distance as possible (Nicklos, 1995). In guava seedlings trees bear fruits of variable size and quality but such trees are generally long-lived. Fully matured seeds of the current season are used for sowing. On the other hand papaya is a cross pollinated crop. It is important, therefore, for the grower to secure his seeds from a reliable source, where selection and perhaps, controlled pollination are done. Otherwise the grower should select seeds only from the best plant on the basis of vigor of the plant, size, shape and colour of the ripe fruit, thickness of flesh (Boss and Mitra, 1990).

### **3.6. Propagation by Seed**

The seed occupies a central position in the higher plant life cycle (Gallardo *et al.*, 2001). Seed propagation of plants involves the exchange of genetic material between parents to produce a new generation and is the only method of producing new varieties or cultivars; cheapest and easier method of producing large numbers of plants; a way to avoid certain diseases; and it may be also the only way to propagate some plant species (Hartmann and Kestler, 1997). The seed is made up of the outer seed coat, which protects the seed; the endosperm, which is food reserve; and the embryo, which is the young plant itself (Relf and Ball, 2001). Propagation by seed is the primary method of plant multiplication and remains the principal way of raising the majority of tropical fruits. The seeds endow the young plant with power to overcome initial adverse features of the environment by means of stored food accompanied by a high root/shoot ratio. Furthermore seeds normally possess power to respond appropriately to the environment by means of inhibitors and timing related to physical features such as moisture, temperature and light with few exceptions. Propagation by seed is the most commonly known method of producing new varieties

(Hartmann and Kestler, 1997). Indeed, propagation by seeds ensures the genetic diversity is maintained by allowing genetic recombination to occur through sexual reproduction. The genetic diversity makes possible the survival and the natural evolution of species in continually changing environmental conditions (Piotto and DiNoi, 2000). Guava seeds lose viability within a short period after extraction that indicates the need to sow the seeds immediately after extraction. However, extension of storage life has been possible to a limited extent through soaking in cold water (Boss and Mitra, 1990) though, could be stored for 104 days, when they were presoaked in ferulic acid at  $10^{-3}$ M concentrations. The seedling raised in polythene bags can be transplanted in the field when they are six to eight weeks old (Ghosh, 1980). Papaya is normally propagated by seed. Since it is cross-pollinated crop, the plants raised from seeds have a mixed inheritance, which makes them highly variable in performance. The viability of papaya seeds can be retained for months if they are preserved in clean and airtight bottle. On the other hand, the viability period of avocado seed is short (2-3 weeks). But can be improved by storing the seed in dry peat or sand at 5°C (Boss and Mitra, 1990)

### **3.6.1. Seed Planting Medium**

Fruit seedling raisers have used many different potting or container media. Most of these are quite satisfactory, but some have proved unreliable, causing loss of valuable plants and consequent delay in fulfilling planting project. Such losses have led to methodical investigations into the basic requirements for the successful production of potting medium (Garner and Chaudhri, 1994).

Plant roots are directly or indirectly related to crop yield. Therefore, the particle size of the root growth medium components is important, because this primarily determines moisture, aeration

and temperature characteristics of the medium. The particle size also must be considered in relation to the size of the seed to be sown in the medium (Hartman and Kestler, 1997). Generally, loam, peat and sand are the basic ingredient of container media. Humus or organic matter can also be supplied in the form of leaf-mould, swamp peat, pulverized bark, and compost manure (Garner and Chaudhri, 1994). Sand is added to obtain correct physical condition and good drainage. The proportion of these main ingredients may be varied according to the quality of each. The test of a well-structured mix is that it will not surface pack when watered and will not shrink from the side of the container when dry. The traditional recipes for potting medium, resulting from long experience, invariably contain a large proportion of well-structured organic matter such as leaf-mould and animal manure, peat or other fibrous material, together with sand or fine grit. Loam or silt soils are often added to provide trace elements and improve water-holding capacity and to meet the soil conditions of the open field. Generally for young fruit seedlings more open structure is required such as sand, loam, and peat in the 2:1:1 ratio. Sowing media used in avocado nursery vary greatly from country to country (Gaillard and Godefroy, 1995). For further growth and development a steady supply of nitrates, phosphate and potash, must be assured (Garner and Chaudhri, 1994). On the other hand under high evaporation, the water storage in the potting medium is usually too small to maintain the water supply of seedlings for more than a few days. Furthermore, the water stress may arise from poor root growth and inadequate water absorption due to weak soil-root contact, low hydraulic conductivity in the container medium and low root temperature (Lopushinsky and Max, 1990). Papaya seedlings are raised in polyethylene bags, in which two to three seeds are sown in each bags filled with mixture sieved soil, farmyard manure and sand in equal proportion. The seedlings will be ready for transplanting in the main fields when they are about 8 weeks old (Boss and Mitra, 1990).

### 3.6.2. Planting the Seed

During planting, there must be sufficient contact between the seed and the particle for exchange of moisture. The proper planting depth differs with seed type. Seeds that require light for germination obviously can't be planted deeply. Generally, a seed should not be planted deeper than two or three times their diameter (Hartmann and Kestler, 1997). Seeds may be sown insitu, in prepared seedbed or in containers such as pots, bags or basket. Raising seedlings in individual containers for later transference to the field, with minimal disturbance of the roots, confess a number of advantages but involves considerably more investment of labour and money than either sowing insitu or in nursery bed. Plants raised in containers can be established in their permanent position in the field with out suffering a sever check so commonly experienced following bareroot planting. Container raised plants can be more readily protected from predators than those grown directly from field-sown seed. These features of container-raised plant favour a full establishment at a single planting and obviate the expensive operation of replacing missing plants, which may go on for more than a season and result in a given plantation with a delay in the attainment of full production (Garner and Chaudhri, 1994).

Included among the adverse features of container usage is the fact that the plants must be transferred to their permanent site before the roots have become twisted around, as seedlings with spiraled roots may never recover (Keever *et al.*, 1985). Another point to be considered is the difficulty of transporting containerized plant over long distances or over awkward terrain, because of their heaviness and require considerable space during transport to accommodate the in upright position, their maximum height having to govern the shelf spacing in the vehicle (Garner and Chaudhri, 1994).

The germination of papaya seeds planted in a pot is variable and usually starts two to three weeks after the beginning of the imbibition period. Intact fresh seeds show a very low germination, or do not germinate at all, but germination is enhanced by the removal of the aril. It is believed that aril membrane acts as a barrier against the liberation of a water-soluble inhibitor, which retards germination (Boss and Mitra, 1990). In avocado seeds the removal of the seed coat before sowing helps to speed up germination. During planting the seed of avocado can be split lengthwise into four or even six parts leaving a piece of the embryo on each to make enough the amount of planting material required (Kenzie *et al.*, 1990).

### **3.6. Seedling Growth**

Plant growth is an irreversible change in the size of a cell, organ or whole plant. It may also be the increase in cell number with out changes in volume or weight. Growth is the increase in the amount of living material which leads to an increase in cell size and ultimately cell division. The increase in protoplasm is brought about as water, carbon dioxide and inorganic salts are transformed into living material. Growth occurs only in living cells by metabolic processes involved in the synthesis of proteins, nucleic acids, lipids, and carbohydrates at the expense of metabolic energy provided by photosynthesis and respiration (Janick, 1979). Whole plant development is the orderly and progressive change from seed germination through juvenile, maturity flowering and fruiting. The growth cycle of most plants is regulated by both internal and environmental factors, which can either collectively or individually, strongly limit or stimulate active growth (Lavender, 1981). Thus, cultivation according to physical guidelines is essential to produce plants with maximum survival and growth rate (Lavender, 1984).

### **3.7.1. Physiological Factors Affecting Seedling Growth**

#### **3.7.1.1. Carbohydrates**

Plants need to balance the availability and demand for carbohydrates to sustain their metabolism and support their growth and development (Smeekens, 2000). Plants are able to produce the carbohydrates they require in mature leaves and transport via the phloem to support the growth of developing tissues to meet the requirements of tissues or to be stored in anticipation of less-favourable environmental conditions. To co-ordinate this partitioning of carbohydrates, plants require information regarding their carbohydrate status and information on where and for what purposes the available carbohydrates are needed (Rook and Bevan, 2003).

Carbohydrates provide the principal substrates for producing the energy necessary for plant metabolism. Carbohydrate levels have been related to development of cold hardness (Weiser, 1980), based on the hypothesis that relatively high levels of substrate are necessary if a plant is to cold-harden fully; and growth of seedling roots (Lavender, 1984). Sugar plays a role as a signaling molecule that regulates a variety of genes. It probably affects various aspects of development in higher plants (Ohto *et al.*, 2001). In papaya, carbohydrate content varies seasonally with peaks in reducing sugars and starch in the leaves, stems and roots during winter, as plant development slows down. Generally, with the cessation of active leaf and stem growth during autumn and winter, there is a build up of sugars and starch, in the petioles and stems in particular, and to a lesser extent in the roots (Allan, 2002).

### **3.7.1.2. Hormones**

Growth and development of plants is the net result of metabolic processes controlled by the natural as well as synthetic hormones. Appropriate concentration of growth hormones can stimulate the activity of key chemical substances and physiological processes, which are reflected by growth (Awan *et al.*, 1999). Plant growth substances are chemicals that accelerate, or inhibit the growth of a plant. They are produced in one part of the plant, and transported through the plant to another place where they exert an effect upon growth and differentiation (Trewavas, 1981; Fullick, 2003). The following are the major, accepted hormones and the growth parameters most characteristic of each (Thimann, 1982). Auxins bring about a number of morphological, genetical and physiological changes in leaf (Chaudhry and Qurat-ul-Ain 2003). Auxins stimulate cell enlargement, and apical dominance; inhibit abscission of leaves and root elongation. Gibberellins stimulate cell division, seed germination and reproductive growth. Ferguson and Guinel (2001) reported that cytokinins are involved in chlorophyll stabilization and may have a role in the altered levels of chlorophyll found in leaves. Cytokinins also retard senescence, promote bud growth as well as cell division, expansion and differentiation. Ethylene stimulates breaking down of dormancy and epinasty; inhibit elongation of shoot and root (Lavender, 1984).

### **3.7.1.3. Frost Hardness**

Frost hardness is the ability of a plant cells to withstand temperature below freezing without suffering irreversible physical damage. The nature of the changes that occur in plant cells during the hardness is not fully understood, but the hardening process apparently involves changes in cell membranes, to allow movement of water to extracellular ice crystals, and in the protoplasm,

to resist effects of desiccation (Weiser, 1980). Significant frost hardness develops in seedling if the plants have an adequate reserve and if active growth has ceased (Hermann, 1984). Frost hardness in plants is quite labile. However, frost damage to buds or foliage may not affect seedling survival significantly (Weiser, 1980). Cooler temperature greatly retards the growth of avocado seedlings (Nakasone and Paull, 1999).

### **3.7.2. Exogenous Factors Affecting Seedling Growth**

#### **3.7.2.1. Light**

Optimum light is critical for proper plant development (Hartmann and Kestler, 1997). Light profoundly affects the growth and development of plants as energy source that drives photosynthesis, the process by which plants create the organic substrates necessary for growth; and the regulation of seedling development through the phenomenon photoperiodism in which daily dark period of less than ten hours stimulate active shoot elongation, whereas daily uninterrupted dark periods longer than 14 hrs stimulate dormancy (Lavender, 1984). Stomatal conductance of avocado leaves was found to increase with increasing light level, thus affecting leaf gas exchange (Xuan Liu *et al.*, 2002). In spite of the extreme importance of light, the light environment of seedling can be affected by reducing light intensity with shading materials; manipulating density of both crop and weed species that significantly affects morphology and carbohydrate reserves (Janick, 1979; Lavender, 1984).

#### **3.7.2.2. Moisture**

The amount of moisture in the air affects the degree of water stress to plants (Hartmann and Kestler, 1997). The rate of photosynthesis, one major key to total seedling growth, may sharply reduce by soil moisture deficits (Zahner, 1988); but it may also be slowed by saturated soils,

which produce an anaerobic environment (Zaerr, 1983). Avocados are sensitive to poor aeration thus requiring air-filled porosities of plant growth media (Kenzie *et al.*, 1990) papayas too. In addition, excess moisture may promote growth of plant pathogens (Filer and Peterson, 1975). Soil moisture content influences plant root growth. For example, dry soil conditions can result in deeper root penetration of the soil, which may lead to greater root distribution in the subsoil than the surface soil. In nursery situations where seedlings are typically root wrenched before lifting and root pruned at grading, soil drying may result in a proportionally greater loss of root biomass (Jacobs *et al.*, 2003). The capacity to store water in soil is improved by the incorporation of organic matter and vermiculite (Brady and Weil, 1996). The incorporation of organic matter into nursery soils also alters physical (Rose *et al.*, 1995) and chemical properties, which may further improve seedling development (Jacobs *et al.*, 2003). Seedlings can be protected from moisture stress by carefully noting both seedling and environmental conditions during nursery operations. Generally, seedlings should be moistened thoroughly during dry days to prevent subsequent reduction in seedling growth (Daniels, 1979). However watering at the wrong time-physiologically can do damage. Frequent watering of nursery stock to relieve moisture stress can cause dormancy to be initiated too late to permit the sequence of physiological changes necessary for vigorous seedling growth (Lavender and Cleary, 1974).

### **3.7.2.3. Nutrient**

Sixteen elements have been shown to be essential to plant growth. A healthy seedling must be supplied with all nutrients in proper proportions (Ingestad, 1979). Any environmental or cultural factor that affects growth will, of course, affect seedling nutrient requirements (Lavender, 1984). Though it is not possible to specify absolute soil fertility standards, ranges within which vigorous seedlings may be grown can be specified. If a given nutrient is deficient, seedlings may

compensate to some extent by increasing their capacity to take up the deficient ion (Ingestad, 1979). Nutrient deficiency stress is reflected by reduced growth and by distinct changes in the plant's habit (Lavender and Walker, 1979). However evaluating the effect of individual nutrient on certain aspect of seedling physiology is difficult because of the possible interactions of these particular nutrients with other aspects of seedling physiology (Van de Driessche, 1990). Using organic matter acts as a slow-release fertilizer, gradually making essential nutrients available to the seedling (Brady and Weil, 1996).

#### **3.7.2.4. Density**

The density of seedlings in seedbeds or per pot dramatically affects seedling development (Benson and Shepherd, 1976). However, age of seedlings at the time of transplanting and variations in seeding method and densities make it impossible to generalize about an optimum density for all nurseries (Chavasse and Bowles, 1976). Density itself affects indirectly by impacting available light, moisture, and nutrients. Generally wide spacing promotes greater root development and higher levels of carbohydrate reserves, which are essential for development of cold hardness (Weiser, 1980), and reduces losses to insect and disease (Smith, 1975).

#### **3.7.2.5. Temperature**

The optimum temperature required by a growing plant differs with plant species (Hartmann and Kestler, 1997). However, higher plants, under normal growth conditions, assume the temperature of their environment. Further the rates of most metabolic processes are strongly regulated by temperature (White *et al.*, 1974). The temperature at which maximum seedling growth occurs does not permit maximum gross photosynthesis for example in avocado in which cessation of

leaf photosynthesis occurs in response to low humidity and high temperature stress (Xuan Liu *et al.*, 2002). But it is the temperature at which the rates of the plant's synthetic process exceed those of its metabolic processes. Generally, high temperatures produce maximum dry matter in the leaves, while low temperature produce it in the roots (Lahav and Trochoulis, 1996). Therefore, scheduling annual growth cycles so that seed and seedling physiology is compatible with environmental conditions can produce superior seedlings. Temperature extremes may damage seedlings. However, proper seedling spacing may minimize effect of high temperatures. On the other hand, seedling damage by low temperature may be avoided by manipulation of seedling spacing that permits maximum photosynthesis and production of carbohydrate reserves (Lavender, 1984). Under subtropical condition papaya growth is adversely affected by minimum daily temperatures below about 11°C. Optimum growth and development occur during the hot summer months when 2.5 new leaves are produced per week (Allan, 2002).

### **3.8. Propagation and Nursery Management**

#### **Avocado**

Avocado is propagated commercially by budding or grafting upon seedling rootstock. However, the variability of seedling populations with respect to certain desirable characteristics, such as resistance to root rots and tolerance to salinity and calcareous soils, has posed problems (Benya'acov and Michelson, 1995). Seedling production has largely changed from grafting nursery-grown trees to grafting container-grown trees. Seeds are taken from fruit picked from trees free of sun-blotch virus and treated in water-bath at 49-50°C for 30 min, cooled and surface-dried in a partially shaded area and are planted (broad side down) in polyethylene bags, with a well-draining potting mix. Seeds germinate in about a month. Propagation is usually done in shade

houses, preferably with temperature control if the environment has wide temperature range (Nakasone and Paull, 1999).

Normally, avocado seeds lose viability within a month. But can be stored up to 5 months if placed in non-perforated polyethylene bags and kept at 4.4°C indicating that it may be possible to successfully store seeds for cultivars ripening at different seasons for later simultaneous planting (Boss and Mitra, 1990). Fresh seeds germinate in 4 to 6 weeks. In nurseries, seeds that have been in contact with the soil are disinfected with hot water. Seedlings should be kept in partial shade and not over watered. While many important selections have originated from seeds, vegetative propagation is essential to early fruiting and the perpetuation of desirable cultivars. Experiments with gibberellic acid and cutting of both ends of the seed with a view to achieving more uniform germination have not produced encouraging results. Seedlings will begin to bear in 4 or 5 years and the avocado tree will continue to bear for 50 years or more (Morton, 1987). In as much as avocado roots are sensitive to transplanting, it is now considered advisable to raise planting material in plastic bags that can be slit and set in the field without disturbing the root system.

At the time of field planting, protection of any exposed part of the stem from sunburn with a coat of whitewash or white latex paint is important. Seedling trees are usually best left unstaked. Because of their shallow rooting, the soil around avocado trees should not be disturbed by cultivation. Established trees, those with a strong, healthy, root system do best in full sun and most varieties will survive mild frosts with minimal damage. The bark on avocados is sensitive to sun burn. A well foliated tree is adequate protection but exposed bark should be painted with white latex paint even in the winter. Young, tender trees should be sheltered from both direct sun

and frost. Filtered light is ideal. An exposure with full sun in the cool morning and some hot afternoon shade is also adequate (Boss and Mitra, 1990).

### **Papaya**

Papaya is propagated primarily from seed, which germinates from two to four weeks after planting if the soil is warm (Moller and Niipale, 1989). Growers select trees with desirable characteristics, from which seeds (generally from open-pollinated hermaphroditic fruit) are saved. Seeds should be obtained from ripe fruit, washed to remove the gelatinous aril and air-dried in the shade. The removal of the aril during washing hastens germination and with a higher germination percentage if the sarcotesta (gelatinous material covering the seed) is removed during seed washing (Malo and Campbell, 1994). Seeds kept at 7-10°C and 50% relative humidity are viable for several years. Seeds may be sown in polyethylene bags or directly in the field. Germination occurs within 12-20 days. Seedlings grown in containers are hardened gradually in sunlight and field-transplanted around 1.5-2 months of germination at about 20cm high. When planting, up to 15-20 seeds are sown in each pot after which seedlings are thinned out to leave three to five seedlings to grow to flowering. This is to allow for uneven germination, birds and field mice loss. At the first flowering a vigorous plant of the desired sex is kept and the others removed (Nakasone and Paull, 1999).

### **Guava**

Guava is propagated by both sexual and asexual means. However, seed is still commonly used for propagation of guava (Khattak *et al.*, 2001). Many existing orchards have been raised from seedlings. Guava seeds show orthodox storage (Becwar, 1983). Seeds germinate poorly and

unevenly and require more time for seedling emergence. Poor germination is mainly attributed to dormancy (Teng and Hor, 1976). Seeds are used to produce seedlings in breeding and selection programs or to produce rootstocks for grafting of desirable cultivars. Seeds are sown in a well drained and more than 90% of fresh seed germinate within 15-20 days (Nakasone and Paull, 1999). Seed soaking in cold water for 12h or in boiling water for 5 min was suggested to be beneficial for higher germination (Singh *et al.*, 1973). Containers-grown seedlings may be budded or grafted when stem diameters are 12-20 mm, with greater diameter being especially suitable for budding (Nakasone and Paull, 1999).

Seedlings used for grafting or budding may be propagated from seeds of wild guava or clonal trees. There appear to be no differences in the seed source at the present time. Regardless of the seed source, fresh seeds should be from healthy, clean, ripe fruit. The seeds should be thoroughly washed free of any pulpy material and treated with a fungicide to prevent damping-off. Otherwise as the seedlings emerge, both the seedlings and the media surface should be treated with a fungicide (Shigeura and Bullock, 1983).

## **4. MATERIALS AND METHODS**

### **4.1. The Study Site**

The study was carried out at “Tulu-korma” (Oromia Region, West Shewa Zone, Ejere Woreda) located 3 km past Addis Alem, in the nursery site of Center for Indigenous Trees Propagation and Biodiversity Development at 2180 m a.s.l. and 09°01’N, 38°21’E. The area receives an average annual rainfall of 1100 mm and bimodal rain fall (Hailu *et al.*, 1990). Short rains from February to May and long rains, *meher*, from June to September. The short rains are mainly used only to break and prepare the soils for crop cultivation. The pattern of rainfall dictates the single cropping period, starting in March and ending in December. The mean maximum and minimum temperatures are 22.5 and 6.3°C, respectively, and average temperatures range between 11.6 and 15.3°C (Buta, 1997).

### **4.2. Growth Medium Analyses**

Samples each weighing 1kg from both topsoil and cattle dung were analyzed the National Soil Laboratory for the determination of some constituents and physio-chemical characteristics of the growth medium (Appendix 4).

### **4.3. Seed Preparation**

Healthy and uniform ripe fruits of avocado; papaya and guava were purchased from fruit markets. The fruits were then washed thoroughly with tap water to minimize seed contamination from the fruit skin. Seeds were extracted manually and washed with tap water and soap to remove any fleshy part remaining on the surface of the seeds. After washing the seeds were transferred to a bowl half-filled with tap water in order to separate unhealthy or empty from those that are healthy

and full seeds. Seeds from the bottom of the plastic bowl were taken and spread over a plastic sheet under a shade for four hours to allow evaporation of surface moisture. The guava seeds however were soaked in cold water for 12 hours to facilitate easy germination as suggested by Singh *et al.*(1973).

#### **4.4. Experimental design**

Each polyethylene bag filled with each propagation media type was arranged in complete randomized design with six treatment and three replications for each of the three fruit crops. Each treatment was applied to 15 individuals.

#### **4.5. Treatment Application and Raising Seedlings**

The study focused on addition of various proportions of locally available organic material (cattle manure) and sand to topsoil. Six mixtures of growth media were prepared based on their ratio by volume as follow. Propagation medium type 1 (T1) = topsoil alone; propagation medium type 2 (T2) = topsoil + cattle manure + sand (3:1:1,v/v); propagation medium type (T3)= topsoil + cattle manure + sand (2:1:1,v/v); propagation medium type 4 (T4) = topsoil + cattle manure + Sand (1:1:1,v/v); Propagation medium type 5 (T5)= topsoil+ sand (1:1,v/v); and propagation medium type (T6)= topsoil + cattle manure (1:1,v/v).

White polyethylene bags (25 cm in diameter, 55cm in length) were filled with the propagation media type prepared following different treatments. The required ratio was determined using flowerpots ( $5.6 \times 10^3 \text{ cm}^3$ ). The bottom of each polyethylene bags was perforated after filling with the propagation medium, so as to allow the drainage of excess water. Two avocado seeds per bag were planted into each respective treatment. Similarly 10 seeds of papaya and guava per bag were

planted at a burial depth of approximately twice the diameter of each seed size. Seedlings were watered evenly 3 times a day under wooden shade that partially allows the entrance of sunlight required for the normal growth of the seedlings and photosynthesis. The polyethylene bags were thinned to two for avocado and three for papaya and guava plants after four weeks of germination.

#### **4.6. Seedling Growth Measurements**

Biomass of the study plants was determined by measuring four variables: Total shoot length (height from soil level to apical bud) (cm); number of fully expanded leaves; and fresh leaf and dry weights. Measurements for plant height and number of leaves were taken every 15 days starting from seven weeks after the seeds had been germinated. After 15 weeks of growth in pots, sample leaves were harvested from each replication of respective treatments for each of the three species. This was done by taking the most expanded leaves from the middle of the shoot. The sample leaves were immediately sealed (separately for replications and treatments) in plastic bags sprayed with tap water to maintain turgidity until their arrival at the Physiology Laboratory of the Biology Department for fresh weight measurements. Fresh weight of the leaves was determined by blotting off excess water from the sample leaves. After fresh weight determination, all sample leaves were oven-dried at 70°C for 24 hours so as to determine dry weights.

#### 4.7. Statistical Analyses

To determine the influence of different growth medium on the studied variables (seedling height, leaf number per plant, and fresh leaf and dry biomass) of the three fruit crops, data taken at the termination of the experiment was subjected to analysis of variance (ANOVA) to calculate the means and standard errors of the variables for the treatment groups compared for a complete block design separately using the STATISTICA 6.0 (Statsoft, Inc. 1984-2001). When significant differences were detected among means for any parameter ( $p < 0.05$  in F test), comparisons between treatments were done by LSD multiple range posthoc ANOVA test to determine significant differences (at  $\alpha = 0.05$ ) among the different treatments used. Data taken on shoot height at interval of two weeks following the development of the seedlings for each species was used to plot the relative height growth rate. Relative growth rate (RGR) of total shoot height was calculated by using the formula below (Evans, 1972):

$$\text{RGR} = \frac{\ln \text{TSL}_2 - \ln \text{TSL}_1}{t_2 - t_1}$$

Where:

$\ln$  = natural logarithm

$\text{TSL}_2$  = total shoot length at final measurement

$\text{TSL}_1$  = total shoot length at initial measurement

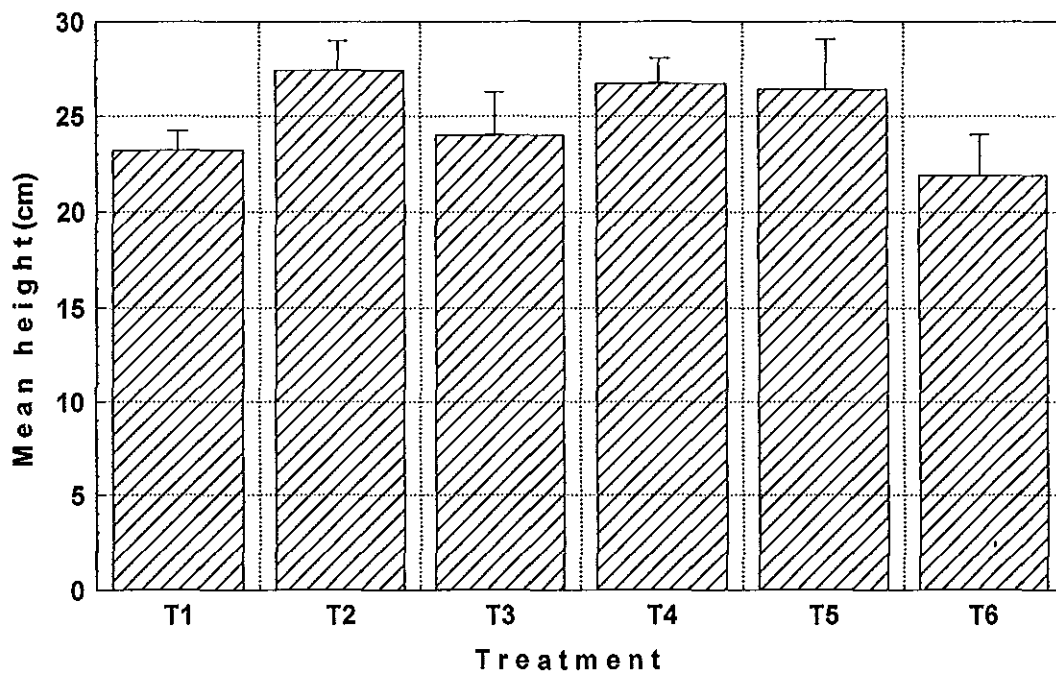
$t_2 - t_1$  = days between measurements

## 5. RESULT

### 5.1. Growth Performance of Avocado Seedlings

#### 5.1.1. Seedling Height

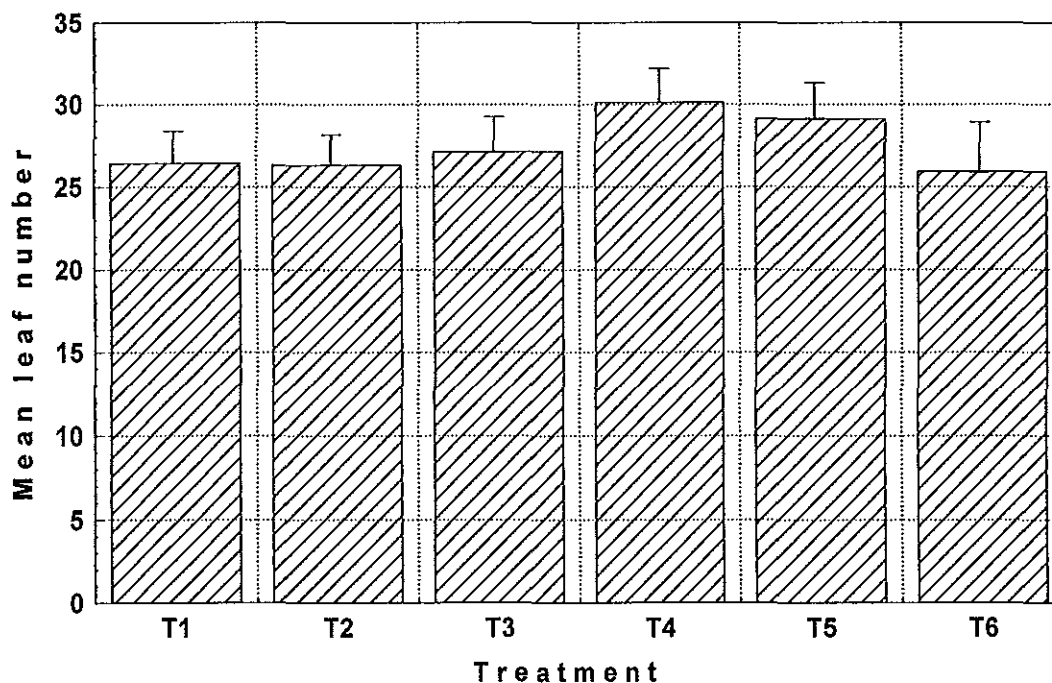
Avocado seedlings did not show significant variation in all treatments except some tendency that seedlings tend to be taller in growth medium 2 containing topsoil, cattle manure and sand in a 3:1:1 ratio. The plant height was lowest in seedlings grown in growth medium 6 that contained equal mixtures of topsoil and cattle manure (Fig.1). Although there was no significant variation among the media composition, there were clear indications that this morphological attribute does explain shoot growth performance of avocado seedlings under different growth media.



**Figure 1.** Height (cm) of avocado seedlings (mean  $\pm$  SE) grown in different mixes of growth media in polyethylene bags. Measurements were taken after 15 weeks of growth in the nursery. Treatments are: 1, topsoil alone; 2, (topsoil + cattle manure + sand (3:1:1,v/v)); 3, (topsoil + cattle manure + sand (2:1:1,v/v)); 4, (topsoil + cattle manure+ sand (1:1:1,v/v)); 5, (topsoil + sand (1:1,v/v)); 6, (topsoil + cattle manure (1:1,v/v)).

### 5.1.2. Number of Leaves

The number of seedling leaves per plant did not show significant differences in the different growth media. However leaf number appeared to be more (30.1) in the growth media 4 containing equal proportion of topsoil, cattle manure and sand than growth medium 6 the one containing equal proportion of topsoil and cattle manure i.e. 25.9 leaves. On the other hand mean height and leaf number per plant of avocado seedlings did not show similar trend of increasing on the same growth medium due to difference in lateral leaf development than apical bud development (Fig.2).



**Figure 2.** Number of fully expanded leaves of avocado seedlings (mean  $\pm$  SE) grown in different mixes of growth media in polyethylene bags. Leaf counts made after 15 weeks of seedling growth in the nursery. Treatments are as for Figure 1.

### 5.1.3. Leaf Biomass

The different growth media types did not significantly influence the total leaf fresh and dry weight of the seedlings. However, growth medium 4 containing equal proportion of the mixture of topsoil, cattle manure and sand gave higher values of both total fresh leaf and dry weight than growth medium of containing equal proportion of topsoil and cattle manure. Growth medium 4 was also superior to growth medium 1, which was composed of topsoil alone (Table 1).

**Table 1** Weights of fresh and dried leaves of avocado seedling grown on different composition of propagation media. Treatments are: T1, topsoil alone; T2, (topsoil + cattle manure + sand (3:1:1,v/v)); T3, (topsoil + cattle manure+ sand (2:1:1,v/v)); T4, (topsoil + cattle manure + sand (1:1:1,v/v)); T5, (topsoil + sand (1:1,v/v)); T6(topsoil + cattle manure (1:1,v/v)).

Treatment	Fresh weight (g)	Dry weight (g)
T1	1.15	0.23
T2	1.33	0.26
T3	1.50	0.30
T4	1.63	0.32
T5	1.52	0.31
T6	0.96	0.19

Numbers with in the matrix are means of 15 replicates. Means within the same column are not statistically different from one another.

#### 5.1.4. Relative Growth Rate in Plant Height

At the initial growth stage, the plant height increase was relatively similar on all growth media up to fifty days; after this time as the seedlings developed the effect of different growth media was clearly seen (Fig 3). There was faster growth in plant height sixty days after planted seeds were germinated. The relative growth rate was maximum on most of the measurement phases in growth media 4 that contained equal proportion of topsoil, cattle manure and sand (2.85, 3.01 and 3.07 cm per two weeks) in the second, third and fourth phase of seedling height measurements, respectively. Growth media 6 containing equal proportion of topsoil and cattle manure had the lowest relative growth rate throughout the plant height measurement phases (2.42, 2.65, 2.77, 2.8, 2.91 per two weeks), respectively.

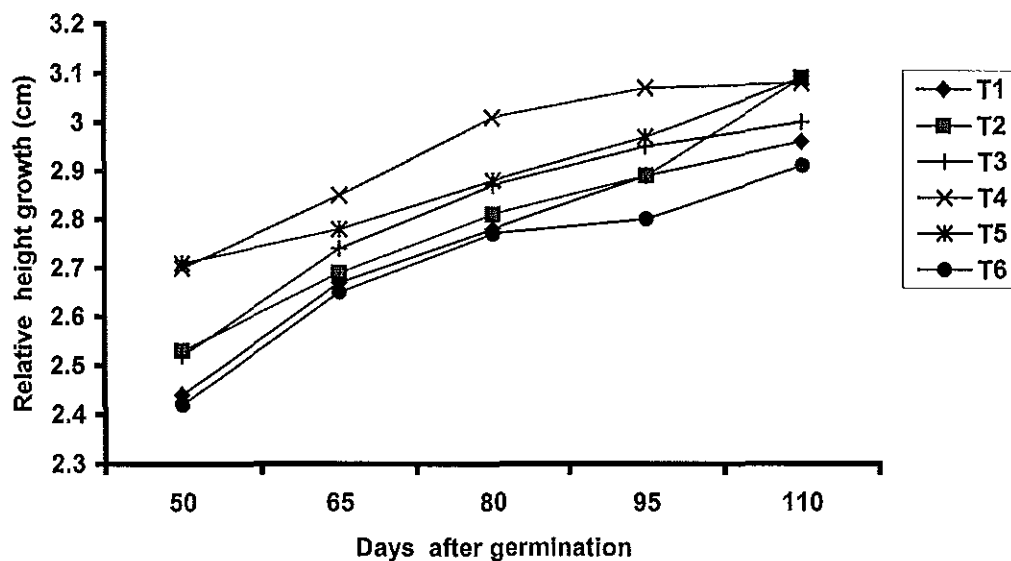


Figure 3. Change in relative (cm) shoot height of avocado seedlings over 15 weeks of growth in the nursery under different compositions of growth media at two weeks interval.  $n=15$ .

## 5.2. Growth performance of papaya seedlings

### 5.2.1. Seedling Height

The different growth media resulted in plants having statistically similar height. However a maximum mean plant height (19.01 cm) was recorded in papaya seedlings grown in growth media 3 which contained topsoil, cattle manure and sand in 2:1:1 ratio while, minimum plant height in treatment 6 (5.01cm) was observed in plants grown in a growth media containing equal proportion of topsoil and cattle manure (Fig. 4).

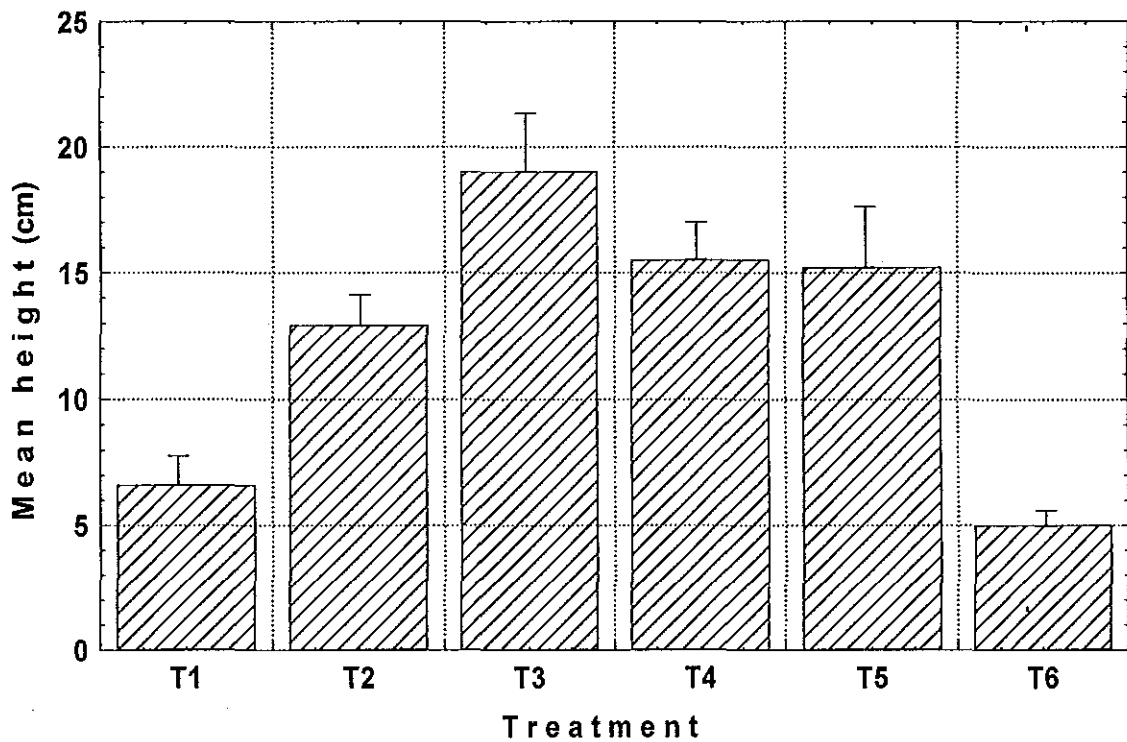
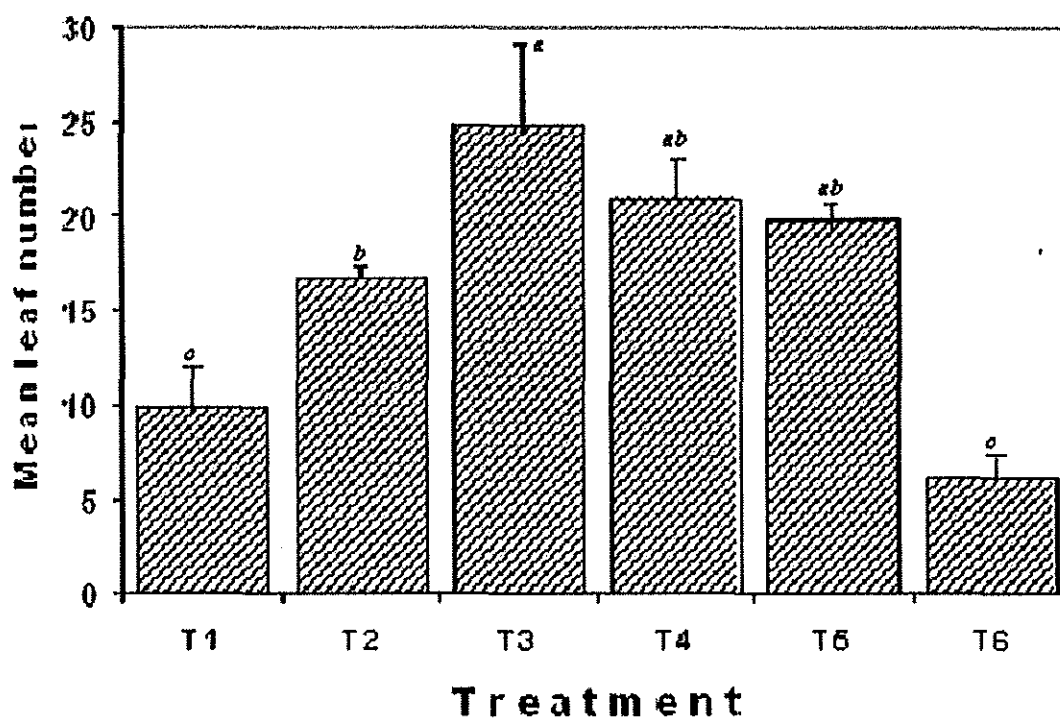


Figure 4. Height (cm) of papaya seedlings (mean  $\pm$  SE) grown in different mixes of growth media in polyethylene bags. Treatments are as for Figure 1.

### 5.2.2. Number of Leaves

Number of leaves per plant was significantly influenced ( $p < 0.05$ ) by the different growth medium. Consequently, minimum number of leaves (9.2 leaves per plant) were found in the growth media 6 containing equal proportion of topsoil and cattle manure, while, maximum number of leaves (24.7 leaves per plant) were observed in seedlings grown in growth media 3 containing equal proportion of topsoil and sand. Seedlings grown in the different growth medium showed generally similar trend i.e. the increase in leaf number is generally similar with the increase in seedling height in each growth media type (Fig. 5).



**Figure 5.** Number of fully expanded leaves of papaya seedlings (mean  $\pm$  SE) in different mixes of growth media grown in polyethylene bags. Leaf counts made after 15 weeks of seedling growth in the nursery. Symbols are as in Figure 1. Treatments connected with the same letter did not differ significantly at  $\alpha = 0.05$ .

### 5.2.3. Leaf Biomass

Papaya seedlings grown in different growth media types showed significant difference ( $p < 0.05$ ) in the leaf dry weight. Growth media 3 that contained different proportion of topsoil, cattle manure and sand in 2:1:1 ratio gave a significantly higher dry weight than growth media 6 with equal proportion of topsoil and cattle manure. However leaf fresh was not significantly different between the different growth media (Table 1).

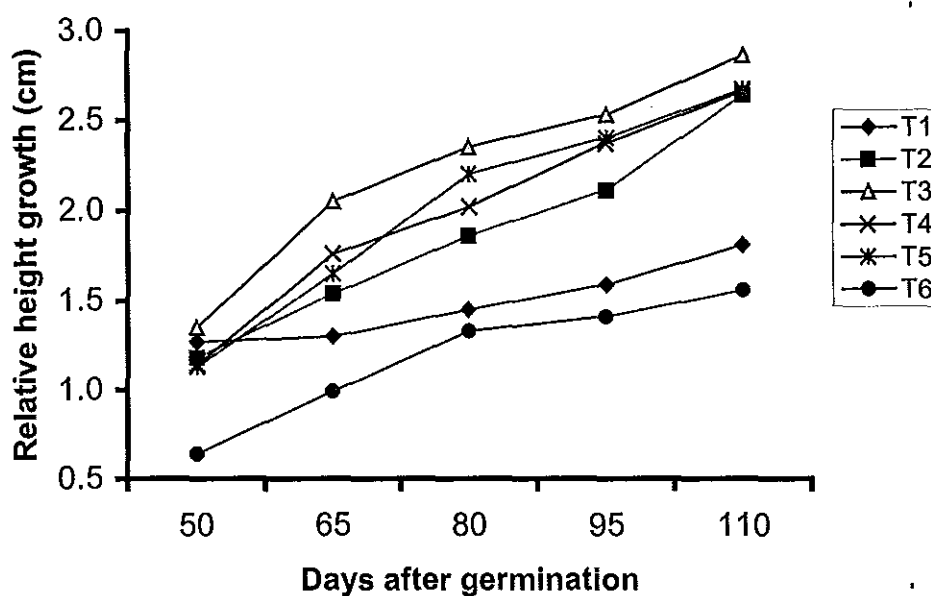
**Table 2.** Weights of fresh and dried leaves of papaya seedling grown on different composition of propagation media. Treatments are as for Table 1.

Treatment	Fresh weight (g)	Dry weight (g)
T1	0.69	0.13 <sup>bc</sup>
T2	0.78	0.14 <sup>bc</sup>
T3	2.72	0.72 <sup>a</sup>
T4	2.14	0.65 <sup>a</sup>
T5	1.59	0.40 <sup>b</sup>
T6	0.16	0.07 <sup>c</sup>

Numbers with in the matrix are means of 15 replicates. Means within the same column with a different superscript letters are statistically ( $p < 0.05$ ) different from one another.

#### 5.2.4. Relative Growth Rate in Plant Height

At the initial growth stage, the plant height increase was similar on all growth media up to fifty days. However, as the seedlings developed the effect of different growing medium started to be clearly visible in which there was faster growth in plant height 65 days after seed germination. The relative growth rate was maximum (1.35, 2.05, 2.35, 2.53, 2.86 cm per two weeks) throughout the five measurement periods in growth media 3 which is with topsoil, cattle manure and sand in 2:1:1 ratio, respectively. The minimum relative growth rate during the measurement periods was 0.64, 0.99, 1.33, 1.41 and 1.56 cm per two weeks in the growth media 6.

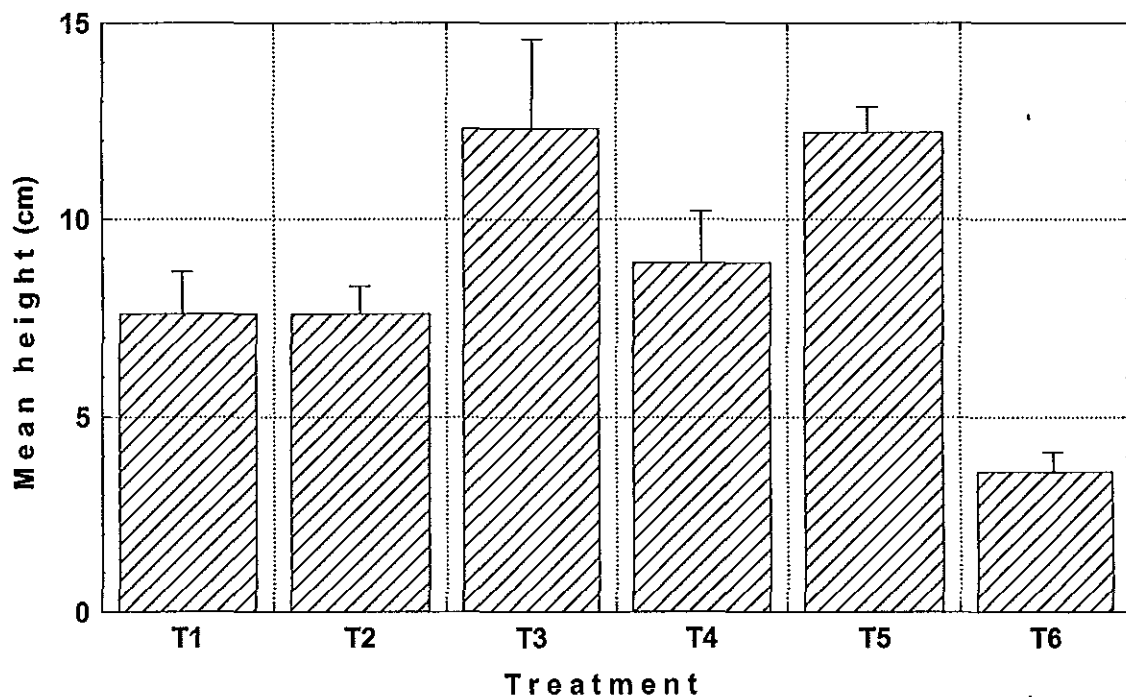


**Figure 6.** Change in relative (cm) shoot height of papaya seedlings over 15 weeks of growth under different compositions of propagation media at two weeks interval.  $n=15$ .

### 5.3. Growth Performance of Guava Seedlings

#### 5.3.1. Seedling Height

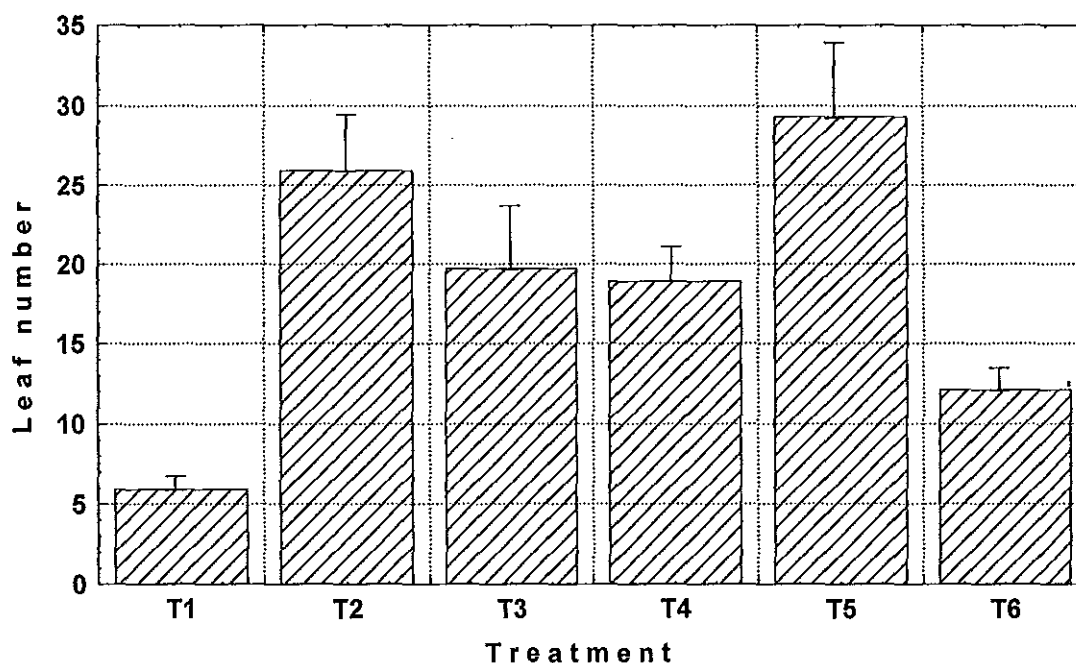
The different growth media did not influence the seedling height of guava. Though statistically not significant, treatment 3 had the largest seedling height (12.3 cm) and treatment 6 had the least seedling height (3.6 cm) (Fig. 7). However, there appeared to be a general trend for the growth of seedling to have a better growth performance with the presence of the mixture of the three components of the propagation medium used.



**Figure 7.** Height (cm) of guava seedlings (mean  $\pm$  SE) grown in different mixes of growth media in polyethylene bags. Treatments are as for Figure 1.

### 5.3.2. Number of Leaves

Similar to height the different growth media did not influence the number of leaves of guava seedlings. However, treatment 5 had the largest mean number of leaves (29.3 leaves per plant) and growth medium 1 had the least number of leaves per seedling (5.9 leaves). Qualitatively, there did seem to be a general trend for the growth of seedling to have a better growth performance with the presence of the mixture of the three components of the growth medium.



**Figure 8.** Number of fully expanded leaves of guava seedlings (mean  $\pm$  SE) grown in different mixes of growth media in polyethylene bags. Leaf counts made after 15 weeks of seedling growth in the nursery. Treatments are as for Figure 1.

### 5.3.3. Leaf Biomass

The different media types significantly ( $p < 0.05$ ) influenced the leaf fresh weight of the seedlings. Growth medium 5 with equal proportion of topsoil and sand gave a significantly higher leaf fresh weight than growth medium 1 (topsoil alone). In addition superior fresh leaf weight was observed growth medium 5 than growth medium 6 that contained equal proportion of topsoil and cattle manure; (Table 3). However, the different growth media did not affect the leaf dry weight significantly.

**Table 3.** Weights of fresh and dried leaf of guava seedling grown on different composition of propagation media. Treatments are as for Table 1.

Treatment	Fresh weight (g)	Dry weight (g)
T1	0.08 <sup>b</sup>	0.02
T2	0.42 <sup>a</sup>	0.14
T3	0.41 <sup>a</sup>	0.12
T4	0.43 <sup>a</sup>	0.17
T5	0.47 <sup>a</sup>	0.31
T6	0.11 <sup>b</sup>	0.03

Numbers with in the matrix are means of 15 replicates. Means within the same column with a different superscript letters are statistically ( $p < 0.05$ ) different from one another.

### 5.3.3. Relative Growth Rate in Plant Height

There was a clear difference in appearance of the seedlings grown in different growth media after 65 days of germination. Seedlings grown in the growth medium 3 had the greatest relative growth rate increase. This had a relative growth rate of 1.2, 1.54, 2.04, and 2.39 on the first, second, third, and fourth phase of growth measurement, respectively. On the other hand, growth medium 6 had the lowest relative growth rate on the first and fourth measurement periods, 0.66 and 1.24 cm per two weeks respectively, while growth medium 1 had the lowest on the second, third and fifth measurement periods, 0.85, 1.11, 1.98 cm per two weeks, respectively.

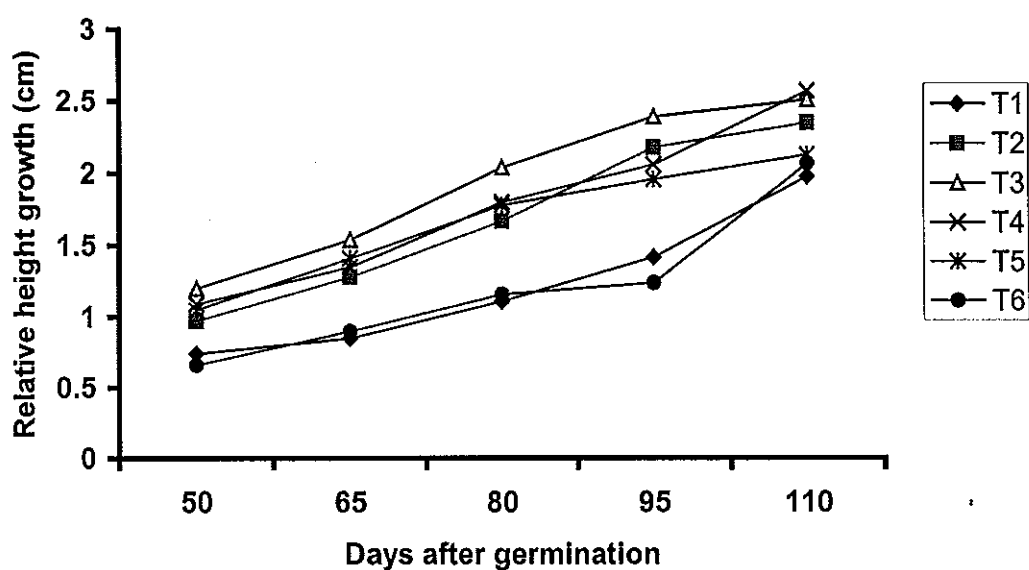


Figure 9. Change in relative (cm) shoot height of guava seedlings over 15 weeks of growth under different compositions of propagation media at two weeks interval.  $n=15$ .

## 6. DISCUSSION

### 6.1 Avocado

#### 6.1.1. Seedling Height

Soil media plays a very important role in the growth and development of various plant parts (Ahmad, *et al.*, 2002). Seedlings grown in different growth media studied did not differ significantly in height growth. The plant height was higher (27.41cm) in growth medium 2 containing the media components: topsoil, cattle manure and sand in the 3:1:1 ratio. Maximum plant height in this medium might have occurred due to the low leaching of nutrients and good structure which created optimum conditions for plant growth. Plants grown in this medium had also sufficient number of leaves per plant that might have enhanced photosynthetic activity supplied sufficient food for plant growth and had a deeper root system, which fully utilized the nutrients. Comparative result was reported by Chattopadhyay and Mohanta (1988) that growth medium containing equal proportion of cowdung and sand had best performance in shoot growth of tamarind [*Tamarindus indica*] seedlings followed by growth media containing cowdung alone. In addition, this result is in agreement with the findings of Singh and Sharma (1984) who concluded that seedling height of *Populus ciliata* increased when sand was added to media and found that the best growth occurred in sand containing topsoil. Minimum plant height (21.8 cm) was recorded in growth medium 6 with equal proportion of topsoil and cattle manure. A decrease in plant height in this growth medium implies the nutrient limitation experienced by the plant partly due to the fact that the possibility of movement of soil solution through the soil was low. Minimum plant height in this growth media also reflects the situation that relatively much water retention capacity of the medium caused saturation and media remained wetted that led to

suppression of root growth, which resulted in lower absorption of nutrients that ultimately caused to have less growth performance. This suggestion is in agreement with Kenzie and Wolstenholme (1990) that avocado seedlings are sensitive to poor aeration that require air-filled porosities growth medium. This was also confirmed by Johannes (2003) that root activity and nutrient uptake depend strongly on soil water contents. The shoot and root growth of avocado seedlings reduce when grown at a root temperature of 13°C (Whiley *et al.*, 1990). An experiment by Wilcox and Davies (1981) showed a decrease in root conductivity of citrus seedlings when root temperatures declined from 40°C to 10°C. Furthermore, low water supply to the shoot might have occurred from reduced root growth due to low root temperature associated with lower temperature of the growth season and high water holding capacity of the medium (Lopushinsky and Max, 1990). High water holding capacity of a growth medium is believed to reduce root temperature. Avocado seedling growth was stabilized between 90 and 120 days in the nursery to reach the required seedling height up to 25 cm (Edossa *et al.*, 2003). From this it can be suggested that seedlings grown in the different growth media were able to attain the required height within the stabilized growth duration.

### **6.1.2. Number of leaves**

Here, though mean differences in leaf number between treatments were less, there was difference in number of leaves per plant. Maximum number of leaves per plant (30.1) was recorded in the growth medium 4 containing equal proportion of topsoil, cattle manure and sand, followed by the medium with equal proportion of topsoil and sand with 29.1 leaves per plant. Maximum number of leaves in the growth medium 4 was due to maximum plant height, which ultimately resulted in maximum number of leaves per plant. An increase in plant height gives space (node) where a leaf

originates on the stem. The results of good performance in this medium are in line with the work of Ahmad *et al.* (1996) who reported maximum number of leaves per plant in a growth medium containing topsoil, sand and composted organic matter in *Ficus elastica* seedlings. Plants in this medium showed maximum number of leaves due to the availability of a suitable soil mixture and timely application of water. Minimum number of leaves per plant (25.9) was counted in growth medium 6 with equal ratio of topsoil and cattle manure. Growth is hampered by low nutrient supply more than photosynthesis per unit leaf mass (Poorter and Villar, 1997). Therefore, reduced number of leaves in this case may be associated to lower plant height and low movement of plant nutrients, resulting in the reduced plant growth and hence produced minimum number of leaves per plant. Low topsoil root activity can also be induced by lack of moisture that results in a lower uptake of topsoil nutrients under high evaporation (Johannes, 2003). A low nutrient availability decreases a plant's nutrient uptake per unit root mass and usually reduces its transpiration per unit leaf dry mass (Evans, 1996). Generally, when grown under near-optimal conditions, plant species show wide variation in their potential growth performance (Poorter, 1989). Thus, in this result the three fruit trees showed different growth performance on the different growth media. The relative difference in water retention capacity between the media brings difference in water uptake per unit root mass, and probably also a reduced nutrient uptake, as the delivery of nutrients by mass flow is hampered in soils with low water content. These factors are expected to happen differently in the different growth media used. At the same time, low water availability will decrease the rate of photosynthesis per unit leaf dry mass. In turn generally low accumulation of sugar in leaves could reduce the development of new leaves.

An increasing number of fruit nurseries and greenhouse growers use compost as a component in their potting soil blends as it provides the organic matter necessary to raise water-holding capacity, improve structure and reduce bulk density in potting. In addition, properly made compost has natural disease suppressive qualities and contains all essential nutrients, reducing the need to add trace elements to a potting mix (Garner and Chaudhri, 1994). Therefore, from this result it can be suggested that the use of manure compost seems reasonable to use to grow avocado seedlings in the nursery but in the presence of sand mixture so as to allow sufficient movement of air and nutrient. On the other hand, the extent of decomposition of the manure should be understood so that nutrients in the manure compost are readily released for the immediate use of the germinating seedlings through out their growth in the nursery as nutrient in partially decomposed manures take time to become available for the seedling. In addition the amount that has to be used as potting media also has to be under consideration.

Furthermore, the use of topsoil alone was not capable to give better performance of seedlings as when mixed either with sand or manure compost and sand. This suggestion was supported by David (2005) that pure field soils are unsuitable for container growing. Because in the small volume of containers, soil packs excessively and forms many small pores. Both of these factors decrease aeration (air movement and exchange) and drainage (water movement and exchange). The value of using some soil as a component of the growing medium is that it supplies many micronutrients and beneficial microorganisms. It appears thus that potting medium requires favorable texture. Soil texture is very important in that it affects soil structure, water holding capacity, nutrient holding capacity, aeration, drainage, and root penetration and growth. From the result obtained it is thus possible to suggest that the addition of sand in any proportion had played

a major role in adding bulk density and improving drainage though no adequate nutrient supply can be expected from sand.

### **6.1.3. Leaf Biomass**

Leaf fresh weight and dry weights of avocado seedlings were not significantly affected by growth media type (Table 1). This results on leaf fresh and dry weight only elucidated that growth medium 4 seem to top rest of the treatments. Leaf fresh and dry weight in this growth medium tended to be the highest (1.63g and 0.32 g respectively), while leaf fresh and dry weights in the growth medium 5 containing equal proportion of topsoil and sand were the second highest (1.52 g and 0.31 g respectively). The minimum leaf fresh and dry weights respectively (0.96g and 0.19g) were recorded in the growth media 6 containing an equal mixture of topsoil and cattle manure. The absence of significant difference between seedlings' leaf biomass may suggest that the seedlings at that developmental stage had developed enough absorption surfaces to take enough amounts of water and available nutrient. On the other hand, leaves must have been similarly effective to undertake the process of photosynthesis with the existing water and nutrient supply from the medium.

### **6.1.4. Relative Growth Rate in Plant Height**

At the initial growth stage, the plant height increase was relatively similar on all growth media up to fifty days; but after this time as the seedlings developed, the effect of different growth media was clearly seen. There was faster growth in plant height sixty days after planted seeds germinated. The relative growth rate was maximum on most of the measurement phases in plants grown in growth media that contained equal proportion of topsoil, cattle manure and sand (2.8, 3.01 and 3.07 cm per two weeks) in the second, third and fourth phases of seedling height

measurements respectively. The increase in the relative growth rate in seedling height was due to increase in surface area for absorption of nutrient and water and an increase in nutrient availability as a result of the slow release from cattle manure. However, this trend is not expected to keep on increasing due to limitation in nutrient supply of the potting medium. This situation reasonably suggests the importance of using larger medium containers for optimizing growth due to the contribution of a larger supply of nutrients and no restriction on root growth. Growth medium 6 containing equal proportion of topsoil and cattle manure provided the lowest relative growth rate throughout the five plant height measurement durations (2.42, 2.65, 2.77, 2.8, 2.91 per two weeks) respectively. This low growth rate suggested that that medium was not enough to supply the required amount of soil air for the metabolic activities of the root, which has a direct effect on the supply of water and available nutrients to the shoot part. The inconsistent response to growth media across the measurement periods provided evidence that environmental factors other than growth media controlled the growth and development of seedlings.

## **6.2. Papaya**

### **6.2.1. Seedling Height**

The different growth media did not affect the growth in height of papaya seedlings. However there was difference in the overall plant height. Therefore, maximum plant height (19.01 cm) was recorded in papaya seedlings grown in growth medium 3 that had topsoil, cattle manure and sand in 2:1:1 ratio. This observation might have occurred due to availability of nutrient and better aeration while, minimum plant height (5.01 cm) in growth medium 6 was observed in plants grown in a growth media containing equal proportion of topsoil and cattle manure. Roots grow in soil through large soil pores and by moving soil particles aside when the roots penetrate pores

that are smaller than the root tips. But when a soil is compacted most pore diameters are substantially smaller than the diameter of growing roots, a situation roots cannot exert enough pressure to overcome the mechanical resistance and move soil particles (Aubertin and Kardos, 1968). Thus, this low performance could have been associated with compaction of the medium that in turn caused low soil aeration and movement of available nutrients in to the root surface. This was confirmed by David (2005) that pure field soils are unsuitable for potted seedling as soil packs excessively and cause decrease in the movement and exchange of water and air. Wert and Thomas (1981) however reported that the effects of soil compaction on plant growth are a complex interaction between many soil and plant properties, but for many situations there appears to be an upper limit where resistance to root penetration is so high that plant root growth essentially stopped.

#### **6.2.2. Number of leaves**

The different growth media affected the number of leaves of papaya seedlings per plant significantly ( $p < 0.05$ ). Almost similar trend was observed for number of leaves per plant i.e. number of leaves increased with increase in plant height. Mean minimum number of leaves (9.2 per plant) were counted in the growth media containing equal proportion of topsoil and cattle manure, while, maximum number of leaves (24.7 leaves per plant) were counted in seedlings grown in growth media containing topsoil, cattle manure and sand in the ratio 2:1:1, which is also statistically different to those produced by the plants grown in the different growth media. The substantial growth response to the media containing topsoil, cattle manure and sand treatment suggested that the nutrient reserves were available to the seedlings with adequate aeration, which is in marked contrast to the topsoil and cattle manure mixture.

### **6.2.3. Leaf Biomass**

It is evident from the data that different soil media had high significant ( $P < 0.05$ ) effect on leaf dry weight but did not affect the leaf fresh weight (Table 2). Significantly maximum leaf dry weight (2.72 g) was recorded for seedlings grown in growth medium containing different proportion of topsoil, cattle manure and sand in 2:1:1 ratio. The minimum leaf dry weight (0.07g) was recorded in growth medium containing equal proportion of topsoil and cattle manure. Although not statistically different ( $p = 0.06$ ) there seem difference in the leaf fresh weight between treatments. The maximum fresh weight (2.72 g) was recorded in seedlings grown in growth medium 3, while the minimum (0.16g) being on medium 6. From this result, variation in dry weight between treatments presented suggested that leaves of papaya seedlings grown in different growth media had different capacity to undertake the process of photosynthesis and thereby accumulated photosynthets differently. The absence of significant differences among the different growth media on the leaf fresh weight also suggested the presence of enough water supplies to the root surface among different growth media. In addition it may show that at the time when leaf fresh weight was taken, root growth in the different growth media was at their status to absorb enough water and supply to the leaves. Environmental variables may cause negligible variability to dry weight values taken immediately after retrieving the samples from the drying oven, but might have affected fresh weight determinations. Therefore, these results indicate the need to give consideration to conditions under which leaf fresh weight is measured, because dry weight does not seem to be affected by the laboratory environment. Thus, dry weight should be considered as a very important parameter to determine effects of propagation medium on papaya seedlings.

#### **6.2.4. Relative Growth Rate in Plant Height**

Fifty days after germination, the different growth media did not show similar growth performance. However, as the growth progressed different growth performance appeared. Growth medium 3 had highest height growth rate through the five measurement periods (1.35, 2.05, 2.35, 2.53, 2.86 cm per two weeks). The increase in relative growth rate was due to increase in surface area for absorption of nutrient and water with advances in root growth with time. On the other hand, it may due to an increase in nutrient release from the cattle manure through time. This also suggested the importance of using larger medium containers for optimizing growth due to the contribution of a larger supply of nutrients and no restriction on root growth before seedlings should be transplanted in to their permanent field. This would be expected to make the papaya plants more durable when planted in the field and less prone to transplant shock. Growth medium 6 had the lowest relative growth rate throughout the five measurement periods, 0.64, 0.99, 1.33, 1.41, 1.56 cm per two weeks respectively. This low relative growth rate could be associated with reduced soil aeration since this medium is believed to have high water retention capacity compared to the other growth media. This situation affected root growth rate which is directly related to reduced nutrient and water absorption. Growth media 3 was able to support seedlings that attained the required height (20 cm) within 110 days after germination as was proposed (Nakasone and Paull, 1999).

## 6.3. Guava

### 6.3.1. Seedling Height

The different growth media did not significantly influence on the seedling height of guava. However, quantitatively there appeared differences in growth performance between treatments. Consequently, maximum plant height (12.3 cm) was recorded in guava seedlings grown in growth medium 3 that contained topsoil, cattle manure and sand in 2:1:1 ratio followed by growth medium 5 with equal mixture of topsoil and sand i.e. 12.2 cm. This situation might have occurred due to availability of nutrient and better aeration resulting from organic source composition in the medium influencing nutrients supplying capacity as proposed by Edossa *et al.* (2003). This may be suggested that the seedlings require adequate soil aeration from the presence of sand while at the same time available nutrients from the topsoil that may have contributed for the seedlings of guava to be metabolically more and requiring oxygen for respiration. In addition it may show how important increased levels of temperature are, because this medium was expected to have high drainage capacity that caused increase soil temperature. This suggestion is inline with previous information that the resistance of root growth into the soil is dependent on water content, bulk density, structure and strength of soil (Bradford, 1986). Cohesion between soil particles increases soil strength, which is greater in fine soil than coarse ones (Lebert and Horn, 1991). In contrast, minimum plant height (3.64 cm) in growth medium 6 was observed in plants grown in a growth media containing equal proportion of topsoil and cattle manure. The relatively low performance in this medium could have been associated with low soil aeration and low movement of available nutrients into the root surface. This suggestion was in accordance with David (2005) that pure field soils are unsuitable for container growing as soil packs

excessively and causes a decrease in air and water movement and exchange. This result may lead to the suggestion that sand mixing to potting media for guava seedling is necessary.

### **6.3.2. Number of leaves**

The type of media composition did not influence the number of leaves per plant in guava seedlings. The number of leaves per plant almost followed similar trend of increment with increase in seedling height. But this trend may not be conclusive because of development of lateral leaves. Although there was no significant variation among media types, there were clear indications of leaf number increment, as sand is included in the medium. Difference in the number of leaves per plant among the different growth medium was seen. Accordingly, maximum number of leaves (29.3 per plant) were found in treatment 5 a growth media containing equal proportion of topsoil and sand, while, minimum number of leaves (5.9 leaves per plant) were observed on seedlings grown in medium 1, growth media containing topsoil alone, followed by growth medium 6 containing equal proportion of topsoil and cattle manure. The growth response to the media containing topsoil and sand suggested that the nutrient reserves in the topsoil were enough to enhance better seedling growth in the presence of adequate soil aeration for better metabolic activities and also due to an increase in plant height.

### **6.3.3. Leaf Biomass**

It is evident from the data that the different soil media had a significant effect on leaf fresh weight ( $p < 0.05$ ) (Table 3). Maximum leaf fresh weight (0.47 g) was recorded for plants grown in growth media containing equal proportion of topsoil and sand. The minimum leaf fresh weight (0.08 g) was recorded in growth media containing equal proportion of topsoil alone. With guava

seedlings, the composition of the planting media however did not affect the leaf dry weight. But, there is a general indication that growth medium, which gave high value of leaf fresh weight, similarly gave high leaf dry weight. The maximum dry weight (0.31 g) was recorded in seedlings grown on treatment 5, while the minimum (0.02g) being on growth medium 1. The results presented give evidence of variation in the leaf physiological status that may be attributed to variation in the accumulation of dry matter. In this case the occurrence of significant differences among the different growth media on the leaf fresh weight suggests the presence of variation in water supply capacity to the root surface among different growth media. On the other hand, it may be suggested that there was difference in root growth in the different growth media due to penetration capacity and difference in media temperature. The temperature of growth media containing topsoil alone, expected to be with high water retention capacity might have been low enough to reduce root growth, which is directly related with amount and rate of water uptake by the root system. The absence of significant difference on the leaf dry matter may suggest that the seedlings' water requirement was enough to undertake the process of photosynthesis and accumulate photosynthates.

#### **6.3.4. Relative Growth Rate in Plant Height**

There was clear difference in the appearance of the seedlings grown in different growth media after 65 days of germination. Seedlings of treatment 3 had the greatest relative growth rate (1.2, 1.54, 2.04, and 2.39) from the first to fourth phase of height growth measurement respectively. On the other hand, treatment 6 had the lowest relative growth rate on the first and fourth measurement periods (0.66 and 1.24) respectively, while, treatment 1 had the lowest on the second, third and fifth measurement periods, and 0.85, 1.11, 1.98 cm per two weeks respectively.

Generally, there was an increase in relative growth rate in all the treatments with time, showing a slow release of nutrient and increase in root surface area for absorption of water and nutrient. Guava seedlings gave better growth performance generally in growth medium containing sand in all proportions as compared to the others not containing sand. This may show that the roots' penetration capacity of the guava seedlings is low as compared to papaya and avocado. It also suggested the high requirement of roots for oxygen and relatively raised temperature. However, guava seedlings did not attain the required seedling height with in the generally accepted growth duration in the nursery.

## 7. CONCLUSION AND RECOMMENDATION

In general this research work could contribute to the knowledge of seed propagation of avocado, papaya and guava using locally available soil sources. It could also provides information that these fruit crops could able to grow in the area, since these fruit crops are not commonly seen in the farmers' farm so far.

From this study, it can be concluded that, the three fruit crops require almost similar growth media, that they gave better growth performance on a medium that contained sand showing the need for better soil aeration and raised temperature in the nursery. At the initial growth stage, the mean shoot height was almost similar in all growth media mixes in all seedling types. But with time, differences in plant height started to be clearly seen showing the importance of using larger medium polyethylene bags for optimizing growth. On the other hand, the relative growth difference that occurred in the different growth media was due to difference in a vailability of oxygen, water-holding capacity, temperature and nutrient supply capacity of the growth media. The use of potting media differed among avocado, papaya and guava may owe to genetic difference between the species. However avocado gave better seedling performance in almost all mixes of topsoil, cattle manure and sand. Papaya seedlings grown in 2:1:1 proportion of the three media components, while guava in an equal proportion of topsoil and sand gave better performing seedlings. But guava did not attain the required seedling height with in the generally accepted growth duration in the nursery. However, differences in benefits to better growth performance in the field associated with the use of different nursery potting media were not strongly conclusive in this experiment though no negative effects were detected.

From this it can be recommended:

- ❖ In the presence of sand the use of topsoil and or cattle manure is appropriate for nursery potting media to raise avocado papaya and guava seedlings.
- ❖ Avocado, papaya and guava could be grown around the vicinity of Tulu-Korma.
- ❖ A long-term research should be undertaken to investigate on their further growth performance in the field up to yield.

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## APPENDICES

Appendix 1. One-way analysis of variance (ANOVA) for testing differences in the seedling height, leaf number and leaf biomass of avocado plant (treatment is fixed, n=15).

Variable	Source	DF	SS	MS	F	P
Plant height	Treatment	5	74.71	14.94	1.26	0.34
	Error	12	141.63	11.80		
	Total	17	216.34			
-----						
Number of leaves	Treatment	5	45.40	9.08	0.93	0.49
	Error	12	117.09	9.75		
	Total	17	162.49			
-----						
Leaf fresh weight	Treatment	5	0.985	0.197	2.90	0.061
	Error	12	0.816	0.068		
	Total	17	1.801			
-----						
Leaf dry weight	Treatment	5	0.038	0.007	2.89	0.061
	Error	12	0.032	0.002		
	Total	17	0.070			

Not significant at  $p < 0.05$ .

Appendix 2. One-way analysis of variance (ANOVA) for testing differences in the seedling height, leaf number and leaf biomass of papaya plant (treatment is fixed, n=15).

Variable	Source	DF	SS	MS	F	P
Plant height	Treatment	5	450.22	90.04	2.71	0.72
	Error	12	397.43	33.12		
	Total	17	847.65			
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Number of leaves	Treatment	5	584.45	116.89	7.25	0.002*
	Error	12	193.22	16.10		
	Total	17	777.68			
-----						
Leaf Fresh weight	Treatment	5	14.213	2.843	2.86	0.063
	Error	12	11.936	0.995		
	Total	17	26.149			
-----						
Leaf dry weight	Treatment	5	1.2107	0.2421	7.42	0.002*
	Error	12	0.3916	0.0326		
	Total	17	1.6023			

\* = Significant at  $p < 0.05$

Appendix 3. One-way ANOVA for testing differences in the seedling height, leaf number and leaf biomass of guava plant (treatment is fixed, n=15).

Variables	Source	DF	SS	MS	F	P
Plant height	Treatment	5	160.13	32.02	1.38	0.29
	Error	12	277.93	23.16		
	Total	17	438.07			
-----						
Number of leaves	Treatment	5	1118.39	223.68	1.99	0.15
	Error	12	1344.48	112.04		
	Total	17	2462.87			
-----						
Fresh weight	Treatment	5	0.4610	0.0922	4.27	0.018*
	Error	12	0.2589	0.0216		
	Total	17	0.7200			
-----						
Dry weight	Treatment	5	0.1699	0.0340	1.87	0.173
	Error	12	0.2177	0.0181		
	Total	17	0.3876			

\*= Significant at  $p < 0.05$

Appendix 4. Physical and chemical properties of individual media components

Properties	Component	
	Topsoil	Cattle manure
pH (H <sub>2</sub> O), 1:2:5	6.5	6.9
EC (ds/m)	0.146	-
Texture class	Clay	-
Na (meq/100g)	0.06	-
K (meq/100g)	1.80	-
Ca (meq/100g)	21.46	-
Mg (meq/100g)	14.57	-
CEC (meq/100g)	56.2	-
BS (%)	67.0	-
TN. (%)	0.172	1.647
OC%	2.554	-
C: N	15	-
Available P (ppm)	2.16	157.00
Available K (ppm)	720	3329.00

Key: TN= Total nitrogen, OC= Organic carbon= , C:N =Carbon to nitrogen ratio