EVALUATION OF COMPOSTED TEA (*melaleuca alternifolia)* TREE AND SAND MEDIA MIXES IN TOBACCO *(nicotiana tabucum* l*)* SEEDLING PRODUCTION

By

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DECLARATION

I, Noel Chimwanda hereby declare that this dissertation represents my own work and that it has not been submitted for a degree at this University or any other University.

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ABSTRACT

Zimbabwe is preparing itself for 2015 dead line for the elimination of methyl bromide through adoption of floating tray system, metham sodium, basamid and other related tobacco nursery chemicals. In an effort to complement this government initiative to fulfil Montreal protocol, a research was carried out at Kushinga Phikelela National Farmer Training College, in Marondera during the 2014-2015 tobacco farming season with intention to evaluate the effect of an on farm composted tea tree and sand media mixes on performance of tobacco (*Nicotiana tabucum*) seedlings in a float bed system. This was being compared to the traditional pine bark media (control). A completely randomized design (CRD) with six treatments and three replications was used. The treatments were; 100% Pine bark, 100% Tea tree substrate, and tea tree growing mixes of 80:20, 70:30, 60:40 and 50:50 of composted tea tree to sand respectively. Composted tea tree was taken for full chemistry analysis before mixing with sand at Zimlab, Harare Zimbabwe. Results showed that composted tea tree substrate had a pH of 6.4. The sample results also showed presence of nitrogen 5.62 ppm, phosphorous (P_2O_5) 207.16, potassium 4.20 (% of CEC)/ppm and total exchangeable bases at 35.99 CEC. During the experiment, the following parameters were measured; seed emergence percentage, seedling height, stems thickness, spiral root development and leaf number. In was concluded that the treatments 70:30, 80:20 and 100% composted tea tree and sand media mixes were not significantly different to pine bark statistically on emergence percentage, stem height, spiral roots, and leaf numbers. A high fall out percentage of media from trays was experienced in 50:50 and 60:40 composted tea tree and sand media. 100% Pine bark recorded significantly ($P<0.05$) highest emergence percentage. There was no significance ($P<0.05$) difference on all other parameters between pine bark and 70:30, 80:20 and 100% composted tea tree and sand media mixes. There was no statistical difference between 50:50 and 60:40 composted tea tree and sand media mixes on emergence percentage, spiral root development, stem height, stem thickness, and leaf numbers; and these two recorded least results on all parameters. It was recommended that tobacco seedling production may be done using tea tree substrate at treatments 70:30, 80:20 and 100% composted tea tree and sand media mixes as alternative growing media to pine bark and may be economic if used at 70:30 composted tea tree and sand media mix.

DEDICATION

This research work is dedicated to all who contributed to my life, from my parents, teachers, work mates, Midlands State University Natural Resources Management and Agriculture, farmers in Marondera as well as to my wife Kudakwashe.

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ABBREVIATIONS

FAO	Food Agricultural Organization
TRB	Tobacco Research Board
TIMB	Tobacco Industrial Marketing Board
ZTA	Zimbabwe Tobacco Association

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CHAPTER 1

1.0 Introduction

Tobacco is the highest revenue earning crop of Zimbabwe, known to contribute about 10% of national revenue on its own (Zimbabwe Tobacco Association report 2014). In 2013 alone, it contributed more than $612 million through sale of tobacco leaf (TIMB, 2014). According to FAO, (2001), about 760 000 individuals were said to depend on tobacco. This includes families and those involved in various areas of the industry. However, there are environmental hazards associated with the crop that have lead to alternative nursery production systems that seek to eliminate methyl bromide use in tobacco seedling production. According to Flower, (2002), methyl bromide is an ozone layer depleting substance that need immediate attention

According to Mazarura, (2004) and Tobacco Research Board's, (TRB) tobacco handbook, (2002), there are two nursery production systems being used in Zimbabwe. These are conventional and the floating tray system, of which the later has been adopted as a result of the Montreal Protocol developed by United Nations Environmental Programme (UNEP) in 1987, in order to address the environmental challenges associated with ozone layer damage from methyl bromide. To fulfil the protocol obligations, developing countries like Zimbabwe are expected to phase out the use of methyl bromide by 2015 (Flower, et al, 2002; Mazarura, 2004). . It is because the chemical has been noted to damage the ozone layer through release of chlorocarborns. The use of methyl bromide is being replaced is replaced by adoption of floating tray system in tobacco seedling production. The float tray system requires use of artificial and organic growing media that are said to be beyond reach of farmers. Information at hand showed many trials and research work in trying to identify a suitable growing media for the floating tray system, of which pine bark was concluded as the best growing media to date (Flower, et al, 2002). This culture of using pine bark has become dominant feature of tobacco nursery production since June 2002 (Flower, et al, 2002; Mazarura, 2004). The success of floating tray system is hinged on finding a sustainable and cheap growing media.

Masaka, et al, (2007) confirmed the success of pine bark as the best media. Pine bark growing media has been of less challenge in terms of supply due to the existence of vast forests of pine trees in eastern highlands of Zimbabwe. However the destruction of pine tree forests by veld fires and local dwellers brought a major blow to constant supply of pine bark substrate. The price of pine bark started to rise upwards beyond farmers,' reach, leading other farmers to backtrack to conventional system of using methyl bromide in seed beds.

Alternatively, undocumented composted tea tree herb, (*Melaleuca alternifolia)* is a potential growing media for tobacco seedling production. The tea tree herb that looks like pine tree, is mainly grown for extraction of tea tree oil that is extracted by distillation process. Then twigs and leaves are left to compost before applied to the fields as organic matter.

1.1 Justification of the problem

There is a need to find a low cost alternative growing media for floating tray system if abolition of methyl bromide by 2015 is to be met, otherwise farmers will not adopt the floating tray system. This can only be done by researchers as farmers are generally not patient to involve themselves in research works. Tobacco and other crops that need to be raised under nursery are generally known to be of high value such that success of this composited growing media evaluation research will promote success of production of tobacco.

The hips of tea tree oil compost produced annually may be an alternative source of sort substrate as well as another source of revenue for the tea tree farmer. In line with The Montreal Protocol of

1987, conservation or protection of environment will be taken care of as farmers remain using floating tray system and reduce deforestation.

1.2 Main Objectives

1.2.1 To evaluate performance of the composited tea tree and sand media mixes in tobacco seedling production.

1.3 Specific Objectives

1.3.1 To determine the effect of tea tree and sand media mixes on emergence percentage of tobacco seedlings.

1.3.2 To evaluate the effect of composited tea tree and sand media mixes on seedling height

1.3.3 To evaluate the effect of composited tea tree and sand media mixes on tobacco seedling thickness

1.3.4 To establish the degree of occurrence of spiral root development in composted tea tree and sand media mixes

1.3.5 To determine the effect of tea and sand media mix on number of leaves to be attained by tobacco seedlings within period of assessment.

1.4.0 Hypothesis

1.4.1 There is significant difference in tea tree and sand media mix on seedling emergence percentage.

1.4.2 There is significant difference in tea tree and sand media mix on height

1.4.3 There is significant difference in tea tree and sand media mixes on seedling thickness

1.4.4 There is significant difference in tea tree and sand mix on seedling root growth pattern.

1.4.5 There is significant difference in tea tree and sand media mixes on number of leaves attained by seedlings.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Economic importance of tobacco

Tobacco is the major cash crop of Zimbabwe. It is grown for its leaves of which most of the crop is exported with little processed into cigarettes for local consumption (Food Agricultural Organization (FAO), 2001). Tobacco is the major source of income or revenue for the Zimbabwean economy (Zimbabwe Tobacco Association (ZTA), 2013). The crop support large scale commercial (LSC) and Small scale commercial (SCL) farms and smallholder farmers as most of their farm systems are said to evolve around the crop, especially in the northern districts of Zimbabwe. It has high profit returns than most crop enterprises like cotton and maize, such that even small growers joined production of the crop. It generates employment for many Zimbabweans as it is believed to support more than 250000 work forces. According to Food Agricultural Organization (FAO) (2001), the crop is said to contribute more than 50% of agricultural exports on year basis, which is 30% of exports and 10% of Gross domestic product (GDP). This range from those directly employed in tobacco farms, research works, companies and families involved in tobacco production. This information supports the fact that Zimbabwe has become the fourth largest producer of tobacco leaf in the world and largest producer in Africa, a situation analysts comment to be reviewed as tobacco may face challenges from World Health Organization (WHO). Government is encouraged to strengthen growth of other enterprises under horticulture, other field crops, as well as industries, mining and tourism. Beside cigar, the cured tobacco is smoked as pipe, cigarette or hookah and as traditional snuff or chewed. In other nations it is used in liquid form (Ahlawat, 2004). Tobacco seed is said to contain 35-38% nicotine free oil that is being used in other countries like India to make soap and colours. The other by product is cake used as cattle feed. Cake contains 3% N, 20 –

27% carbohydrates, and30-35% crude protein (Ahlawat, 2004). Same author mention other plant species as ornamental plants.

2.2.0 Float tray system of tobacco seedling production

It is a non-soil technique that uses artificial or organic growing media for tobacco seedling production, which is done using trays moulded from expanded polystyrene (Flower, *et al*., 2002). The term “floating tray” originates from the fact that about 98% of these moulded expanded polystyrene trays are composed of air with only the remaining part, 2% is polystyrene. This allows the tray to float if placed in water pond or water bed (Mazarura, 2004). The trays are made at Kutsaga Tobacco Research Board (TRB). The tray dimension are 670mm in length, are 345mm wide and 60mm deep. The Zimbabwean tray types have 200, 242 and 300 cells, which are the recommended designs though one can get trays in different tray cell sizes (Mazarura, 2004). The economic sense of the trays is witnessed when one uses trays with more cell numbers. However the high cell numbers the higher the quality management is required (Flower, *et al*., 2002). It has been observed that 75% of seedlings from the trays are transplantable in Zimbabwe and researchers are encouraged to come with an improved system to increase the percentage of transplantable seedlings (Flower, *et al*., 2002). The Zimbabwean tobacco floating tray system uses pine bark substrate as a growing media. The use of this growing media eliminates the need for methyl bromide for fumigation through use of artificial media and polystyrene trays (Mazarura, 2004).

2.3.0 Media used in float tray system

The use of pine bark substrate in Zimbabwe is the dominant future, but other materials are present and more are still under research (Mazarura, 2004; Flower, *et al*., 2002). According to Smith, et al., (2003), and Douglass, *et al*., (2009), peat moss, vermiculite, perlite and hypnum are other primary media that are used in floating bed tray system, but known to be expensive for areas like Zimbabwe due to transport and absence from local environment. These are used mostly in combination of either two or more, but it is possible to use one type if measures are taken. Mixing of peat moss, vermiculite and perlite is done to come out with suitable particle size distribution desired for transplant production. Particle size distribution of medium is important for determination of characteristics like water holding capacity, drainage, aeration and capillarity (wicking) (Smith, *et al*., 2003). Peat moss has become the most component of artificial growing media, which is known to have a very good water-holding capacity due to leaves which have open spores, also high CEC, low nutrient levels, and a comparatively low pH, often ranging from 3 to 4.5 (Douglass, *et al*., 2009).

Vermiculite is a hydrated aluminium-iron-magnesium silicate material that has an accordion-like structure, mainly desired for its very low bulk density and extremely high water - holding capacity, approximately five times its weight characteristic. This material also has a neutral pH, a high CEC, and contains small amounts of potassium and magnesium (Landis, *et al*., 2010). Perlite is a siliceous material of volcanic origin. It is important for preparation media, especially where well drained and lightweight growing media is needed to be formulated. This occurs because perlite particles have a unique closed-cell structure so that water adheres only to their surface; they do not absorb water as peat moss or vermiculite do. Douglass, *et al*., (2009) say the media has a general good porosity characteristic.

2.4.0 Characteristics of an ideal growing media

A growing media have two major characters, which are physical and chemical properties (Douglas, *et al.*, 2009) . Also an ideal growing media is there to provide a supportive role to plants (anchorage role) and facilitate occurrence of chemical reactions without itself interacting with the process or having little interaction. According to Smith, (2003), an ideal growing media should have a good physical and proper chemical properties that favours seed germination, seedling growth and development, facilitate smooth nutrient uptake and allows water and air movement. Also it is important to take note of the positive and negative characteristics of the various components and how they will affect plant growth when one makes own growth media.

2.4.1.0 Physical Properties

2.4.1.1 Water-Holding Capacity

In evaluation of a growing media, water holding capacity is of paramount importance as it has a bearing on germination of seedlings, watering frequency and long term planting (Percy, 1997; Masaka, 2007). Microspores are important for absorption of water and holding it against the pull of gravity, which makes it available to plants. According to Hartmann and Kesters (2007), a good growing medium will have a high water-holding capacity but will also contain enough macrospores to allow excess water to drain away and prevent water logging. In pine bark based medium, only 50% of water is said to be available to plant while the other 50% is not (Van Schoor *et al*., 1990) There are factors that affect media spores which lead to poor water-holding capacity, which are degree of compaction and ratio of coarse particle to coarse particle of medium (Percy, 1997). Compaction occurs as a result of particle damage that sometimes is experienced during growing media mixing or due to compaction during tray or container filling (Robinson, 2000). Therefore precaution is to be taken when filling containers and trays.

2.4.1.2 Aeration

The other characteristic of a good growing medium is ability to provide aeration condition, which is important for good healthy roots (Spiers, 2005). It is known as aeration porosity, which is percentage of air filled macrospores that are left after drainage of excess water. Van Schoor *et al*., (1990) advise producers of growing media or those who make own growing media to mix small particle based media with large particles for improvement of aeration. Just like in water – holding capacity discussion above, aeration depends on percentage of macrospores, the higher the percentage the more oxygen supply is attained, hence larger macrospores are important (Percy, 1997). These macrospores promote carbon dioxide from root respiration to dissipate (Percy, 1997). Aeration is linked to porosity. Porosity is one of the most important physical characteristic of a media. Total porosity is known to be the sum of the space in the macrospores and microspores or simply sum of air filled porosity and water holding capacity (Smith and Mullins, 1999). It is generally attained through use of a material that contains a mixture of components with different particle sizes and characteristics. This promotes aeration and balance in solid, liquid and gaseous state of a media. An example this is peat moss and vermiculite. If one decides to use a single component medium, particle sizes should range from 0.8 to 6 mm (Swanson, 1989).

2.4.2.0 Chemical Properties

2.4.2.1 Fertility

Fertility is the most important chemical property, especially in tobacco seedling production where nitrogen content matters most (Masaka, *et al*., 2007). A good growing media should exhibit inherently low fertility characteristic, for example peat vermiculite (Landis, *et al*., 2010) This is important because generally plants at seedling stage just grow better under low fertilization; in addition, beneficial microorganisms, such as mycorrhizal fungi, sometimes require low fertility to become established on plant roots (Douglass, *et al*., 2009; Gordon, 2004). The growing medium should not interact with fertilizers. It should be well decomposed and stable (preferably with 20:1 CN ratio) (Gartner, *et al*., 2001)

2.4.2.2 pH

It is a measure of its relative acidity or alkalinity of a growing medium (Douglass, *et al*., 2009; Landis, *et al.,* 2010). The most preferred pH for native plants is between 5.5 and 6.5, although some species are more pH tolerant (Gartner, *et al*., 2001) Its effect on plant growth is its control on nutrient availability, for example, phosphorus availability drops at extreme pH values because it binds with iron and aluminium at low pH levels and with calcium at high pH levels. It was also observed that the availability of micronutrients, such as iron, is even more affected by pH, for example high pH result in iron chlorosis. pH is said to be the key to availability or absence of pathogens and beneficial microorganisms, for example, low pH can predispose young plants to damping-off fungi (Landis, *et al* 2010).

2.4.2.3 Cation Exchange Capacity

It is the ability of a growing medium to hold positively charged ions like K^{+}, Mg^{2+} chemically (Landis, *et al*., 2010; Puustjarvi and Robertson, 1975). A good growing medium should have ability to hold positively charged ions like those indicated above to able to supply nutrients and prevent leaching. CEC of a growing medium reflects its nutrient storage capacity, it provides an indication of how often fertilization will be required (Gordon, 2004). Generally nurseries prefer a growing medium with a very high CEC that stands high rates of irrigation that is associated with nutrients leaching (Landis, *et al*., 2010; Wightman, 1999). Growing medium should not adsorb cations so strongly like soils that contain clay, which always result in cations being unavailable for plant uptake, while the very low CEC of sandy soils causes most nutrients to be lost by leaching (Robinison, 2000;Whitcomb, 2003).

2.4.2.4 Shrinking and Swelling

This occurs differently in some soil-based media and in artificial growing media with the later has no such problems. It is the soil-based media especially those containing clays, shrink when drying or swell when wet (Landis, 2010; Schundler Company, 2002) .

2.4.2.5 Bulk Density

Bulk density simply refers to weight per volume. A good growing medium must have enough weight to provide physical support (Allison *et al*, 1998). There is a general acceptable bulk density that is known to support plantlets at nursery stage. In the case of Pine bark, it is known to have low wet bulk density of 608g per cubic decimetre rather than 640g -1200g per cubic decimetre required to support plants (Allison 2000). For a given container type and growing medium, excessive bulk density is a measure of compaction. According to Douglas, *et al* (2009), Bulk density and porosity are said to be inversely related; when bulk density increases, porosity decreases. Even a very porous growing medium can be ruined if it is compressed when the containers are filled, hence to avoid this when filling floating trays no compression is encouraged. One is encouraged to fill the tray raise it to 20cm above ground twice and allow free fall, Muzarura, (2004).

2.5.0 Biological Properties

Artificial growing media are generally pest free. An exception is peat moss which is not technically sterile (Landis, et al., 2010). Though it is not technically sterile, it should not contain pathogens or weed seeds when obtained from reliable sources (Douglass, *et al.*, 2009; Martin and Gershuny, 1992).

For soil media, pasteurization with heat or sterilization with chemicals before use is encouraged, whereas for composts, there must be well-prepared to eliminate pests through generated high temperatures during composting that also kill most of pathogens (Wilson, *et al*., 2004). Composting is also beneficial as beneficial microorganisms increase in the final stages of the process. According to Castillo, (2004), composted pine bark, for example, contains microbes that suppress common fungal pathogens and nematodes. However, suppressive action depends on the parent material and composting time.

2.6.0 Growing Medium

Homemade medium are formulated as a result of poor availability of commercial media, price, shipping or transport costs, lack of adequate storage, or simple preference. It may involve use of traditional media, which is soil.

2.61. Understanding soil as a growing media

The soil is composed of solids, liquids and gases. Figure 2.1 shows a general representation of soil media or summary on a pie chart.

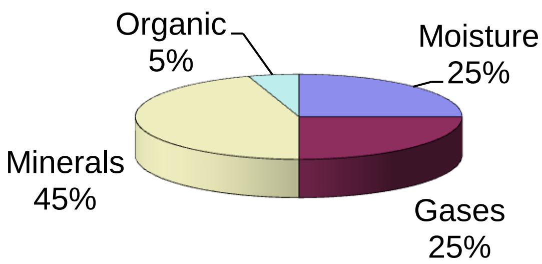

FIGURE 2.1 A general representation of soil media

Solids are either organic or inorganic components. Inorganic part consists of the residue from parent rock after decomposition resulting from chemical and physical weathering. The organic portion of the soil consists of both living and dead organisms that decay forming humus. The liquid portion of the soil solution is made up of water containing dissolved salts in various quantities. Gaseous portion is important to plant through gaseous exchange, thus depriving the roots of air hampers respiration. The relative portions of clay, silt and sand affect the texture of a mineral soil. Sand ranges from 0.05-2mm, silt from 0.05 to 0.002mm and clay is below 0.002mm. Soil-based media are considered to be more natural or organic (Landis, *et al*., 2010). However soil-based media have challenges which begin with natural variability and ecological sustainability. This makes it difficult to maintain the same quality from container to container or crop to crop and sustain environment especially where harvesting topsoil is actually a mining operation that uses up a limited resource that took thousands of years to develop respectively. It requires sterilization before use (Johnson, 2001). Soil can safely be used as a media through incorporating a small amount (10 to 20 percent) of it into the mix when transplanting into larger containers (Landis, *et al.*, 2010). Advantages of soil media are that it contains desirable microorganisms needed for the medium and adds weight for greater stability; however, the most topsoil contains weed seeds that will germinate quickly in the ideal growing environment of a nursery (Douglass, et al., 2009). This may require sterilization or pasteurization as mentioned above. When selecting soil, use dark topsoil that has a high percentage of organic matter; and lighter sandy loams are better than heavy clays (Lu 2005).

2.6.2 Sand

It is the oldest and most traditional media that is now used as a component in the first artificial growing media but is almost being abandoned for its weight (Gordon 2004). If one is to use sand, siliceous sands are encouraged than those derived from calcareous sources such as coral can have dangerously high pH values (Landis, *et al.*, 2010).

2.6.3 Pine bark as growing medium

As per discussion above peat mixes is a worldwide acceptable growing media, but its unavailability in areas like South Africa (SA) lead to a research on possibility of using pine bark as an alternate substrate (Smith, n.d). It is made from *Pinus patula*, *Pinus. elliota* and *Pinus. taeda* as by product of the paper and pulp industry in SA (Sinsamut, 1999). Drums and ring debarkers are used to remove it for composting, which reduces toxic tannin levels and adjust carbon to nitrogen ratios also. Urea (nitrogen source), lime (pH regulator) and along with water are added. A suitable stack size is made for easy regular turning. According to Lawrence, 2010 temperature is allowed to rise to 70^{o}C. It will be hammer milled to facilitate quick compositing and attainment of proper particle size for seedling. It is encouraged to add trace elements and phosphorous as pre-plant fertilizer as the material is very poor in nutrient status (Gartner, 2010). In order to reduce plantlets damage from pine bark media, one need to decompose the media for 10-14weeks as this reduce phenol levels, insects and pathogen levels as well as resins, terpenes and tannins. Wetting agents are of advantage if added as there to improve water-holding capacity of the growing medium, but this is not necessary for floating bed system (Hartman and Kesters, 2007). Pine bark is known to have low wet bulk density of 608g per cubic decimetre rather than 640g -1200g per cubic decimetre required to support plants (Allison 2000). The challenge with the media is its high C: N ratio which is known to be 300:1(Nelson, 1998). This is generally considered to be of less important as the material releases nitrogen slowly.

2.6.4 Making Compost

Organic compost is preferred than soils as it has less risk and is used as “green” alternative to peat moss. Composts are an excellent sustainable organic component for any growing medium. It significantly enhances the medium’s physical and chemical characteristics as it improves water retention, aeration porosity, and fertility. Some compost has also been found to suppress seed borne and soil borne pathogens (Castillo, 2004). Good compost takes several months to create. It requires proper mix of organic materials and creating the ideal environment for the microorganisms that decompose the materials. It involves frequent mixing to foster good aeration. Long thermometers are required to monitor temperature curve due to a succession of different microorganisms, which occurs during the process. Composts allows use of locally available resources like grass, leaves, fruit wastes, coffee shells, rice hulls, wood waste such as sawdust or bark, sugar cane, manure, and even chicken feathers. Also organic nursery wastes, such as used growing media or cull seedlings, can be composted, which reduces the costs and hassle of their disposal. However, making good compost is a rather technical process that takes some practice to learn (Martin and Gershuny, 1992; Wightman, 1999; and Castillo 2004).

Composting is a natural process in which a succession of insects, fungi, and bacteria decompose organic matter and change its composition. The purpose of composting is to accelerate and control this process by modifying environmental conditions, especially moisture and temperature. Other factors that can be controlled include carbon-to-nitrogen ratio (C: N), aeration, and particle size (Landis, *et al.,* 2010). Finished composts should have a C: N of about 30:1. Materials such as sawdust have much higher C: N that slows the composting process unless nitrogen fertilizer is added. When choosing materials for composting, maintain a mixture of 25 to 50 percent green organic matter and 50 to 75 percent brown organic matter. Green organic materials (fresh grass and fruit wastes) have a higher proportion of nitrogen compared with brown materials (tree leaves or sawdust), which contain more carbon. The particle size of your organics is very important. Particles that are too large reduce the surface area available for microbial attack whereas particles that are too small become compacted and create anaerobic conditions. A mixture of particles in the 0.5-to-2 in (1.2-to-5 cm) range works best. Maintaining adequate aeration and moisture is an important, yet often overlooked, factors. Microorganisms need an adequate and continual supply of oxygen and moisture, so it is important to turn over your compost pile once or twice a week in order to hasten the process. Moisture content of approximately 50 to 60 percent is ideal. It has the feel of a damp sponge on feeling.

2.7.0 Determination of compost maturity status

According to the article from an Anonymous, (2004), signs of mature compost are invisibility of original components. This is followed by increase in earthworm populations and other soil insects. If one does handy feeling, it feels crumbly. These procedures should also be used when purchasing commercial composts (Landis, *et al.,* 2010). The following techniques may be used to determine compost maturity;

2.7.1 Sniff-and-Feel Test

A small sample of compost may be collected and sealed in a plastic bag for a day. An immature compost will feel hot or smells like manure or ammonia. If this is experienced, one is discouraged to use such compost since it may interact with chemical reactions during seedling production (Wilson, et al., 2004; Martin and Gershuny, 1992; Landis, *et al*., 2010).

2.7.2 Germination Test

The method involves sowing seeds of a rapidly growing plant such as radish or lettuce on compost. The sample may be placed by the window or in the greenhouse assess germination. Mature compost allows the seeds to germinate and grow normally within a week or so (Douglass, *et al.*, 2009; Wilson, *et al*., 2004)

2.7.3 Use of commercial test kits

Last but not least, commercial test kits, such as the Solvita® can be used (Landis, *et al*, 2010). It involves use of a calorimetric process to measure the carbon dioxide and ammonium levels in a sample of compost. According to Douglass, *et al.* (2009), the level of these two factors correlates well with compost maturity.

2.8.0 Sterilization of Growing Media

Generally some commercial growing media are pasteurized to kill pathogens. For nurseries making their own media, pasteurization with steam or solar heat is applicable technique. It is simple, effective. Heat pasteurization is the most common way that involves use of steam. It is recommended to heat the growing medium to 140 to 177 °F (60 to 80 °C) for at least 30 minutes. But for commercial purpose, pasteurization is done with large, expensive equipment. For small scale a certain technique was developed. The technique involves enclosing small batches of media in black plastic tarps on an inclined table to expose it to maximum sunlight. Long-stemmed thermometers should be used to make sure that temperatures stay in the recommended range for the proper amount of time. There is portable equipment for such technique that suit small scale growing media producers (Douglass, *et al*., 2009; Thomas, n.d). However media sterilization is the most ideal technique. Sterilization refers to the complete elimination of all living organisms in the medium; pasteurization is less drastic. Completely sterile growing media may not be particularly desirable because many beneficial microorganisms, including bacteria, actinomycetes, and fungi, normally found in growing media can actually be antagonistic to pathogens (Douglass, *et al*., 2009)

2.9.0 Mixing Growing Media

The mixing process is critical to producing custom growing media; the quality of the best components is compromised if the growing medium is improperly mixed. Whitcomb (2003) emphasized that improper mixing is one of the major causes of variation in container plant quality. The proper operating procedures are just as important as purchasing the right type of mixing equipment. Mixing should be performed by diligent and experienced personnel for production of quality growing media. Commercial growing media companies use special paddle-and-belt mixers used to the best job of thoroughly mixing components without breaking down their structure, but most small native plant nurseries do it manually by preparing small batches of growing medium by hand (Douglass, *et al*., 2009). Up to 5 or 6 cubic ft (0.15 cubic m or 155 L) of a medium can be mixed on a clean, hard surface by workers with hand shovels. One should be careful to screen soil or compost to remove sticks and break up large clods. For nurseries that require larger quantities of growing media on a regular basis should purchase a mixer. A cement mixer is often used and works well as long as care is taken to avoid excessive mixing ("over mixing"), which breaks down the size and texture of components. Fragile materials such as vermiculite and peat moss are particularly vulnerable to over mixing (Douglass, *et al*., 2009; Landis, et al., 2010).

CHAPTER 3

3.0 Materials and Methods

3.1 Description of the site

The experiment was carried out at Kushinga Phikelela National Farmer Training College demonstration Block, in Marondera. It is located 90km South East of Harare along Mutare road. Latitude is 18^0 11^1S and longitude is 31^0 30^1E and is elevated at an altitude of 1200m above sea level. The site is in Agro-Ecological Region 11b which receives mean annual rainfall of 750-1000mm. The mean annual temperature ranges from 15-20^oc.

3.2 Experimental design and Treatments:

The experiment was laid in Complete Randomized Design with three replicates and a plot size of three trays per treatment was used. Six treatments (T) were prepared as following;

Table 3.1: Growing media mixes combinations

Treatment	**Components –Volume in percentages (%)**		
	Composted tea tree	**Sand**	**Pine bark**
1	100	-	-
2	80	20	-
3	70	30	-
4	60	40	-
5	50	50	-
6 (Control)	-	-	100

3.3.0 Experimental procedures

3.3.1 Media collection and sterilization

Three empty 90Kg poly sacks were filled with composted tea tree from hips of mature compost. Since composited tea tree was available in hips and lying on the open, it was important to solarise it for control of weeds and pathogens. The media was wetted then tightly enclosed in plastic bag and left under tightly closed seed bed covers for four weeks.

Tea tree (Melaleuca alternifolia) and its hips of compost products in pictures

3.3.2 Tea tree analysis

A sample from solarised composited tea tree was collected, dried and sends for full analysis to determine substrate pH and other chemical properties. The sample was sieved through 6mm sieve; impurities removed and packed in sample plastic bag. It was labelled and a full analysis box ticked and stapled together with the sample for submission to ZimLab. The method used for mineral elements is Resin Extraction (Dowex 21k). Pine bark's physical and chemical information was extracted from Tucker, (1995).

3.3.3 A floating bed construction, media preparation and tobacco sowing

This was done by firstly levelling the ground. Sand was spread on the ground before marking the dimension of the bed. It was done to protect the black sheeting against rough surface. Loose bricks were used to construct the bed; two courses were done. Size of the pond was guided by number of trays, which were 18, a length of 3.6m by width of 1.05m giving a volume of 0.422m^3. Standard farm bricks were used.

Media was mixed at percentage ratio indicated on treatments. It was then remoistened to prevent fall out during tray filling but done to a point where if moulded into a ball it breaks but without losing shape if left. Moistening was guided by TRB recommendations which state that one should use a 50% Water volume to total growing media mixture. Trays were filled with growing media and marked for each treatment identification purpose, three trays representing same treatment given same mark of sack knot on same cell position. To achieve proper filling, trays were raised 20cm above ground and allowed to free fall in order to remove undesirable large pore spaces. This was done twice. A dibbler was used to mark holes before placement of seed. KRK66 pellet seeds were used, at one seed per cell. Sowing was done on the same day and all trays floated in water bed same day. The trays were covered by seed bed cover sheet in order to provide favourable germination and emergence environment.

3.4.0 Data collection

3.4.1 Emergence measurement

Emergence percentage data was collected by physical counting seedlings only in cells at the center floating trays. The figures from same treatment trays were averaged and recorded. The process was repeated thrice, but only once a week from time of emergence and stopped two weeks later. This was done to enable all seeds to emerge and grow to identifiable stage since Marondera is a slow growing area. Measurements for same treatments were averaged and recorded for ANOVA analysis using GenStat 14^{th} version.

3.4.2 Seedling height measurement

Ten seedlings from 100 cells mentioned above were randomly selected for measurement from each tray. A set of veneer callipers was use to measure height from root crown to apical meristem with veneer callipers. It was done once at week 11. The seedlings were easily returned into their cells since their media was still bound to the roots. Measurements for same treatments were averaged and recorded for ANOVA analysis using GenStat 14^{th} version.

3.4.3 Collection of stem thickness data

Measurements were done by using veneer callipers in simultaneous with seedling height measurement. To maintain standards, stem thickness was measured at the middle of seedling height for each seedling, which is between root crown and apical meristem. Data for each treatment trays was averaged and then recorded. Finally, this was subjected to analysis of variance (ANOVA) using GenStat 14^{th} version.

3.4.4 Collection of spiral root data

Spiral root data considered seedlings with roots that were observed to have aerial nature near to the root crown. Only 10 cells from 100 at the tray centre selected for assessment. It was done randomly. Average number per treatment was recorded and subjected to ANOVA analysis using GenStat 14^{th} version. Data for same treatments were averaged and recorded for ANOVA analysis using GenStat 14^{th} version.

3.4.5 Leaf numbers counting

Ten plantlets per tray were selected randomly from 100 cells at the centre of trays. Only developed leaves were considered for leaf numbers. Counting from same treatments were averaged and recorded for ANOVA analysis using GenStat 14th version.

3.5 .0 Management of non experimental variable

The agronomic practices or management activities were water management, fertilizer management disease and pest management. Water was filled to a depth of 12cm. This left a space for tray depth that is desired for a floating tray to be level with bed. No water samples were sent for quality testing but assumption was based on 2012 tests done for College by Marondera municipality laboratory, which showed a pH of 6.1. Major elements were said to be 4.7ppm. Calcium and alkalinity was at 48ppm and 60ppm respectively. Other trace elements, Zn, Cu, Fe and Mn were at 1.6ppm. Mg was at 25ppm. Conductivity (iS/cm) was 650 and alkalinity 60ppm. Since this was done in August 2012, the assumption was that no significant changes were experienced over the production within area of boreholes was very little for past seasons. Water refilling was done as significant reductions in water levels were noticed to maintain trays at level with bed. No water withdrawal was done at hardening stage; only nutrients withdrawal at day 42 was done by applying last top dressing of calcium nitrate as per fertilizer management recommendation.

Fertilizer management

In the experiment, a ZFC soluble hydrofert (Compound S), basal fertilizer known as 20:10:20 or seed bed fertilizer was applied in three splits that are at day 7, day21 and day 35. Total basal application rate was to meet 150mgN applied at 25mgN, 50mgN and 75mgN respectively. The calculation for hydrofert fertilizer at each stage was done using the following formula: [volume of water in bed (m^3) X fertilizer requirement at each stage (mgN/litre)]/[%N in fertilizer X 10]. The volume was determined by bed size ($0.422m^3$) as stated above. At day 42, calcium nitrate (15:5:0:0) was applied as top fertilizer to meet 100mgN requirement

Pest and disease management

Ridomil mz 68%w.p was applied at week 5 after sowing at 55g for water volume of $0.422m^3$ .It was aimed at preventing phythium root rot, a fungal disease For pest threat preventative, methamidophos was applied to water at week 4 to guard against shore fly (a dipteran) and other pests like cut worms, grasshoppers and aphids.

Controlling of algae in floating tray system

Spore kill (TYPE OF QAC) was applied to control algae at a rate of 0.25-0.30ml/litre of float bed water, but directly to water. The chemical was firstly mixed with water in a litre container, before spatial application along the bed.

Growth, clipping and hardening process in floating system

Clipping was done at week 8 and 10, using secateurs. For hygienic purpose, the tool was dipped in disinfectant after completing clipping of seedlings in every tray. Once uniformity was achieved no further clipping was done. To achieve hardening, the last fertilizer application was done at week 6 and only water remained applied.

CHAPTER 4

4.0 Results

4.1: Effect of composited tea tree and sand media mixes on emergence

There were significant (P<0.05) differences between the media mixes. Pine bark gave the highest emergence percentage of tobacco seedlings. There was no significant difference among the treatments 70:30, 80:20 and 100% of composted tea tree and sand media mixes. It was noted that 50:50 and 60:40 composted tea tree gave the least emergence percent of tobacco seedling.

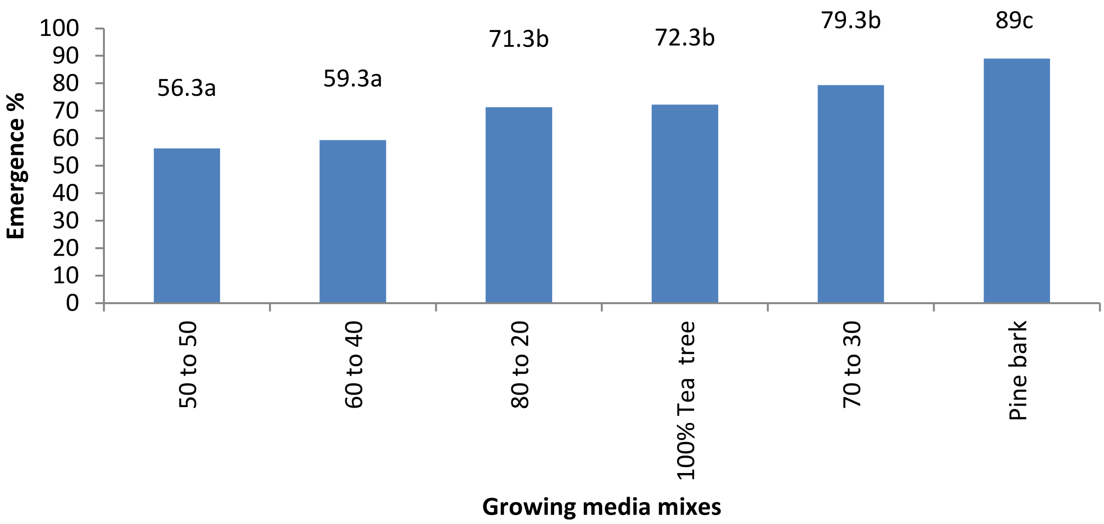

Figure 4.1: Effect of composted tea tree and sand media mixes on emergence percentage (%).

4.2: Effects of composited tea tree and sand mixes on seedling growth height

There is significant difference ($p<0.005$) on effect of composted tea tree and sand media mixes on growth height (Table 4.1). Pine bark was not statistically different from 70:30 and 100% composted tea tree and sand media mixes. The treatment 50:50 and 60:40 composted tea tree and sand media mixes were statistically not different though 50:50 recorded a significant low seedling height value. Table 4.1, below statistically present the findings. Numbers with different letters are significantly different.

Table 4.1: Effects of composted tea tree and sand mixes on seedling height (cm)

100% pine bark and Tea tree mixes ratio	**Mean**
50:50	8.93^{a}
60:40	9.63^{ab}
80:20	10.93^{bc}
100% composted tea tree	12.1^{cd}
70:30	12.9^{d}
100% Pine bark	13.53^{d}
Grand mean	11.34
SED	0.794
LSD	1.730
CV%	8.0
Fpr	<0.05

4.3: Effect of composited tea tree and sand media mixes on stem thickness

There is no significant difference (p<0.05) on the effect of composted tea tree and sand media mixes on stem thickness (Appendix 4.4).

4.4 Effect of composited tea tree and sand media mixes on spiral root development

There is no significant difference (p<0.05) on effect of composted tea tree and sand media mixes on spiral root development (Appendix 4).

4.5: Effect of composited tea tree and sand media mixes on number of leaves at week 11

There is significant difference ($p<0.05$) on effect of composted tea tree on leaf numbers (Fig 4.2). Pine bark gave the highest average leaf numbers per tobacco seedling, but was not statistically different to 70:30, 80:20 and 100% of composted tea tree and sand media mixes. There was statistical similarity on 50%, 60% and 80% composted tea tree and sand media mixes on number of leaves at week 11.

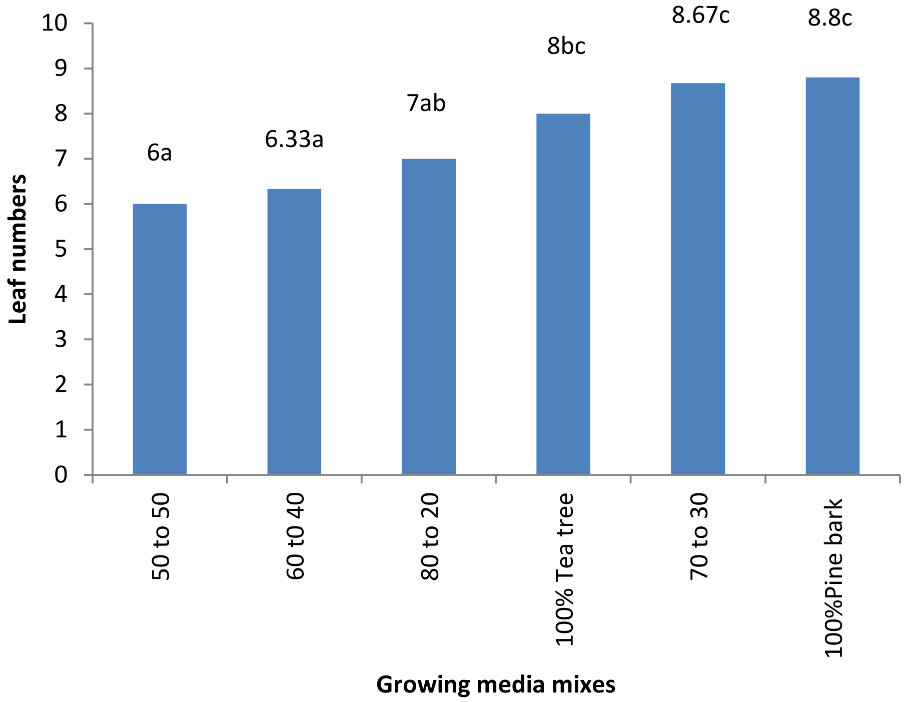

Figure 4.2: Effect of composted tea tree and sand media mixes on leaf numbers

CHAPTER 5

5.0: Discussion

5.1: Effect of composted tea tree and sand media on Tobacco seedling emergence

There was significant difference ($p<0.05$) noted on recorded seedling emergence percentage. Pine bark had the highest emergence percentage of 89% almost confirms with results achieved at TRB (Masaka, *et al*., 2007; Chilembwe, et al., 2005). The record should be as result of good water supply, aeration, nutrient supply and less compaction in the media. Also 70:30, 80:20 and 100% composted tea tree and sand media mixes recorded comparable results to pine bark a sign of comparable good physical and chemistry properties (appendix 6).

5.2: Effect of composted tea tree and sand media mixes on seedling growth height

Difference in seedling growth height and weekly growth trends were generally responding to treatments as witnessed by results. There was a probability of lack good aeration and lack of good nutrient movement as a result of high packing density that might have occurred during growing media filling. Also high density due to increase in sand particles in 60% composted tea tree and 50% composted tea tree should have contributed towards same problem. However the absence of significant difference in 100% composted tea tree, 70% composted tea tree and pine bark means it is possible to use some of these growing media mixes in the absence of the pine park. According to Tuker, 1995; Mazarura, 2004., pine bark has a better nutrient retention capacity which should have influenced performance of seedlings in pine bark trays to record highest results. High porosity percentages in composited tea tree and sand mixes should have influenced poor nutrient retention that make pine bark superior (Table 4.2).

5.3: Effect of composted tea tree and sand media mixes on tobacco seedling thickness

There was no significant ($p<0.05$) difference on the means of stem thickness. However, the thickness means of 50:50 and 60: 40 of composted tea tree compared and sand media mixes should have been influenced by compaction during filling that retards growth but supply of nutrients was not much compromised. This resulted in dwarf seedlings formation, a case known as cabbage by farmer seedlings (TRB, 2012-13).

5.4: Spiral root development in tobacco seedlings

There was no significance ($p<0.05$) difference on means of spiral root development that were noted during the experiment. Spiral root development was noted in pine bark where as 100% tea tree had no such problem. There were aerial root developments in other composted tea tree, but of interest to note is that the treatments with survival challenges (appendix 9) were also observed to record highest spiral root challenge which was confirmed somewhere (Masaka, *et al.,* 2007. According to literature, the spiral root development causative is not known. It may have been caused by pellet material used in encasing seed, growing media, seed variety and variation in day and night temperatures. It may have risen from high particle density and variation in tray packing; where some of the trays might have been compacted, resulting in aerial root development (Mazarura, 2004; Douglass, *et al*., 2010). For pine bark (control), poor initial conductivity should have influenced spiral root development at early growth stage as seedlings were struggling to access water.

5.5: Effect of composited tea tree on leaf numbers

There was significance difference ($p<0.05$) on the effect of composted tea tree and send media mixes on means of leaf number. Recorded number of leaves showed that 100%, 70:30 composted tea tree and 100% pine bark were not statistically different. This should have been caused by successful of supply of nutrients to seedlings by media mixes. There was no statistical difference between 60:40 and 80:20 of composted tea tree and sand media mixes a sign that the nutrient uptake and growth as shown in table 4.1 was comparable the same. Lowest statistical record obtained by 50:50 and 60:40 composted tree should have been due to compaction as a result of tray feeling, high bulk densities and particle densities.

CHAPTER 6

6.0 Conclusion and recommendations

6.1 Conclusion

- The treatments 70:30, 80:20 and 100% of composted tea tree and sand media mixes were not significantly different on emergence percentage to pine bark.
- The treatments 70:30, 80:20 and 100% composted tea tree and sand media mixes were not significantly different to pine bark statistically on stem height.
- There was no statistical evident of variation in spiral roots development in all treatments.
- There was no statistical difference on stem thickness as all results were comparably similar to pine bark (control) results.
- The treatments 70:30, 80:20 and 100% of composted tea tree and sand mixes were statistically not different from pine bark on leaf numbers respectively.

6.2 Recommendations

- Farmers are recommended to use mixtures 70:30, 80:20 and 100% of composited tea tree and sand media mixes in floating tray system since there produced results which were comparable similar to pine bark. For economic purpose, one may use media mix with tea tree component content of 70% and for environmental protection one may use pure composted tea tree (100% composted tea tree), which do not need sand.

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APPENDICES

A1. Appendix1

An evaluation on the mean of composted tea tree and sand media mixes on tobacco seedling emergence

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	5	2238.28	447.66	21.72	
Residual	12	247.33	20.61		
Total	17	2485.61			

Treatment	Mean	Means separation	Percentage decrease
50% Composted tea tree	56.33[a]	3	36.74
60% Composted tea tree	59.33[a]	12	33.37
80% Composted tea tree	71.33[b]	1	19.89
70% Composted tea tree	72.33[b]	7	18.76
100% Composted tea tree	79.33[b]	9.7	10.89
100% Pine bark (control)	89.00[c]		

Grand mean	71.3
SED	3.71
LSD	8.08
CV%	6.4
Fpr	<.05

*Numbers with different letters are significantly different.

A2. Appendix 2

An evaluation on the mean of composted tea tree and sand media mixes on tobacco seedling height (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	5	50.0761	10.0152	10.59	
Residual	12	11.3467	0.9456		
Total	17	61.4228			

Treatment	Mean	Percentage decrease
50% Composted tea tree	8.93^{a}	34.00
60% Composted tea tree	9.63^{ab}	28.82
80% Composted tea tree	10.93^{bc}	19.22
100% Composted tea tree	12.1^{cd}	10.57
70% Composted tea tree	12.9^{d}	4.66
100% Pine bark (control)	13.53^{d}	

Grand mean	11.34
SED	0.794
LSD	1.730
CV%	8.0
Fpr	<.05

[*]Numbers with different letters are significantly different.

A3. Appendix 3

An evaluation on the mean of composted tea tree and sand media mixes on tobacco seedling thickness

Variate: Stem thickness (mm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	5	2.0267	0.4053	1.52	0.254
Residual	12	3.1933	0.2661		
Total	17	5.2200			

Treatment	Mean	Percentage decrease
50% Composted tea tree	5.03	2.56
70% Composted tea tree	5.07	14.50
70% Composted tea tree	5.6	0.06
80% Composted tea tree	5.63	0.05
100% Composted tea tree	5.73	0.03
100% Pine bark (control)	5.93	

Grand mean	5.50
SED	0.421
LSD	1.918
CV%	9.4
Fpr	<.05

Nb. All treatments showed no significant difference, hence no analysis for separation of means were done.

A4. Appendix 4

An evaluation on the mean of composted tea tree and sand media mixes on spiral root development

Analysis of variance

Variate: Spiral root development percentage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	5	2.444	0.489	0.44	0.812
Residual	12	13.333	1.111		
Total	17	15.778			

Treatment	Mean	Percentage decrease
100% Composted tea tree	0	10.89
80% Composted tea tree	0.33	18.76
100% Pine bark (control)	0.67	
70% Composted tea tree	0.67	19.89
60% Composted tea tree	0.83	33.37
50% Composted tea tree	1.17	36.74

Grand mean	0.61
SED	0.861
LSD	1.875
CV%	172.5
Fpr	<.05

Nb. All treatments showed no significant difference, hence no analysis for separation of means were done.

A5. Appendix 5

An evaluation on the mean of composted tea tree and sand media mixes on number of leaves

Variate: Average number of leaves per stalk

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	5	21.4667	4.2933	6.15	0.005
Residual	12	8.3733	0.6978		
Total	17	29.8400			

Treatment	Mean	Percentage decrease
50% Composted tea tree	6.00[a]	31.82
60% Composted tea tree	6.33[a]	28.07
80% Composted tea tree	7.00[ab]	20.45
100% Composted tea tree	8.00[bc]	9.09
70% Composted tea tree	8.67[c]	1.48
Pine bark (control)	8.8[c]	

Grand mean	7.47
SED	0.682
LSD	1.486
CV%	11.2
Fpr	<.05

*Numbers with different letters are significantly different.

A6. Appendix6 – Full analysis results

	Tea tree sample	**Pine bark**	**Units**
Elements or parameters			
pH	6.4	3.4 – 4.5	
Total Soluble Salts	3724.80	-	Ppm
Nitrate Nitrogen	5.62	-	Ppm
Phosphorous-P2O5	207.16	11.5 – 23.0	
Calcium	20.73	8.50 – 24.0	(% of CEC)
Potassium	4.20	134 – 215	(% of CEC)/ppm
Magnesium	10.78	4.5 – 6.20	(% of CEC)
Sodium	0.28	-	(% of CEC)
Copper	1.75	0.22 – 0.50	
Zinc	73.05	1.80 – 4.40	
Iron	467.50	-	
Manganese	173.00	4.5 – 15.0	
Total Exch. Bases	35.99	6.3 – 9.92	CEC
Composted tea tree analysis summary:			
Elements	**Method Code**	**Summary of Method (s)**	**Source**
pH	CHS209	0.5M $CaCl_2$	Zimlab
TSS	CHS208	Electrode	Zimlab
NO_3	CHS203	Spectrophotometric	Zimlab
P2O5	CHS205	Resin Extraction (Dowex 21k).	Zimlab

Ca,Mg,K,Na	CHS201	1.0M Ammonium Extraction pH 7	Zimlab
Cu,Zn,Fe,Mn	CHS206	EDTA 0.1M Extraction pH 7.0	Zimlab

A7. Appendix 7 - Composted tea tree and sand media mixes' densities and porosity

Treatment	Total Volume (cm^3)	Bulk density (g/cm^3)	Particle density (g/cm^3)	Porosity %
T6 100% Pine bark	290	0.45	1.86	75.86
T1 100% Composited Tea tree	290	0.77	4.44	82.76
T2 80% Composited Tea tree	290	0.77	2.98	74.14
T3 70% Composited Tea tree	290	0.78	5.67	86.21
T4 60% Composited Tea tree	290	1.11	6.44	82.76
T5 50% Composited Tea tree	290	1.28	3.36	62.07

A8. Appendix8 - survival percentage

Treatment	Seedling survival %
T2 80% Composited Tea tree	68.5
T4 60% Composited Tea tree	71.4
T5 50% Composited Tea tree	71.4
T3 70% Composited Tea tree	74.6
T1 100% Composited Tea tree	81
T6 100% Pine bark	92.3