BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF NATURAL RESOURCES

INFLUENCE OF SELECTED ARTIFICIAL AND NATURAL GROWTH HORMONES ON NURSERY PERFORMANCE OF SELECTED TREE SPECIES CUTTINGS

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APPROVAL FORM

The undersigned confirms that they have read and recommended this research project entitled, “Influence of selected artificial and natural growth hormones on nursery performance of selected tree species cuttings” of in partial fulfillment of the Bachelor of Science Honors Degree in Natural Resources Management.

Supervisor

I certify that i have supervised TAFADZWA KAGUMBATE B192676B for this research entitled “Influence of selected artificial and natural growth hormones on nursery performance of selected tree species cuttings” in partial fulfilment of the Bachelor of Science Honours Degree in Natural Resources Management and recommends that it can proceeds for examination.

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DEDICATION

This dissertation is dedicated to my father and mother who raised me from my childhood up to who I am now with all their sacrifices for my success. More importantly, I dedicate this project to the Almighty for being my creator and giving me strength, courage, wisdom, knowledge, understanding, and faith. I also dedicate this project to Bindura University, and my nation at large.

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ABSTRACT

The study compared the effects of three common natural stimulants namely honey, *aloe vera gel*, and banana peel as well as a commercial rooting hormone (Dynaroot No. 1) and a control (no treatment) on shoot development, survival rate and root development of *Persea americana* (avocado), *Mangifera indica*(mango),*Citrus sinensis*(orange),*Cassia abbreviata*(muremberembe), *Bobgunnia madagascariensis* (mucherekesi), *Erythrina abyssinica* (mutiti) cuttings. Experiment was laid out in a (3 x 3) completely randomized design with two replications. Analysis variance of (ANOVA) were conducted for the analysis of data using SPSS.Cuttings were treated with the different stimulants at the time of propagation. Shoot growth, survival rate, root number, and root length were assessed at 8 weeks. Results showed poor development attributed to inappropriate timing of seasonality. *Aloe vera* gel hormone had the highest mean of (4,00±1,00) overall shoot development in all cuttings planted, followed by dynaroot which had a competitive value of (3,00±1,00) while honey , banana peel and the control had least shoot development rate (2,50±.0,50). This therefore means natural *Aloe vera* root hormone can be recommended for raising cuttings in the nursery considered for growth of cuttings. In terms of survival performance, cuttings in *aloe vera gel*, had the the highest value of 60% followed by dynaroot 40%, hence banana peel, honey and the control treatment recorded the least survival rate of 20%. Cuttings treated with Aloe vera gel exhibited the highest overall growth outcomes. Shoot growth was greatest for *C. abbreviata* cuttings (4,00 ±1,00) while *C. sinensis*, *E. abyssinica* and *B.madagascariensis* fail to develop shoot. No root develop in any hormones maybe it could be due to inappropriate timing of seasonality and environmental factors of the area. These findings demonstrate the potential of using *aloe vera gel* natural stimulants as inexpensive alternatives to commercial growth hormones for plant propagation by cuttings. The natural options used viz honey, *aloe vera gel*, and banana peel are readily available and can stimulate survival and shoot growth. However, effectiveness depends on the plant species and good timing of the right season to propagate. Future research should explore concentrations and combinations of these natural stimulants to optimize results.

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LIST OF ABBREVIATIONS

ANOVA……………………………………………………..analysis of variance

IBA…………………………………………………………indole 3 butyric acid

IAA…………………………………………………………indole 3 acetic acid

NAA……………………………………………………….Naphthalene acetic acid

CHAPTER 1

INTRODUCTION

1.1 Background to the study

Every year, vegetative production yields millions of plants for usage in many fields. Cutting-based production is used when the genetic makeup of an individual is meant to be preserved. In this manner, the exact genetic make-up of rootstock is preserved. Using this technique, millions of plants are created each year for use in forestry, agriculture, and other industries (Bonga et al., 2016).Plants can reproduce from vegetative organs by a process known as vegetative propagation, which ensures that the progeny will have the same genotypes and physiological conditions as the parent plant (Reddy et al., 2022). It is now commonly acknowledged as methods to greatly increase the quantity and quality of forest products produced by commercial plantings in the tropics and subtropics are ideal for preserving genetic diversity and creating high-quality planting material.

Bonga et al. (2019), revealed that plantation forests make up 3% of the world's total forested land, but despite this small share, they currently provide more than one third of the industrial wood used in construction and furniture. By 2050, it is predicted that this production will increase to a total of 3% of the world's forested land, or almost 75%. Plantations are without a doubt very productive, and with more genetic using biotechnology and altering the kind of planting stock results in increased output and there is a chance of growth. Schmidt et al. (2000), in a different study cited that over the past few decades, many governments have placed a lot more focus on using local species, when formerly foreign species predominated in plantations. The need for a considerably greater diversity of species, particularly local and lesser-known species, has developed as a result of this tendency and the above-mentioned wider planting operations.

Mejury et al. (2019), cited that the method of cutting, the rooting medium, the type and potency of the rooting hormone used, as well as the thickness of the cuttings, all affect how well cuttings root. *Citrus sinensis* (orange), *Persea americana* (avocado), and *Mangifera indica* (mango) are three examples of fruit alien plants that can be reproduced through cuttings. *Cassia abbreviata* (muremberembe), *Bobgunnia madagascariensis* (Mucherekesi), and *Erythrina abyssinica* (mutiti), are indigenous medicinal trees that will be propagated. The four root hormones media that are being compared are dynaroot, honey, aloe vela gel, and banana mesh. Rooting media is regarded as a crucial component of the propagation. The hormones directly affect the rooting process and the quality of the developed roots. The suitability of the media depends on the species, the cutting type, the season, the propagation method, the cost, and the availability of the medium because there is no standard mix or medium for cuttings (Mejury et al., 2019).

The ability of various media to physically support the cuttings and hold water also varies. Regardless of the season, this method has the benefit of growing a large number of plants in a short length of time. Local rooting hormone has been used as a supplement to promote plant cell regeneration in numerous labs (Dada et al., 2019) . It has previously been claimed that the use of synthetic rooting hormones like IBA (Indole-Butyric Acid) and NAA (Naphthalene Acetic Acid) is effective but costly. The expense of employing these artificial hormones is considerable, and there are few easy ways to get them. Therefore, it is necessary to find adequate and less expensive sources of natural root-promoting agents that may be used right away by local farmers. In order to compare the effectiveness of locally sourced chemicals with synthetic hormones for the survival rate, this research was created. shoot and root development of different species (Topacoglu et al., 2016).

Artificial root hormones are known to increase adventitious root growth of stem cuttings by encouraging the onset of lateral root primodia and improving glucose transport to cuttings' bases (Hartmann et al., 2000). One of the biggest barriers to the employment of propagation methods has been the lack of understanding about the possible uses, production methods, and management of native tree species, whether for productive or environmental objectives (Stuepp et al., 2018). Because of this, using it is a barrier for those who are illiterate, and those who are poor cannot afford to purchase it. One of the additional issues is that if demand rises, chemical prices will as well. Lack of knowledge about the many applications, production methods, and management of native tree species, whether for agricultural or environmental goals, has been one of the largest barriers to the adoption of propagation techniques in clonal forestry (Stuepp et al., 2018).

1.2 Problem statement

The propagation methods in Zimbabwe are increasing at a higher rate, but there is limited Information regarding the best root growth hormones for tree cuttings. Despite this, it's unclear for many native tree species if hormones could be used for vegetative growth. So, this review also includes role of plant growth regulators in improving success of reproducing species. There is also little or no Information about good root growth hormones to use between Artificial and natural hormones. Also there is lack of information about the performance of root development, growth development and shoot development. Our nation is experiencing shortage in medicinal indigenous trees due to deforestation by anthropogenic and natural factors. There is also shortage of exotic fruit trees, due to lack of knowhow on how best to propagate the plants with the best root hormone for cuttings. Lack of knowledge and skill is the major hurdle to use vegetative propagation. So, an attempt was made to discuss various techniques with their advancement and significance

1.3 Justification

The project is very essential in clarifying the best root hormone between Artificial and Traditional root growth hormone. This project seeks to help in the documentation of information related to the performance, in terms of shooting, root development and growth which will elaborate the acceptability of either Traditional or Artificial root growth hormone. It will also help to restore the aesthetic value of the environment by promoting green through afforestation, to mitigate climatic changes caused by deforestation.

1.4 Aim

To compare the influence of artificial and natural growth hormones in tree cuttings on shoot development, survival rate, and root development of *Erythrina abyssinica, Cassia abbreviata ,Bobgunnia madagascariensis, Citrus sinensis , Persea americana and Mangifera indica* cuttings.

1.5 objectives

1.5.1 To assess the shooting performance of the plants grown using traditional and artificial root hormones.

1.5.2 To determine time taken for rooting to develop.

1.5.3To compare the survival rate of the cuttings treated with growth hormones.

1.6 Research Questions

a) What are the effects of each growth hormone treatment on shoot development, root development and survival rate of selected species?

b) Does type of cuttings affect the performance of growth hormone in shoot development, root development and survival rate?

c) Does seasonality affect growth of cuttings in different regions?

CHAPTER 2

LITERATURE REVIEW

2.1 PERFORMANCE OF GROWTH HORMONES ON TREE CUTTINGS

The type of cutting, the rooting medium, the type and concentration of rooting hormone employed, and the thickness of the cuttings are all factors that affect how well cuttings root (Mejury et al., 2019). Rooting media is regarded as a crucial component of the propagation system because it has a direct impact on the percentage of rooting and the quality of the roots that are formed (Kiuru et al., 2015). Since there is no standard media or mix for cuttings, the suitability of the medium relies on the species, the cutting type, the season, the propagation mechanism employed, the cost, and the availability of the medium (Leakey et al., 2004). Different media have varying water holding capacities and abilities to hold the cuttings physically (Mejury et al.,2019). Sand, pine bark, and a peat to perlite (1:1) mixture are the most often utilized medium (Offord et al., 1998).

Peat perlite is another growth medium used in plant propagation. The high temperature processing has rendered perlite, a grey-white salicaceous substance of volcanic origin, infertile. With no CEC and no buffering capacity, it is essentially neutral. For cutting propagation, perlite and peat are typically combined (Shiri et al., 2019) . Pine bark is made from the softwood bark of the pine tree that has been shredded or ground into a fine powder. Pine bark is acidic (pH 3.2-4.5), contains just a little amount of nitrogen (approximately 1%), and has a high moisture retention capacity of 15 times its dry weight (Bunt et al., 2012). The velocity of rooting, the final rooting percentage, and the number of roots all increase when exogenous hormones like indole-3-butyric acid (IBA) are applied (Elmongy et al., 2018).

In terms of structure and function, synthetic indole-3-butyric acid (IBA) is very similar to the naturally occurring plant growth regulator (Kaczmarek et al., 2020). IBA is a hormone that is mostly used on horticultural plants to encourage cutting germination. However, it was found that other species did not benefit from higher doses (Stewart & Hill, 2014).

2.2 SHOOTING PERFORMANCE

Olive tree cuttings given honey developed considerably more and longer shoots than control cuttings (El Deen et al., 2014). Similarly (Rahman et al., 2013) ,reported that honey treatment increased the number of shoots and shoot length in *Ficus benjamina* cuttings. The nutrients and growth regulators present in honey likely enhanced bud sprouting and shoot elongation. While, (Rahman et al., 2013). I another study reported that dynaroot application increased the number of shoots in CUR-21 guava cuttings. The auxin dynaroot, which contains the synthetic auxin IBA and thiamine, stimulated the production of new shoots. However,(Chatterjee & Mukherjee, 1980) discovered that dynaroot had no significant effect on the number or length of shoots in jackfruit cuttings when compared to controls. The effects may depend on the plant species and the concentrations used.

Aloe vera gel has been shown to have a positive impact on shoot growth. (Rajan & Singh, 2021) reported that aloe vera gel increased the shoot length, number of shoots and shoot fresh weight in *bougainvillea* cuttings compared to control. The nutrients and growth regulators in aloe vera likely enhanced bud break and shoot growth (Sharma et al., 2013). The effects were more pronounced than IBA treatment. Banana peel, which contains IAA and polyphenols, has been found to improve shoot growth. Yang et al. (2012), reported that fermented banana peel extract increased the shoot height and shoot number in *Jatropha curcas* cuttings compared to control. The endogenous auxin and other compounds in the fermented banana peel probably stimulated shoot elongation and sprouting, the effects were higher than that of IBA.

On the use of other hormones Kugedera et al. (2019), emphasized that during the rainy season, malura trees have high shooting percentages. Since cuttings are obtained from recognized female trees, it is quite simple to produce female Marula trees using them. Cuttings utilized for experiments attained a shooting rate of 76%.While, Dada et al. (2019), in another study on planting of *annona muricata* species from cuttings using different hormones which is IAA, Coconut water, distil water and IBA ,the results reviewed that, For fresh shoot, IAA had the highest mean value (1.80). While cuttings treated with IBA had the lowest mean value (1.00) for new shoots, coconut water and distillate water both had mean values of 1.25 for new shoots. Another study conducted at Ekiti University in Nigeria found that cuttings treated with IAA had significantly more of an impact on new shoots than cuttings treated with other hormones. The research revealed that IAA helped this species' stem cutting development to some extent (Dada et al., 2019).

Stuepp et al. (2018),on search on effects of growth media, which is pine bark, peat-lite and river sand as control and IBA on D.erecta tree.IBAcontained concentrations of 5000, 700, and 200 parts per million. The highest average shoot number and longest shoot were found in cuttings from 500ppm. The fact that the same concentration supported higher root quality (length and number), which increased surface area for nutrient absorption from below ground parts to the above ground parts, can actually be used to explain why the maximum number of shoots produced from 5000 ppm IBA concentration. Mejury et al. (2019), cited that the most shoots were produced by pine bark grown cuttings, followed by river sand, which was similar to peat lite. These results are consistent with those from Akwatulira et al. (2011), who saw the most *W. ugandensis* shoots in pine bark cultivation. Pine bark may improve the availability of water and mineral nutrients at the basal end of the cuttings because of its superior water-holding capacity. Due of this, cuttings' above-ground sections may more easily translocate water and nutrients, which causes bud break to occur quickly (Mejury et al., 2019).

2.3 ROOTING DEVELOPMENT

A quick and low-cost way of propagation is to use cuttings (stem or root).Root cuttings for *P. curatellifolia* have had up to 60% success at taking root (Mng'omba et al., 2008). Cutting position, rooting medium, and rooting hormone are some of the key elements that have a significant impact on the success of rooted stem cuttings. (Rajan & Singh, 2021),reported higher rooting success, number of primary and secondary roots in *F. benjamina* cuttings treated with honey has been used as a natural rooting stimulant. It contains sugars, amino acids, vitamins, minerals and enzymes that can promote root growth (Hammad & Ali, 2014). Banana peel contains polyphenols and indole acetic acid (IAA) which have root promoting effects fermented banana peel extract increased rooting percentage, number of roots, root length and shoot height in Jatropha curcas stem cuttings compared to control (Alamgir & Alamgir, 2017).The fermented banana peel was more effective than IBA in root).

According to the findings of Moabelo et al. (2022), dynaroot has been found effective in increasing rooting success in various plant species, dynaroot is a commercial rooting powder that contains IBA and thiamine. IBA is a synthetic auxin that stimulates root formation. Thiamine acts as a coenzyme to synthesise amino acids and promote carbohydrate metabolism, important for root growth (Palacios et al., 2014).While, on another study (Rajan & Singh, 2021), reported that in comparison to control *Bougainvillea* cuttings treated with aloe vera gel had better rooting percentages, numbers of roots, root lengths, and shoot lengths. Aloe vera gel contains various nutrients and antioxidants including acetylated mannans, polysaccharides and phenolic compounds that can enhance rooting Aloe vera was more effective than IBA in most root and shoot parameters (Nova et al., 2022).

Conventionally, the most popular vegetative propagation technique involves establishing stem cutting roots in a variety of media, including pearlite, peat, and sand, by exposing the cuttings to rooting hormones with a high concentration, such as IBA, IAA, and NAA (Topacoglu et al., 2016). However, this conventional method involves huge areas in the rooting stage of mass production, prohibits monitoring the rooting process, and requires a significant amount of ingredients used as hormones and rooting media. There is another study by Mejury et al.(2019)), concerning *D. erecta's* reaction to rooting medium and indole -3-butyric acid (IBA). The amount of IBA used during propagation affects the number and size of roots. The results trend on root length can be explained by the fact that IBA proteins disrupt hydrogen bonds between cellulose microfibrils, promoting cell wall thinning and eventual cell elongation. River sand and peat lite produced nearly equal numbers of roots, while pine bark grown cuttings had the highest number of roots (Mejury et al., 2019).

To increase the number of *D. erecta* cuttings produced, use pine bark and IBA at a concentration of 5000 ppm as the rooting medium. In addition as cited by Dada et al. (2019), another study observed the results of root development on *A. muricata* species using four different hormones which includes (IAA), (IBA), coconut water and distilled water as control. IAA has a noticeable value of 4.00, while IBA had a mean value of 1.75 that was comparable to distill water's mean value of 2.00. The highest mean value for the number of roots was recorded in the coconut water treatment (5.25) and IAA had the lowest mean value for IBA (1.75) that was recorded (Dada et al., 2019). As a result, nurseries may reproduce *J. sabina*, a fascinating shrub used for decorative and forest restoration reasons worldwide, in a quick and simple manner (Schmidt et al., 2000).

2.4 SURVIVAL RATE

Shen et al. (2008), cited that cuttings of *Dieffenbachia* treated with honey had 20% higher survival rate compared to the control. Honey has been shown to enhance the survival of stem cuttings. The carbohydrates and nutrients in honey stimulate cell division and root growth (Oh et al., 2020). Makatini et al. (2014) , found that dynaroot significantly increased survival success and quality of grapevine cuttings compared to the control. The IBA in Dynaroot is absorbed and translocated to stimulate root initiation.

Dada et al. (2019), highlighted the survival rate effects of *A. muricata* using four different root hormones which includes, (IAA), (IBA), Coconut water and distilled water demonstrate that the four treatments had diverse effects on the different species. Cuttings treated with coconut water had the best survival rate (100%) ever observed. The cuttings treated with IAA had a mean percentage survival rate of 50%, while the cuttings treated with IBA had the lowest mean percentage survival rate of 25%, but there was no difference in the values obtained from IBA and distilled water. This was followed by those treated with distil water (75%), and then those treated with IAA and IBA (Dada et al., 2019).

There is also a study on *D.erecta* which consist of IBA with a concentration of 500 ppm, 700 ppm and 200 ppm and other three media types which includes river sand as control, pine bark, and a mixture of peat and perlite at a 1:1 ration. The highest percentage of survival was observed in cuttings cultivated with an IBA concentration of 5000 ppm, with an average survival rate of 81.85%. Cuttings grown at the highest IBA concentration (7500 ppm) had a similar rate of survival to those grown at the lowest dosage (2500 ppm) or in the control treatment. The survival of the cutting varied, with pine bark grown cuttings having the best survival, followed by river sand, which was similar to peat-lite in terms of survival (Mejury et al., 2019). Given the physical characteristics of pine bark in comparison to river sand and peat-lite, which have a looser texture, it is possible to explain the accelerated survival supported by pine bark is due to its low pH range as well as by the high water holding capacity of pine bark (Mejury et al., 2019).

CHAPTER 3

METHODOLOGY

3.1 DESCRIPTION OF THE STUDY AREA

The study was conducted at the Bindura University of Science Education's Astra campus Nursery, which is situated at longitude 0310 19' 23"S and latitude 170 18' 58"E. The campus is situated in Agro Ecology Region 2 of Zimbabwe's Central Province of Mashonaland. 1996 (Agritex). The yearly average temperature is 20°, and there is 700 mm of rainfall. The area receives chilly winters from May through August and wet summers between November and April (Nyakudya et al., 2010). Cuttings of medicinal plants were gathered in the areas surrounding Bindura University, Shamva Road, close to Astra Campus, and some of them were collected near Trojan Mine. *M.indica* and *C.sinensis* fruit tree cuttings were obtained on the Astra campus, and *P.americana* were acquired from chipadze area.

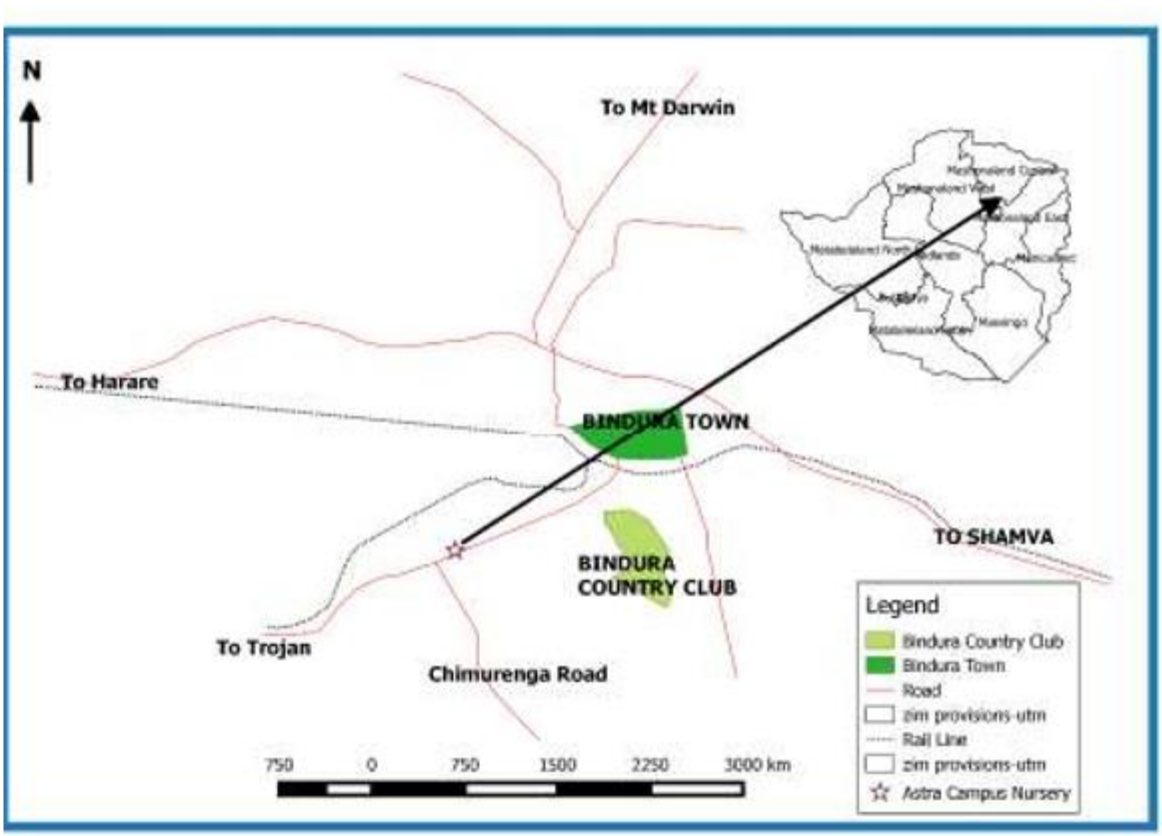

Figure 3.1: Map showing location of Astra Campus where the nursery is located.

3.2 MATERIALS AND METHODS

Stem cuttings, twelve different tree species' young shoots have been used. These experiments were conducted in a greenhouse or beneath a nursery. Nonetheless, cuttings were always set up in randomized blocks and treated as detailed below. For each species, there were five replicate cuttings in each treatment. There were reported standard errors for percentage rooting.

3.3 PREPARATION OF CUTTINGS

From mature tree species, including *Cassia abbreviata, Erythrina abyssinica* and *Bobgunnia madagascariensis,* which are medicinal plants*, and Persea americana, Mangifera indica, and Citrus cinensis,* which are exotic fruit trees, stem cuttings of about 10 cm in length with two or more lateral buds were sequentially harvested. Each species' tip cuttings totaled 50 in total, for a total of 300 cuttings across all species. The cuttings' top and basal leaves were both removed, as well as their basal leaves. The clippings were collected in the late afternoon, and a wet mutton cloth was used to keep them cool or damp at all times. The chosen cuttings were hardwoods taken from young, succulent stems that had just begun to grow. From the mother plant cuttings were taken, cuttings each measuring 5 to 10 cm in length (species dependent), were taken and kept moist in a mutton cloth. We only used stock plants that appeared vigorous, healthy, and devoid of signs of disease or pests. The selection of cuttings was based primarily on hardwood plant components. Each cutting's base was chopped using a pair of knives at a 45o angle to help with roots. All cuttings were submerged in water before planting in an effort to increase the humidity level around each plant. Using various rooting hormones, a total of 25 cuttings from each species were planted into five blocks.

3.4 CUTTING PROPAGATION

The cuttings were briefly submerged to a depth of 2 cm in dynaroot, honey, alovera, and banana mesh. Each hormone was applied to five cuttings before planting. The outer layer of bark was removed from the cut basal end for about 2 cm. To hasten growth, the excised layer was planted in the ground with root hormones. The cuts had extra powder knocked off of them. Each pair of tree cuttings was duplicated twice and placed into each type of rooting media. This was carried out for all six species, totaling 60 blocks. Each cutting was placed in the soil of each compartment two centimeters deep, being careful not to push them to the bottom to provide enough room for root development. Using the fingers, the medium was firmed up around each cutting's base. Randomly, five cuttings from each group of five with a different root hormone were assigned to each block. Banana mesh, *aloe vera gel*, honey, and dynaroot were among the four rooting hormones that were applied to two replications of each of six species in this experiment.

3.5 PREPARATION OF ROOTING MEDIA

Banana peel was prepared by drying it for two days at 91 degrees in an oven until it was dry enough to crumble. After it dries, we used a blender to grind it into powder by turning it into ash. While dynaroot was purchased in Bindura Farm and City Chemical Stores and *aloe vera gel* was gathered at Bindura University Astra campus, honey was taken from Bindura University Apiary. Each species was randomly assigned a separate block of rooting material, and each hormone was planted into each species.

3.6 IRRIGATION MANAGEMENT

The cuttings were inserted into the sand-filled propagation bed. Using a hosepipe, a small amount of water was applied to the clippings every day. For a total of 10 minutes each day, the cuttings were watered once. After two days, plants underwent routine inspection.

3.7 EXPERIMENTAL DESIGN AND TREATMENTS

The experiment was conducted in a greenhouse with a controlled environment. The various growing mediums (banana peel, dynaroot, *aloe vera gel*, and honey) were applied to blocks of various species and dispersed at random in a bed in the greenhouse. In the placebo treatment, no hormone was administered. A 6 times 4 factorial experiment using a Randomized Completely Block Design (RCBD) and two replications was used to set up the study. Six species and two factors (four types: banana peel, dynaroot, *aloe vera gel*, and honey) were used as the rooting media.

3.8 PARAMETERS MEASURED

Six measurements, including the quantity and length of roots, the quantity and length of shoots, and the survival of cuttings (rooted and shooted), were included in the traditional growth study. following a method by (Mejury *et al.*, 2019). After loosening the media in the bed, the cuttings were gently pulled up and measured for root length and root count. Root and shoot length was determined using a thread and a ruler, while root and shoot number was determined by counting.

CHAPTER 4

RESULTS

4.1 SHOOTING PERFORMANCE OF CUTTINGS TREATED WITH GROWTH HORMONES

Cuttings of *M. indica* treated with *aloe vera gel*, honey, dynaroot, banana peel, and in control shows no significant different (P > 0.05), Analysis of variance (ANOVA) were conducted. *M. indica* cuttings treated with *aloe vera gel* hormone recorded the highest mean of shoots developed per each block (1, 00 ± 1, 00), while mango cuttings treated with honey, dynaroot and banana peel recorded the least mean of (0, 00 ± 0, 00).

For *P. americana* cuttings, an Analysis of variance (ANOVA) were conducted, which shows no significant different (P > 0.05), between those treated with *aloe vera gel*, dynaroot, honey, banana peel, and in control. *P.american* treated with *aloe vera gel* and dynaroot had the highest mean value of shoots developed per each block (2, 50 ± 0, 50), however avocado treated with honey and banana peel recorded the least mean value (0, 00 ± 0, 00).

Cuttings of *C. sinensis* s treated in *aloe vera gel*, honey, dynaroot, banana peel, and in control shows no significant different (P > 0.05), analysis of variance (ANOVA) were conducted. *C. sinensis* treated with honey recorded high mean of shoots (0, 50 ± 0, 50), while those treated in banana peel, dynaroot, *aloe vera gel*, and control recorded the same least mean of (0, 00 ± 0, 00).

On *E. abyssinica* cuttings, one way Analysis variance of (ANOVA) were conducted, there were significant different (P < 0.05), in shoot development between *aloe vera gel* and all other root growth hormones, however there were no significant different (P > 0.05),in shoot development between honey, dynaroot, banana peel and in control. *E. abyssinica* cutting treated with *aloe vera gel* recorded the highest mean of shoots (2, 00 ± 0, 00) and mutiti cuttings treated with honey recorded the least mean of (0, 00 ± 0, 00).

For *B. madagascariensis* cuttings, treated with *aloe vera gel*, honey, dynaroot, banana peel and control, there were no significant different(P > 0.05) in shoot development, Analysis variance of

(ANOVA) were conducted *B. madagascariensis* treated in control had high mean of shoots (1,00 ± 1,00), while mucherekesi treated in other four hormones recorded the least mean value of (0,00 ± 0,00).

Cuttings of C. abbreviata ,an Analysis variance of (ANOVA) were conducted, shows that there were significant different($P < 0.05$), in shoot development between *aloe vera gel* and all other different hormones used, however there were no significant different($P > 0.05$), in shoot development between those treated with honey, dynaroot, banana peel and control. *C abbreviata* treated with *Aloe vera gel* recorded the highest mean of shoots (4, 00 ± 1, 00), while muremberembe treated with honey recorded the least mean of (1, 50±0, 50).

Table 4.1 shoot development of cuttings treated with growth hormones

Shoot development	Aloe vera	honey	dynaroot	banana peal	control
Persea americana	2,50±0,50^{b}	0,00±0,00^{b}	2,50±0,50^{b}	0,00±0,00^{b}	1,50±1,50^{b}
Mangifera indica	1, 00±1,00^{b}	0, 00±0,00^{b}	0, 00± 0,00^{b}	0, 00 ±0,00^{b}	0,50±0,50^{b}
Citrus sinensis	0, 00±0,00^{b}	0, 50±0,50^{b}	0, 00±0,00^{b}	0, 00± 0,00^{b}	0,00±0,00^{b}
Erythrina abyssinica	2 , 00±0,00^{a}	0,00±0,00^{b}	0,50±0,50^{b}	0,50± 0,50^{b}	1,00±1,00^{b}
Bobgunnia madagascariensis	0, 00±0,00^{b}	0, 00± 0,00^{b}	0, 00± 0,00^{b}	0, 00±0,00^{b}	1,00±1,00^{b}

Cassia abbreviata	4,00±1,00^{a}	1,50±0,50^{b}	3,00±1,00^{b}	2,50±0,50^{b}	2,00±0,00^{b}

Means ±SE with difference superscripts within the same row are significant different p<0, 05

4.3 SURVIVAL RATE OF CUTTINGS TREATED WITH GROWTH HORMONES

Cuttings of *M. indica*, treated with *aloe vera gel*, honey, dynaroot, banana peel, and in control there were no significant different (P > 0.05), in survival rate. Analysis variance of (ANOVA*).M. indica* treated with *aloe vera gel* recorded the highest mean of (28, 50±1, 50), while *M. indica* treated with honey recorded the least mean of (9, 50±2, 50).

Cuttings of *P.americana* species, Analysis variance of (ANOVA) were conducted, shows that there were no significant different (P > 0.05), in survival rate between *aloe vera gel*, honey, dynaroot, banana peel and in control .the highest mean for *P. americana* cuttings were recorded in control (44, 50 ± 11, 50), while the least mean for *P.americana* cuttings were recorded in banana peel hormone (20, 00 ± 11, 00).

Survival rate of *C. sinensis* cuttings, treated by honey, *aloe vera gel*, dynaroot, banana peel and in control, there were no significant different (P > 0.05). Analysis variance of (ANOVA) were conducted. *C. sinensis* in control had the highest mean for survival rate (14, 00 ± 7, 00), while *C. sinensis* treated with honey had the least mean of survival rate (6, 00 ± 5, 00).

For *E. abyssinica* cuttings, Analysis variance of (ANOVA) were conducted, shows that there were no significant different (P > 0.05), in survival rate between those treated with *aloe vera gel*, honey, banana peel, dynaroot and in control in each block. The highest mean of survival rate for *E. abyssinica* cuttings were recorded in *aloe vera gel* (16, 00 ± 5, 00), while the least mean of survival rate for *E. abyssinica* were recorded in honey, dynaroot and control (14, 50±2, 50).

Survival rate of *B. madagascariensis* cuttings, treated *with aloe vera gel*, honey, dynaroot, banana peel and in control, there were no significant different (P > 0.05). Analysis variance of

(ANOVA) were conducted .*B. madagascariensis* cuttings treated with banana peel recorded the highest mean of survival rate (17, 50 ± 0, 50), while *B. madagascariensis* treated in dynaroot recorded the least mean of survival rate (12, 50 ± 0, 50).

For *C. abbreviata* cuttings, Analysis variance of (ANOVA) were conducted, shows that there were significant different ($P < 0.05$), in survival rate between those treated in banana peel and those treated with all other hormones, however there were no significant different between those treated in *aloe vera gel*, honey, dynaroot, and in control ($P > 0.05$), The highest mean of *C. abbreviata* cuttings for survival rate were recorded in banana peel (54,00±2,00), while the least mean of *C.abbreviata* for survival rate were recorded in control (36,00±6,00).

Table 4.2 survival rate of cuttings treated with growth hormones

Survival rate	aloe vera	honey	dynaroot	banana peal	control
Persea americana	$32,50\pm2,50^{b}$	$32,00\pm13,00^{b}$	$32,00\pm6,00^{b}$	$20,00\pm11,00^{b}$	$44,50\pm4,50^{b}$
Mangifera indica	$28,50\pm1,50^{b}$	$9,50\pm2,50^{b}$	$26,00\pm12,00^{b}$	$21,00\pm9,00^{b}$	$15,00\pm3,00^{b}$
Citrus sinensis	$10,50\pm1,50^{b}$	$6,00\pm5,00^{b}$	$11,00\pm3,00^{b}$	$12,00\pm3,00^{b}$	$14,00\pm7,00^{b}$
Erythrina abyssinica	$16,00\pm5,00^{b}$	$14,50\pm5,50^{b}$	$14,50\pm4,50^{b}$	$15,50\pm2,50^{b}$	$14,50\pm2,50^{b}$
Bobgunnia Madagascariensis	$13,00\pm2,00^{b}$	$14,50\pm2,50^{b}$	$12,50\pm0,50^{b}$	$17,50\pm0,50^{b}$	$13,00\pm1,00^{b}$
Cassia abbreviata	$42,00\pm0,00^{b}$	$38,50\pm3,50^{bc}$	$42,00\pm6,00^{b}$	$54,00\pm2,00^{b}$	$36,00\pm6,00^{b}$

Means ±SE with difference superscripts within the same row are significant different p<0, 05

4.3 ROOT DEVELOPMENT OF CUTTINGS TREATED WITH GROWTH HORMONES

The species failed to develop roots in all root hormones, while the collection season had a big impact on everyone who was dependent. These findings supported the substantial seasonality (harvest time) of stem cuttings' rooting ability. There were no significant different in all hormones used.

CHAPTER 5

DISCUSSION

5.1 SHOOT DEVELOPMENT OF CUTTINGS TREATED WITH GROWTH HORMONE

The results for *M.indica* cuttings showed that the species reacted to the four treatments differently. *M. indica* indica's shooting development effect was examined utilizing four different hormones, including honey, dynaroot, banana peels, and *aloe vera* gel. The results reveal that *aloe vera* gel produced the highest levels of shooting. Dynaroot competitive value against *Aloe vera gel*. This backed up the claim made by Sreelekshmi et al. (2021), regarding *Stevia rebaudiana*, which showed that the cuttings treated with Aloe vera gel also had a significantly higher number of shoots per cutting and longer shoots compared to the control treatment. This suggests that *aloe vera gel* should be used more frequently due to its adaptability to environmental factors like temperature, humidity, and light as well as possible sensitivity to compounds (Alizadeh-Sani et al., 2020). Due to the honey's sweetness, termite attacks on *M.*

indica cuttings treated with it prevented them from developing shoots. Similarly, banana peels and honey may have prevented the development of shoots because of a concentration that was too high, which could have caused toxicity and harm to the cuttings.

Results showed that *Aloe vera gel* treated *P.americana* cuttings had the most shoots compared to honey, banana peel dynaroot, and control treatment, supporting a prior claim made by Svitina et al. (2019), regarding *Stevia rebaudiana.* In comparison to the control treatment, the Aloe vera gel-treated cuttings exhibited a significantly larger number of shoots per cutting and longer shoots. cuttings that had been Dynaroot treated were competitive with alovera for the quantity of shoots, thereby corroborating the earlier research by Babiker et al. (2019), on the growth of Roselle *(Hibiscus sabdariffa)* cuttings, which found that dynaroot-treated cuttings produced noticeably more shoots per cutting and longer shoots than control-treated cuttings. It's possible that some of the cuttings utilized were juveniles, which are not strong enough to form shoots, and that this is why other hormones are unable to do so. As a result of the sweetness of the honey, termites invaded and harmed the growth of the plant.

The study found that none of the hormones used to develop shoots in *C. sinensis* cuttings, this was in contrast to earlier studies by (Kuris et al., 1980), which found that all of the aforementioned hormones also had a significantly higher number of shoots per cutting and longer shoots compared to the control treatment. Failure may have been caused by employing an overly high or low concentration. While a dosage that is too low could not be beneficial in stimulating roots and growth, a concentration that is too high could be poisonous and harm the cuttings. The length of the cuttings' hormone exposure time may also have an impact on how they develop. Insufficient exposure time may prevent the proper uptake of the active chemicals, while prolonged exposure can harm the cuts. Climate variables including temperature, humidity, and light can also have an impact on how cuttings form. Cuts exposed to unfavorable climatic conditions may develop their shoots more slowly and exhibit species-specific responses. Not all plant species react to cuttings; other species respond better to seedlings.

The study on *E. abyssinica* cuttings showed that few shoots developed in *aloe vera gel*, which was somewhat similar to a previous study on *Stevia rebaudiana* by (Uddin et al., 2020), which found that cuttings treated with aloe vera gel had significantly more shoots per cutting and longer shoots than cuttings treated with control. While in dynaroot, honey, banana peel, and control they do not produce shoots, this may be because of the species' reaction to the hormones supplied, or perhaps they respond fast to alternative propagation methods. The level of focus used should be modest. Long-term exposure can harm the tissues, whilst short-term exposure may prevent the proper uptake of the active chemicals.

None of the hormones encourage shoot development in *B. madagascariensis* cuttings, which is inconsistent with earlier research on *Pelargonium graveolens, Solanum lycopersicum, and Syzygium cumini* by Ali and Ashraf (2019), Kaur and Arora (2019), Gowthami et al. (2017), and Moyo et al. (2016), demonstrates that compared to the control treatment, cuttings treated with banana peel, honey, *aloe vera gel*, and dynaroot also significantly produced more shoots per cutting and longer shoots. The influences of seasonality, the type of propagation technique, and the caliber of the cuttings utilized can all have an effect on how the plant develops. Even when treated with a rooting hormone, cuttings taken from unwell or diseased plants may have slower development.

The findings showed that *C.abbreviata* cuttings were significantly changed by *aloe vera gel* treatment; with the maximum shoot number of (2.00 ± 0,00) , this was comparable to the *Stevia rebaudiana* study (Gantait et al.,2014), in comparison to the control treatment, the cuttings treated with aloe vera gel produced noticeably more and longer shoots per cutting. Dynaroot outperformed alovera in terms of competitiveness, supporting a claim made earlier (Ntombekhaya et al., 2017), on *Pelargonium graveolens*, in comparison to the control treatment, cuttings treated with dynaroot also produced noticeably more and longer shoots per cutting. All hormones produced shoots for *C. abbreviata* cuttings; this may be due to the plant's tolerance to environmental conditions including temperature, humidity, and sunlight disease- and pest-resistant.

5.2 SURVIVAL RATE OF CUTTINGS TREATED WITH GROWTH HORMONES

According to the study by Shen et al. (2008), *M. indica* cuttings have a lower survival rate of 10% for all treatments up to f This is contrary to previous research(Van Wyk et al., 2011), on *Pelargonium graveolens* and *Withania somnifera*, which found that cuttings treated with *Aloe vera gel*, honey, banana peel, and dynaroot had a significantly higher survival rate (93.33%) than the control treatment. It's possible that employing an overly high or low concentration was the cause of the failure. A concentration that is either too high or too low might have negative effects on the cuttings, including toxicity and damage. A concentration that is too low could not be as effective at encouraging roots and growth. Environmental elements like temperature, humidity and sunlight also maybe be considered.

The results for *P. americana* cuttings showed that control had a high survival rate of 20%, while those treated with *aloe vera gel*, honey, banana peel, and dynaroot had less than 10% survival rates. This was in contrast to a previous study by (Rakibuzzaman et al., 2018), on *Stevia rebaudiana*, which found that control had the lowest survival rate of 5% when compared to other hormones. This may be a result of the plant's ability to adapt to its surroundings, and the failure may also be related to the cuttings' quality, which may have affected the growth. Even when given a rooting hormone treatment, cuttings derived from ill or diseased plants may have a lower survival rate and exhibit slower development. Some species may be more sensitive to pest and diseases.

The results for *C.sinensis* cuttings indicate that they did not survive in all treatments it had 5%, which is inconsistent with earlier studies by (Moabelo et al.,2022) claimed that in CUR-21 guava cuttings had high survival rate of 87% when compared to control and improved the survival rate with 70 %. In comparison to controls, *Jatropha curcas* cuttings exhibited higher survival rates of 80% when treated with fermented banana peel extract, according to (Rajan & Singh, 2021). *Aloe vera gel* improved *Bougainvillea* cutting survival rates by 90% when compared to controls, according to Singh et al. (2011).Umer et al. (2018), discovered that honey improved *F. benjamina* cutting survival rate of 99% compared to IBA. Honey's nutrients and growth regulators likely helped roots develop and establish themselves, which increased survival rates. Failure could have occurred as a result of utilizing an extremely high or low concentration, among other things. While a dosage that is too low could not be beneficial in stimulating roots and growth, a concentration that is too high could be poisonous and harm the cuttings. Climate variables including temperature, humidity, and light can also have an impact on how cuttings form. Not all plant species react to cuttings; other species respond better to seedlings.

According to the data on the survival rate of *E. abyssinica* cuttings obtained 15% it was low for all hormones. This finding is consistent with a recent study by Sultana et al. (2017), which revealed no evidence of a substantial impact of dynaroot on survival rate which yields 5% and rooting of jackfruit cuttings. The plant species and concentrations seem to affect the effects. A concentration that is either too high or too low might have negative effects on the cuttings, including toxicity and damage. A concentration that is too low could not be as effective at encouraging roots and growth. Cutting development can also be impacted by environmental elements as temperature, humidity, and light.

In contrast to a previous study by (Kalanzi & Mwanja, 2023), which indicated that honey boosted survival rate by 75%, of *Ficus benjamina* cuttings compared to IBA, *B. madagascariensis* cuttings demonstrate no significant influence of dynaroot, honey, banana peel, and *aloe vera gel* on survival rate. In comparison to controls, *Jatropha curcas* cuttings survived more in honey with 99% survival rate,(Lustosa Sobrinho et al., 2022) according to research. According to (Pholo et al., 2012), dynaroot application enhanced the quantity of cuttings and raised the survival rate of CUR-21 guava cuttings by 70% when compared to control. Failure reasons might be because toxicity and harm to the cuttings might result from high concentrations, while roots and growth can be hindered by low concentrations. Climate variables including temperature, humidity, and light can also have an impact on how cuttings form. Not all plant species react to the procedure of cuttings, other species only respond to seedlings.

For cuttings of *C.abbreviata* cutting survival rates were high in banana peel for about 60%, which was consistent with a prior study by (Mulaei et al., 2020)that indicated banana peel treated *Jatropha curcas* cuttings had high survival rate of 90% than control samples. The endogenous auxin and other chemicals in the fermented peel probably encouraged root growth and facilitated cutting establishment, resulting in increased survival. Compared to IBA therapy, the effects were stronger. Aloe vera gel includes nutrients and growth regulators that can increase survival rate of 90% in *Bougainvillea* cuttings compared to control(Rajan & Singh, 2021).Alovera and dynaroot had a competitive value to banana peel. Dynaroot, which contains the synthetic auxin IBA and thiamine, has been observed to enhance survival rate by 85% and in CUR-21 guava cuttings compared to control, honey and control also showed high survival rate. This was supported by (Rajan & Singh, 2021) Olive tree cutting survival rates of 65%and root growth have been found to be improved by honey, which contains sugars, amino acids, and growth regulators. The results might be attributable to the plant's ability to respond to environmental changes and be pest- and disease-resistant.

5:3 ROOT DEVELOPMENT OF CUTTINGS TREATED WITH HORMONES

No rooting occurred for any species in either of the four treatments, which is in contrast to a previous study by Sood et al. (2012), Ghani et al. (2012), Moyo et al. (2016), and Gowthami et al. (2017), found that cuttings treated with *aloe vera gel*, honey, dynaroot, and banana peel had significantly more roots per cutting and longer roots than cuttings treated with the control. The failure may have been caused by the incorrect seasonality of cutting propagation; the cuttings prefer winter temperatures but were planted in summer. Cutting development may suffer if a concentration is used that is too high or low. While a dosage that is too low could not be beneficial in stimulating roots and growth, a concentration that is too high could be poisonous and harm the cuttings. The length of time the cuttings are exposed to the banana peel extract can also have an impact on how they grow. Long-term exposure can harm the clippings, whilst short-term exposure may prevent the proper uptake of the extract's active ingredients. Climate variables including temperature, humidity, and light can also have an impact on how cuttings form. Even when treated with root hormones, cuttings exposed to poor environmental conditions may establish their roots more slowly. Additionally, how well the cuttings are might have an effect on how they grow. Even when treated with a rooting hormone, cuttings taken from unwell or diseased plants may have a lower survival rate and slower development. Different plant species react differently to banana peel extract. Some species may respond to the hormones' active ingredients more strongly than others, depending on the species.

Chapter 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The best method for preserving particular features in different tree species is through vegetative propagation. Natural and artificial growth hormone growth used in plant propagation and have been shown to have positive effects on rooting, survival and shoot development in many tree species. Despite the fact that some artificial hormones have been shown to encourage the development of stem cuttings' shoots, the current study found that natural hormone (*Aloe vera gel)*-treated cuttings responded better in terms of shooting development and survival rate in cuttings of some tree species, such as *C. abbreviata*, *E. abyssinica* and *P. americana* than cuttings treated with other hormones. Therefore, it is advised to apply natural hormone to promote the optimal development of this species' stem cuttings. There is evidence to suggest that the use of artificial and natural growth hormones can have a positive influence on the nursery performance of selected tree species cuttings. However, the effectiveness of these hormones can vary depending on the species, the concentration and timing of application, and environmental factors.

Overall, the use of growth hormones can be beneficial for the nursery performance of selected tree species cuttings, it is important to consider the specific needs of each species and to carefully manage the concentration and timing of hormone application to achieve optimal results. Additionally, it is important to consider the potential environmental impacts of using synthetic growth hormones such as dynaroot and to explore more sustainable alternatives, such as natural growth promoters and other plant bio stimulants.

6.2 RECOMMENDATIONS

The study recommend the foresters to use natural hormones which shows variability particularly *alovera gel*, which yields a better results on shoot development of cuttings, also they are locally available and cheap to use than artificial growth hormones. The effectiveness of these hormones can vary depending on the species, the concentration and timing of application, and environmental factors However, the researcher recommends further studies on the best hormone to use also on the good season of period.

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APPENDICES

Appendix 1 Post hoc analysis: comparison of growth hormones on shoot development

Multiple Comparisons

LSD

Dependent Variable	(I) shootdevelopment	(J) shootdevelopment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Alovera	1	2	-1.50000	.86603	.134	-3.6191	.6191
		3	1.00000	.86603	.292	-1.1191	3.1191
		4	-1.00000	.86603	.292	-3.1191	1.1191
		5	1.00000	.86603	.292	-1.1191	3.1191
		6	-3.00000*	.86603	.013	-5.1191	-.8809
	2	1	1.50000	.86603	.134	-.6191	3.6191
		3	2.50000*	.86603	.028	.3809	4.6191
		4	.50000	.86603	.585	-1.6191	2.6191
		5	2.50000*	.86603	.028	.3809	4.6191
		6	-1.50000	.86603	.134	-3.6191	.6191
	3	1	-1.00000	.86603	.292	-3.1191	1.1191
		2	-2.50000*	.86603	.028	-4.6191	-.3809
		4	-2.00000	.86603	.060	-4.1191	.1191
		5	.00000	.86603	1.000	-2.1191	2.1191
		6	-4.00000*	.86603	.004	-6.1191	-1.8809
	4	1	1.00000	.86603	.292	-1.1191	3.1191
		2	-.50000	.86603	.585	-2.6191	1.6191

		3	2.00000	.86603	.060	-.1191	4.1191
		5	2.00000	.86603	.060	-.1191	4.1191
		6	-2.00000	.86603	.060	-4.1191	.1191
	5	1	-1.00000	.86603	.292	-3.1191	1.1191
		2	-2.50000*	.86603	.028	-4.6191	-.3809
		3	.00000	.86603	1.000	-2.1191	2.1191
		4	-2.00000	.86603	.060	-4.1191	.1191
		6	-4.00000*	.86603	.004	-6.1191	-1.8809
	6	1	3.00000*	.86603	.013	.8809	5.1191
		2	1.50000	.86603	.134	-.6191	3.6191
		3	4.00000*	.86603	.004	1.8809	6.1191
		4	2.00000	.86603	.060	-.1191	4.1191
		5	4.00000*	.86603	.004	1.8809	6.1191
honey	1	2	.00000	.28868	1.000	-.7064	.7064
		3	.00000	.28868	1.000	-.7064	.7064
		4	.00000	.28868	1.000	-.7064	.7064
		5	.00000	.28868	1.000	-.7064	.7064
		6	-1.50000*	.28868	.002	-2.2064	-.7936
	2	1	.00000	.28868	1.000	-.7064	.7064
		3	.00000	.28868	1.000	-.7064	.7064
		4	.00000	.28868	1.000	-.7064	.7064
		5	.00000	.28868	1.000	-.7064	.7064
		6	-1.50000*	.28868	.002	-2.2064	-.7936
	3	1	.00000	.28868	1.000	-.7064	.7064
		2	.00000	.28868	1.000	-.7064	.7064
		4	.00000	.28868	1.000	-.7064	.7064
		5	.00000	.28868	1.000	-.7064	.7064

		6	-1.50000*	.28868	.002	-2.2064	-.7936
		1	.00000	.28868	1.000	-.7064	.7064
		2	.00000	.28868	1.000	-.7064	.7064
	4	3	.00000	.28868	1.000	-.7064	.7064
		5	.00000	.28868	1.000	-.7064	.7064
		6	-1.50000*	.28868	.002	-2.2064	-.7936
		1	.00000	.28868	1.000	-.7064	.7064
		2	.00000	.28868	1.000	-.7064	.7064
	5	3	.00000	.28868	1.000	-.7064	.7064
		4	.00000	.28868	1.000	-.7064	.7064
		6	-1.50000*	.28868	.002	-2.2064	-.7936
		1	1.50000*	.28868	.002	.7936	2.2064
		2	1.50000*	.28868	.002	.7936	2.2064
	6	3	1.50000*	.28868	.002	.7936	2.2064
		4	1.50000*	.28868	.002	.7936	2.2064
		5	1.50000*	.28868	.002	.7936	2.2064
		2	-2.50000*	.70711	.012	-4.2302	-.7698
		3	.00000	.70711	1.000	-1.7302	1.7302
	1	4	-.50000	.70711	.506	-2.2302	1.2302
		5	.00000	.70711	1.000	-1.7302	1.7302
		6	-3.00000*	.70711	.005	-4.7302	-1.2698
		1	2.50000*	.70711	.012	.7698	4.2302
dynaroots		3	2.50000*	.70711	.012	.7698	4.2302
	2	4	2.00000*	.70711	.030	.2698	3.7302
		5	2.50000*	.70711	.012	.7698	4.2302
		6	-.50000	.70711	.506	-2.2302	1.2302
		1	.00000	.70711	1.000	-1.7302	1.7302
	3	2	-2.50000*	.70711	.012	-4.2302	-.7698
		4	-.50000	.70711	.506	-2.2302	1.2302

		5	.00000	.70711	1.000	-1.7302	1.7302
		6	-3.00000*	.70711	.005	-4.7302	-1.2698
	4	1	.50000	.70711	.506	-1.2302	2.2302
		2	-2.00000*	.70711	.030	-3.7302	-.2698
		3	.50000	.70711	.506	-1.2302	2.2302
		5	.50000	.70711	.506	-1.2302	2.2302
		6	-2.50000*	.70711	.012	-4.2302	-.7698
	5	1	.00000	.70711	1.000	-1.7302	1.7302
		2	-2.50000*	.70711	.012	-4.2302	-.7698
		3	.00000	.70711	1.000	-1.7302	1.7302
		4	-.50000	.70711	.506	-2.2302	1.2302
		6	-3.00000*	.70711	.005	-4.7302	-1.2698
	6	1	3.00000*	.70711	.005	1.2698	4.7302
		2	.50000	.70711	.506	-1.2302	2.2302
		3	3.00000*	.70711	.005	1.2698	4.7302
		4	2.50000*	.70711	.012	.7698	4.2302
		5	3.00000*	.70711	.005	1.2698	4.7302
bananapeal	1	2	.00000	.40825	1.000	-.9989	.9989
		3	.00000	.40825	1.000	-.9989	.9989
		4	-.50000	.40825	.267	-1.4989	.4989
		5	.00000	.40825	1.000	-.9989	.9989
		6	-2.50000*	.40825	.001	-3.4989	-1.5011
	2	1	.00000	.40825	1.000	-.9989	.9989
		3	.00000	.40825	1.000	-.9989	.9989
		4	-.50000	.40825	.267	-1.4989	.4989
		5	.00000	.40825	1.000	-.9989	.9989
		6	-2.50000*	.40825	.001	-3.4989	-1.5011
	3	1	.00000	.40825	1.000	-.9989	.9989
		2	.00000	.40825	1.000	-.9989	.9989

		4	-.50000	.40825	.267	-1.4989	.4989
		5	.00000	.40825	1.000	-.9989	.9989
		6	-2.50000*	.40825	.001	-3.4989	-1.5011
	4	1	.50000	.40825	.267	-.4989	1.4989
		2	.50000	.40825	.267	-.4989	1.4989
		3	.50000	.40825	.267	-.4989	1.4989
		5	.50000	.40825	.267	-.4989	1.4989
		6	-2.00000*	.40825	.003	-2.9989	-1.0011
	5	1	.00000	.40825	1.000	-.9989	.9989
		2	.00000	.40825	1.000	-.9989	.9989
		3	.00000	.40825	1.000	-.9989	.9989
		4	-.50000	.40825	.267	-1.4989	.4989
		6	-2.50000*	.40825	.001	-3.4989	-1.5011
	6	1	2.50000*	.40825	.001	1.5011	3.4989
		2	2.50000*	.40825	.001	1.5011	3.4989
		3	2.50000*	.40825	.001	1.5011	3.4989
		4	2.00000*	.40825	.003	1.0011	2.9989
		5	2.50000*	.40825	.001	1.5011	3.4989
control	1	2	-1.00000	1.08012	.390	-3.6430	1.6430
		3	.50000	1.08012	.660	-2.1430	3.1430
		4	-.50000	1.08012	.660	-3.1430	2.1430
		5	.50000	1.08012	.660	-2.1430	3.1430
		6	-1.50000	1.08012	.214	-4.1430	1.1430
	2	1	1.00000	1.08012	.390	-1.6430	3.6430
		3	1.50000	1.08012	.214	-1.1430	4.1430
		4	.50000	1.08012	.660	-2.1430	3.1430
		5	1.50000	1.08012	.214	-1.1430	4.1430
		6	-.50000	1.08012	.660	-3.1430	2.1430

	1	-.50000	1.08012	.660	-3.1430	2.1430
	2	-1.50000	1.08012	.214	-4.1430	1.1430
3	4	-1.00000	1.08012	.390	-3.6430	1.6430
	5	.00000	1.08012	1.000	-2.6430	2.6430
	6	-2.00000	1.08012	.114	-4.6430	.6430
	1	.50000	1.08012	.660	-2.1430	3.1430
	2	-.50000	1.08012	.660	-3.1430	2.1430
4	3	1.00000	1.08012	.390	-1.6430	3.6430
	5	1.00000	1.08012	.390	-1.6430	3.6430
	6	-1.00000	1.08012	.390	-3.6430	1.6430
	1	-.50000	1.08012	.660	-3.1430	2.1430
	2	-1.50000	1.08012	.214	-4.1430	1.1430
5	3	.00000	1.08012	1.000	-2.6430	2.6430
	4	-1.00000	1.08012	.390	-3.6430	1.6430
	6	-2.00000	1.08012	.114	-4.6430	.6430
	1	1.50000	1.08012	.214	-1.1430	4.1430
	2	.50000	1.08012	.660	-2.1430	3.1430
6	3	2.00000	1.08012	.114	-.6430	4.6430
	4	1.00000	1.08012	.390	-1.6430	3.6430
	5	2.00000	1.08012	.114	-.6430	4.6430

*. The mean difference is significant at the 0.05 level.

Appendix 2 survival rate of cuttings treated with growth hormones

Multiple Comparisons

LSD

Dependent Variable	(I) survivalrate	(J) survivalrate	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Alovera	1	2	13.50000*	4.23281	.019	3.1427	23.8573
		3	-4.00000	4.23281	.381	-14.3573	6.3573
		4	11.00000*	4.23281	.041	.6427	21.3573
		5	14.50000*	4.23281	.014	4.1427	24.8573
		6	-14.50000*	4.23281	.014	-24.8573	-4.1427
	2	1	-13.50000*	4.23281	.019	-23.8573	-3.1427
		3	-17.50000*	4.23281	.006	-27.8573	-7.1427
		4	-2.50000	4.23281	.576	-12.8573	7.8573
		5	1.00000	4.23281	.821	-9.3573	11.3573
		6	-28.00000*	4.23281	.001	-38.3573	-17.6427
	3	1	4.00000	4.23281	.381	-6.3573	14.3573
		2	17.50000*	4.23281	.006	7.1427	27.8573
		4	15.00000*	4.23281	.012	4.6427	25.3573
		5	18.50000*	4.23281	.005	8.1427	28.8573
		6	-10.50000*	4.23281	.048	-20.8573	-.1427
	4	1	-11.00000*	4.23281	.041	-21.3573	-.6427
		2	2.50000	4.23281	.576	-7.8573	12.8573
		3	-15.00000*	4.23281	.012	-25.3573	-4.6427
		5	3.50000	4.23281	.440	-6.8573	13.8573
		6	-25.50000*	4.23281	.001	-35.8573	-15.1427

	5	1	-14.50000*	4.23281	.014	-24.8573	-4.1427
		2	-1.00000	4.23281	.821	-11.3573	9.3573
		3	-18.50000*	4.23281	.005	-28.8573	-8.1427
		4	-3.50000	4.23281	.440	-13.8573	6.8573
		6	-29.00000*	4.23281	.000	-39.3573	-18.6427
	6	1	14.50000*	4.23281	.014	4.1427	24.8573
		2	28.00000*	4.23281	.001	17.6427	38.3573
		3	10.50000*	4.23281	.048	.1427	20.8573
		4	25.50000*	4.23281	.001	15.1427	35.8573
		5	29.00000*	4.23281	.000	18.6427	39.3573
honey	1	2	3.00000	8.36660	.732	-17.4723	23.4723
		3	-12.50000	8.36660	.186	-32.9723	7.9723
		4	-4.00000	8.36660	.650	-24.4723	16.4723
		5	-.50000	8.36660	.954	-20.9723	19.9723
		6	-25.00000*	8.36660	.024	-45.4723	-4.5277
	2	1	-3.00000	8.36660	.732	-23.4723	17.4723
		3	-15.50000	8.36660	.113	-35.9723	4.9723
		4	-7.00000	8.36660	.435	-27.4723	13.4723
		5	-3.50000	8.36660	.690	-23.9723	16.9723
		6	-28.00000*	8.36660	.015	-48.4723	-7.5277
	3	1	12.50000	8.36660	.186	-7.9723	32.9723
		2	15.50000	8.36660	.113	-4.9723	35.9723
		4	8.50000	8.36660	.349	-11.9723	28.9723
		5	12.00000	8.36660	.201	-8.4723	32.4723
		6	-12.50000	8.36660	.186	-32.9723	7.9723
	4	1	4.00000	8.36660	.650	-16.4723	24.4723
		2	7.00000	8.36660	.435	-13.4723	27.4723
		3	-8.50000	8.36660	.349	-28.9723	11.9723

		5	3.50000	8.36660	.690	-16.9723	23.9723
		6	-21.00000*	8.36660	.046	-41.4723	-.5277
	5	1	.50000	8.36660	.954	-19.9723	20.9723
		2	3.50000	8.36660	.690	-16.9723	23.9723
		3	-12.00000	8.36660	.201	-32.4723	8.4723
		4	-3.50000	8.36660	.690	-23.9723	16.9723
		6	-24.50000*	8.36660	.026	-44.9723	-4.0277
	6	1	25.00000*	8.36660	.024	4.5277	45.4723
		2	28.00000*	8.36660	.015	7.5277	48.4723
		3	12.50000	8.36660	.186	-7.9723	32.9723
		4	21.00000*	8.36660	.046	.5277	41.4723
		5	24.50000*	8.36660	.026	4.0277	44.9723
dynaroots	1	2	9.50000	6.75154	.209	-7.0204	26.0204
		3	-11.00000	6.75154	.154	-27.5204	5.5204
		4	6.50000	6.75154	.373	-10.0204	23.0204
		5	8.50000	6.75154	.255	-8.0204	25.0204
		6	-22.00000*	6.75154	.017	-38.5204	-5.4796
	2	1	-9.50000	6.75154	.209	-26.0204	7.0204
		3	-20.50000*	6.75154	.023	-37.0204	-3.9796
		4	-3.00000	6.75154	.672	-19.5204	13.5204
		5	-1.00000	6.75154	.887	-17.5204	15.5204
		6	-31.50000*	6.75154	.003	-48.0204	-14.9796
	3	1	11.00000	6.75154	.154	-5.5204	27.5204
		2	20.50000*	6.75154	.023	3.9796	37.0204
		4	17.50000*	6.75154	.041	.9796	34.0204
		5	19.50000*	6.75154	.028	2.9796	36.0204
		6	-11.00000	6.75154	.154	-27.5204	5.5204
	4	1	-6.50000	6.75154	.373	-23.0204	10.0204
		2	3.00000	6.75154	.672	-13.5204	19.5204

		3	-17.50000*	6.75154	.041	-34.0204	-.9796
		5	2.00000	6.75154	.777	-14.5204	18.5204
		6	-28.50000*	6.75154	.006	-45.0204	-11.9796
	5	1	-8.50000	6.75154	.255	-25.0204	8.0204
		2	1.00000	6.75154	.887	-15.5204	17.5204
		3	-19.50000*	6.75154	.028	-36.0204	-2.9796
		4	-2.00000	6.75154	.777	-18.5204	14.5204
		6	-30.50000*	6.75154	.004	-47.0204	-13.9796
	6	1	22.00000*	6.75154	.017	5.4796	38.5204
		2	31.50000*	6.75154	.003	14.9796	48.0204
		3	11.00000	6.75154	.154	-5.5204	27.5204
		4	28.50000*	6.75154	.006	11.9796	45.0204
		5	30.50000*	6.75154	.004	13.9796	47.0204
bananapeal	1	2	7.50000	8.61201	.417	-13.5728	28.5728
		3	-3.50000	8.61201	.699	-24.5728	17.5728
		4	3.00000	8.61201	.739	-18.0728	24.0728
		5	2.50000	8.61201	.781	-18.5728	23.5728
		6	-34.50000*	8.61201	.007	-55.5728	-13.4272
	2	1	-7.50000	8.61201	.417	-28.5728	13.5728
		3	-11.00000	8.61201	.249	-32.0728	10.0728
		4	-4.50000	8.61201	.620	-25.5728	16.5728
		5	-5.00000	8.61201	.583	-26.0728	16.0728
		6	-42.00000*	8.61201	.003	-63.0728	-20.9272
	3	1	3.50000	8.61201	.699	-17.5728	24.5728
		2	11.00000	8.61201	.249	-10.0728	32.0728
		4	6.50000	8.61201	.479	-14.5728	27.5728
		5	6.00000	8.61201	.512	-15.0728	27.0728
		6	-31.00000*	8.61201	.011	-52.0728	-9.9272
	4	1	-3.00000	8.61201	.739	-24.0728	18.0728

		2	4.50000	8.61201	.620	-16.5728	25.5728
		3	-6.50000	8.61201	.479	-27.5728	14.5728
		5	-.50000	8.61201	.956	-21.5728	20.5728
		6	-37.50000*	8.61201	.005	-58.5728	-16.4272
		1	-2.50000	8.61201	.781	-23.5728	18.5728
		2	5.00000	8.61201	.583	-16.0728	26.0728
	5	3	-6.00000	8.61201	.512	-27.0728	15.0728
		4	.50000	8.61201	.956	-20.5728	21.5728
		6	-37.00000*	8.61201	.005	-58.0728	-15.9272
		1	34.50000*	8.61201	.007	13.4272	55.5728
		2	42.00000*	8.61201	.003	20.9272	63.0728
	6	3	31.00000*	8.61201	.011	9.9272	52.0728
		4	37.50000*	8.61201	.005	16.4272	58.5728
		5	37.00000*	8.61201	.005	15.9272	58.0728
		2	-3.50000	9.08754	.713	-25.7364	18.7364
		3	-32.00000*	9.08754	.012	-54.2364	-9.7636
	1	4	-6.50000	9.08754	.501	-28.7364	15.7364
		5	-5.00000	9.08754	.602	-27.2364	17.2364
		6	-23.50000*	9.08754	.041	-45.7364	-1.2636
		1	3.50000	9.08754	.713	-18.7364	25.7364
control		3	-28.50000*	9.08754	.020	-50.7364	-6.2636
	2	4	-3.00000	9.08754	.753	-25.2364	19.2364
		5	-1.50000	9.08754	.874	-23.7364	20.7364
		6	-20.00000	9.08754	.070	-42.2364	2.2364
		1	32.00000*	9.08754	.012	9.7636	54.2364
	3	2	28.50000*	9.08754	.020	6.2636	50.7364
		4	25.50000*	9.08754	.031	3.2636	47.7364

		5	27.00000*	9.08754	.025	4.7636	49.2364
		6	8.50000	9.08754	.386	-13.7364	30.7364
		1	6.50000	9.08754	.501	-15.7364	28.7364
		2	3.00000	9.08754	.753	-19.2364	25.2364
	4	3	-25.50000*	9.08754	.031	-47.7364	-3.2636
		5	1.50000	9.08754	.874	-20.7364	23.7364
		6	-17.00000	9.08754	.111	-39.2364	5.2364
		1	5.00000	9.08754	.602	-17.2364	27.2364
		2	1.50000	9.08754	.874	-20.7364	23.7364
	5	3	-27.00000*	9.08754	.025	-49.2364	-4.7636
		4	-1.50000	9.08754	.874	-23.7364	20.7364
		6	-18.50000	9.08754	.088	-40.7364	3.7364
		1	23.50000*	9.08754	.041	1.2636	45.7364
		2	20.00000	9.08754	.070	-2.2364	42.2364
	6	3	-8.50000	9.08754	.386	-30.7364	13.7364
		4	17.00000	9.08754	.111	-5.2364	39.2364
		5	18.50000	9.08754	.088	-3.7364	40.7364

*. The mean difference is significant at the 0.05 level.