Effects of *Litsea glutinosa* (Lour.) C.B. Rob. plant biowaste-derived media on plant growth and development of thyme and rocket

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ABSTRACT

Enhancing and sustaining agricultural productivity is critical, as soil quality in many parts of the world deteriorates becoming unsuitable for agriculture. Plant bio-waste derived from composted alien invasives could be recycled and reused to enrich media used for plant production. This bio-waste could improve soil fertility and thereby enhance agricultural productivity. KwaZulu-Natal (KZN) is threatened by numerous alien invasive plants which negatively impact on the natural environment, human welfare and quality of life. Biological plant invasion is a natural process; however, human intervention has accelerated the rate of spread and naturalisation of many species across a multitude of landscapes. Composting some species of such alien invasives into bio-waste has been reported as a viable source of nutrients and organic matter. Farmers can, therefore, use these outputs as livestock-feed products and/or fertilizer for crops. The purpose of this study was to assess the effects of compost, derived from the IAPs (invasive alien plant species) - *Litsea glutinosa* – (Lour.) C.B. Rob., as enrichment for plant growth and development of two herb species, *Thymus vulgaris* (thyme) and *Eruca sativa* (rocket).

This experimental study was conducted using three media into which rocket and thyme were planted: control medium (Gromor® Potting Soil, PS); experimental medium (composted *Litsea*, EM) and a combination (1:1) of control and enriched medium (PSEM). This study was carried out over three growing periods: eight-week experiments between April and May (autumn to winter), between September and October (winter into spring) and between February and March (summer into autumn). Composting of *Litsea glutinosa* plants was started at a vacant site in Verulam (KZN) before being moved to the experimental study site, at the Durban University of Technology Horticultural Practical Centre. Five replicates per treatment of the rocket and thyme plants were planted in the three media (PS, EM and PSEM). The following measurements were taken to assess plant growth and development: leaf diameter and plant height (rocket) and length of side shoot and plant height (thyme). Fresh and dry mass (g) were determined and the concentrations of total chlorophylls and carotenoids were measured spectrophotometrically.

The growth of the thyme plants was positively influenced by cultivating the plants in EM and PSEM media resulting in increased plant height and length of side shoots, growth parameters significant for the culinary and cosmetic thyme industry. The leaf diameter of rocket was positively influenced when grown in the winter to spring period, particularly when cultivated in the PSEM medium compared with PS. Rocket displayed the most vigorous growth (fresh and dry mass of rocket leaves) during the winter to spring period when grown in PSEM. Results showed that herbs grew similarly in PS and PSEM media. It is, therefore, feasible to use PSEM as a medium for thyme production. Thyme grew best in EM in the autumn season (April-May), while PSEM performed best when used in summer/autumn (February-March). Thyme, therefore, grows well in this composted IAP in the summer and autumn months, rather than in winter or spring. The chlorophyll concentration of rocket plants was also affected by the season (highest concentration in plants grown during summer months) and medium (highest concentration in plants grown in PS) compared with PSEM and EM, as plants grew slowly and showed low values of pigment concentrations. Growing rocket and thyme in the composted *Litsea glutinosa* did not affect the taste and texture of the leaves determined by the consumer evaluation panel.

Litsea glutinosa compost used to enrich potting soil (PSEM) was beneficial to the growth and development of rocket as well as thyme. Therefore, this study recommends the use of composted IAPs mixed in a 1:1 ratio with a general potting soil which would benefit the environment, the ornamental industry, as well as nurseries/wholesalers. A higher dosage of the composted *Litsea glutinosa* in a PSEM medium should be experimented with to grow thyme plants, while the potting soil is better suited to grow rocket plants. This study, therefore, highlights the usefulness of composted plant bio-waste derived from alien invasive plants as enrichment of media for growing herbs for human consumption.

DECLARATION

I hereby declare that the experimental work described in this dissertation was conducted at the University of KwaZulu-Natal, Pietermaritzburg as well as the Durban University of Technology, Durban campus, from 2015 to 2019, under the supervision of Professor I. Bertling (University of KwaZulu-Natal).

I, **Thagen Anumanthoo**, **Student No 215082652**, further declare that these studies are of my own independent original work and have not been submitted in any form to another tertiary institution. Where the work of others has been used, explicit referencing is appropriately provided in the text.

Signed: ______________________ Date: 17 March 2020

I hereby certify that this statement is correct.

Signed: ______________________ Date: 17 March 2020

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TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS

DEA – Department of Environmental Affairs

IAPs – Invasive Alien Plant species

Lg – *Litsea glutinosa* (Lour) C.B. Rob. (Indian Laurel)

WWP – Working for Water Programme

EPWP – Expanded Public Works Programme

EM – Composted *Litsea glutinosa*

PS - Gromor® Potting Soil

PSEM - Gromor® Potting Soil + Enriched Composted *Litsea glutinosa*

DoA - Department of Agriculture

LIST OF FIGURES

CHAPTER 1: GENERAL INTRODUCTION

1.1 Herb production

The demand for herbs on a local and international scale has increased due to the expansion in population as well as for the medicinal and health benefits that different herbs entail (Van der Veken et al., 2007) In the Egyptian era, different herbs, like frankincense, myrrh, lotus, poppy and cornflower were grown for religious ceremonies, mummification and spiritual/cultural centres (Koizumi, 1985). Islamic and Christian followers included herb gardens close to the buildings they stayed in and as the number of spiritual followers grew, the need for herbs became more prominent (Gamliel and Yarden, 1998). The development of towns and cities made herb production more demanding, catering for the increase in population and medicinal requirements (Hongzhang and Xiaowei, 2012). Universities and colleges became more research-orientated to explore different avenues of better and safer ways to grow herbs in a more commercialised way which could take care of the needs of the consumers (Craker et al., 2003). The production and exportation of herbs today is a commercial billion rand business to many growers in the green industry (Konczak et al., 2010).

Organic herb production is increasing due to the growing population as well as the demand for healthier foods which are safe to consume as organic food comprises 5.3% of the world's food sales which exceeds in value by 35 million dollars (Debertin, 2012). Organic food consumption increased by 8.4% which is due to the high demand for organic produce from restaurants, farmers' markets, community markets, food health awareness programmes, schools, universities and micro-breweries (Oberholtzer et al., 2005). The restaurant industry has over 1 million outlets servicing the entire population of the USA with a staff capacity of 14.7 million employees which is anticipated to increase by another 1.6 million by 2027 (Greene, 2013). The herb production industry is growing worldwide and the demand will continue to rise according to population density (Van Asselt et al., 2018).

Greenhouse and nursery production of herbs can be carried out during all seasons of the year with conditions suitable for growing due to the ability to control water supply, temperature, light and humidity in controlled environments, resulting in superior growth (Treadwell et al., 2007). A fully functional greenhouse requires mechanisms to control climatic conditions, including pest and disease management systems, to maximize growth and successfully produce the required quantities of herbs to supply the market (Burnett et al., 2016). These mechanisms are of high input cost and, therefore, experts are needed to manage and facilitate the production of herbs to get maximum profits and produce high-quality herbs (Manukyan, 2011). Therefore, the herb industry needs to find effective and alternative methods of growing herbs due to limited resources (Kummu et al., 2012).

Well-drained loam is the medium in which agricultural herbs and vegetables are currently grown. Such soils can be improved by enrichment with animal manure, compost and peat. A soil pH between 6 and 7 is optimal for the production of most gardens herbs (Burnett *et al.*, 2016). The costs involved in producing a soil of the required composition are high; therefore, the usage of composted IAPs as a medium or partial medium could be an alternative to the current media used. Certain IAPs are toxic, but most of them can be composted for plant growth as a result of their strength characteristics, high water holding capacity, air-filled porosity and high compositions of nutrients of a medium (Rai et al., 2012a).

1.2 Impact of IAPs

Invasive alien plants are plants introduced into a country unintentionally by means of spores or seeds being carried in food and by humans and animal life (Richardson et al., 2000). These plants are a major problem that can threaten human livelihoods, natural biodiversity and economic development (Brooks et al., 2004). Stakeholders of the agricultural and non-agricultural sectors need to understand the importance of controlling IAPs that are easily adaptable in natural habitats which disrupt the environment for indigenous species of plants to survive (McNeely, 2001). Due to the IAPs being difficult to control, the government provides guidelines for the best methods to control IAPs in South Africa (Van Wilgen et al., 2007). In terms of Section 4(2)(a) of the National Environmental Management: Biodiversity Act (NEMBA), all departments involved within the municipalities are required to conserve and manage the natural biodiversity of the country (Cullis et al., 2007). This includes managing IAPs with certain steps and frameworks which govern the procedures and policies of eradication and control (Von Schirnding et al., 2002). The costs involved to control IAPs are very high and are determined by the IAPs that are found in that specific area (Ivarsflaten and Parties, 2005). The mechanisms of seeding and dispersal of the IAPs are the main propagation means to increase the number of plants in that area which suppresses the natural plants (Van Wilgen et al., 2001). Seeds of the black wattle remain in the ground dormant for several years before germination (Roura-Pascual et al., 2009). Burning of IAPs induces germination due to the heat requirement of seeds to germinate (Keeley, 2006). Chemical control could reduce the spread of certain IAPs, but is very expensive (Marais et al., 2004). The residual from these chemicals also affects other indigenous plants and surrounding rivers and lakes supplying water for animals and humans (Schemske and Horvitz, 1988).

The Department of Environmental Affairs (DEA), of the South African Government, has actioned steps involved in the control, monitoring and eradication of IAPs of different species in certain areas which do not pose any impact on the natural resources (Moran et al., 2005). The methods used to control these IAPs should be implemented by preventing new growth to ensure that the environment concerned is kept in its natural state to continue the chain of events within the flora and fauna of South Africa (Ozer et al., 2007). The Minister of DEA in South Africa may establish an entity of public workers to control, prevent and eradicate IAPs wherever required (Jeong, 2004).

1.3 An alternative approach to eradicate IAPs

An alternative to the burning, spraying of herbicides, or manually or biologically removing IAPs, is to recycle the plant material produced by these IAPs by turning it into compost (Blignaut et al., 2007). Compost is made from a variety of biodegradable materials such as paper, untreated wood, livestock manure, green waste (leafy vegetables as well as grass clippings and leaves of trees) (Handreck et al., 2002). The compost generated acts as a cheaper and more environmentally friendly alternative to inorganic fertilizer that can be used in agriculture to grow certain produce (Rahman et al., 2014).

1.4 Composting IAPs

Compost additions to soil increase the organic matter of the soil and create a slower release of nutrients, such as phosphates, potassium, magnesium and sulphur (Stafford et al., 2018). Compost added to soil improves the water-holding capacity and drainage of media, allowing plants to grow at optimum capacity (Martínez-Blanco et al., 2013b). The soil structure then becomes more suitable for crop growth and development. The organic action of compost can repel pests and diseases within that soil (Cogger, 2005).

Compost can improve certain features of the soil by adding nutrients whilst inorganic fertilizers have a harmful effect on the environment and human life (Brown et al., 2015). The soil profile requires different micronutrients and macronutrients, rather than only the NPK (Cogger, 2005). The use of inorganic fertilizers requires water to dissolve it, and thus, can contaminate the underground water table (Agegnehu et al., 2016). Excessive nitrogen fertilizers may cause heart and cancer-related ailments in humans and affect plant life by consuming much of the oxygen which impacts on sea life, and, in turn, on humans who depend on this food source (Alvarenga et al., 2015). Organic compost is a source which adds most of the required nutrients for plant uptake without negatively impacting on the plant lifecycle (Martínez-Blanco *et al.*, 2013a). The pH levels of naturally acid soils are neutralized when organic compost is added, thus keeping the soil pH at an optimum level for growing herbs (Favoino and Hogg, 2008).

1.5 Layout of the study

This study consisted of growing rocket and thyme plants in three media mixes. Firstly, Gromor® Potting Soil, secondly, the experimental study included composted *Litsea glutinosa*. Thirdly the study consisted of the control - Gromor® Potting Soil and the experiment-composted *Litsea glutinosa* mixed.

1.6 Problem statement

The DEA, through the 'Working for Water' Programme, as well as smaller horticultural and agricultural organisations is moving towards recycling IAPs (Turpie, 2004). The different cycles occur through composting IAPs which has beneficial characteristics to improve soil fertility, however research on growing herbs in the media has not been completed (Meier et al., 2014). Any improvements to the soil using recycled plant material, which can enhance crop growth, can reduce costs and ultimately, increase profits for commercial and subsistence farmers who commercially grow these herbs (Rai et al., 2012b).

1.7 Hypothesis

Compost produced from *Litsea glutinosa* can be used as a fill or potential substitute of standard potting soil for the growth of *Thymus vulgaris* (thyme) and *Eruca sativa* (rocket) plants, without altering the growth and quality of the product.

Null hypothesis:

Organic media containing composted *Litsea glutinosa* have no impact on growth and taste or thyme and rocket.

Therefore, this study is an important contribution to the rapid implementation of legislation and policy by pointing out how these IAPs can be used in plant production.

CHAPTER 2: LITERATURE REVIEW

Means of eradicating invasive alien plant species

2.1 Impact of invasive alien plant species (IAPs) on the environment

Invasive alien plant species are an important aspect of global warming (Vilà et al., 2011). These species have been relocated from their original habitat without the assistance of people (Sun et al., 2017). They tend to spread quite rapidly in 'new' environments, outcompeting indigenous plants that are endemic to that area, as they fight for water, nutrients, lights and physical space, but lack natural enemies, diseases or animals that feed on them (Foxcroft et al., 2003, Lesoli et al., 2013, Liu et al., 2017, van Rensburg et al., 2017). Many noxious weeds have come to new regions through contaminated shipments of feed and seeds or were intentionally introduced as ornamental plants for horticultural use (Gulezian et al., 2012). These IAPs commonly use large amounts of natural resources (water, light, air, nitrogen) (Chamier et al., 2012). The more established these IAPs are in a certain area, the more difficult it is to eradicate them, as well as the stronger their impact on indigenous plants and the ecosystem, including animal life (Kueffer and Vos, 2003).

IAPs in different locations are managed differently according to their understanding as well as the local governments controlling methods (Gaertner et al., 2016). In Cape Town, Cape Nature contributes to control methods of IAPs by clearing the waterways, rivers and streams and using the produce to make furniture products (Moran *et al.*, 2005). The alien vegetation removal management programme teaches the local communities on how to identify IAPs, usage of chainsaws, health and safety, use of chemicals, nutrition and drug awareness (van Wilgen, 2012).

In South Africa, the Department of Environmental Affairs passed a Primary Act in 2004 which specifically manages IAPs. The minister published the Alien and Invasive Species Regulations in terms of section 97(1) of the National Environmental Management: Biodiversity Act 2004 (ACT NO. 10 OF 2004) to manage and control IAPs, Further to this, the negative aspect of IAPs is their potential to add to the severity of disasters by increasing floods (van Rensburg *et al.,* 2017) as they become competitors to indigenous flora and agricultural crops (Richardson and van Wilgen, 2004). The IAPs have high usages of the natural water resources as well as increasing the intensity of fire damages (Dorrough et al., 2018). Furthermore, IAPs are a major threat to natural biodiversity (Hejda et al., 2009), human livelihoods and economic development *(*Sun *et al.*, 2017). Most IAPs could, on the other hand, become useful and beneficial (Dorrough *et al.*, 2018), as food for human and animal consumption, for fibre and building material and their medicinal and pharmaceutical properties (Raj and Syriac, 2016).

Various habitats are impacted on by the infestation of IAPs that can have severe, negative effects on the indigenous flora and fauna, as well as on forestry and agricultural production, which, in turn, puts pressure on economic outputs (Potgieter et al., 2019). This is due to its wide distribution with indigenous plant species due to vigorous growth, ease of self-propagation and the resistance to pests and diseases (Omokhua et al., 2018). The growing habit of IAPs is commonly vigorous, as they multiply at a significant rate without the existence of natural controlling mechanisms (Heywood and Brunel, 2008). Many IAPs display mechanisms that allow them to compete well and grow vigorously in the habitat which they occupy with few or any natural enemies that can control and manage their spread (Zachariades et al., 2017). The fact that IAPs lack natural enemies, depending on the habitat they occupy, has had a tremendous impact of the surface water runoff, or intensification of wildfires due to the disruption of the natural environment and ecosystem (Allen et al., 1974).

In agriculture and forestry, IAPs populate areas and can outgrow indigenous plants; thus, their presence makes it practically impossible to eradicate them in these areas (Richardson and van Wilgen, 2004). Control mechanisms have then been employed to eradicate the problem plants over scheduled periods (Shrestha et al., 2018). Fire control programmes can be altered due to the flammability of certain IAPs, thus affecting soil composition when burnt (Görgens and van Wilgen, 2004). Fruit-bearing IAPs also add to the complexity of eradication strategies, as seeds can be randomly dispersed by birds and other animals (van Wilgen *et al.*, 2012). These IAPs often become more concentrated in indigenous forests because of the ease of entry and overcrowd the indigenous plants (Chamier *et al.*, 2012). Many IAPs are acclimatized to water systems, causing serious damage to the wastewater ecosystem by slowing downstream flow, blocking river and dam flows, thereby impacting on irrigation systems (Görgens and van Wilgen, 2004, Le Maitre et al., 2016). This, in turn, can impact on the water quality, restrict water sport and reduce the amount of water that can be used for irrigation (Chamier *et al.*, 2012). A high concentration of IAPs in properties depreciate that land value due to the high costs involved for their removal or eradication (Hejda *et al.*, 2009). Some IAPs are also dangerous and poisonous to human and animal life.

As a result of the potentially large negative effects of IAPs, the DEA passed the IAPs Act in KZN on all properties which list the species that need to be eradicated (Molewa, 2014). The

WFW-'Working for Water' programme, in conjunction with the DEA, aims to reduce and eradicate IAPs (Hussner et al., 2017). The WFW programme was launched in 1995 and managed through the Department of Water Affairs and Forestry, now run by the DEA (Coetzer and Louw, 2012). This programme initiated job opportunities and training for the local communities which reduced the unemployment rate (Bek et al., 2017), The WFW programmes were established in 1995 and currently resulted in over one billion hectares clearing of IAPs and the employment of over 20,000 people in the eradication and control sector, as well as the training sector, to educate communities about the negative impact most IAPs have on our natural environment (Van Wilgen et al., 1998). Over 300 projects in all nine provinces throughout South Africa try to manage, control and eradicate IAPs using the safest and quickest methods, including mechanical, chemical, biological and integrated control (Zimmermann et al., 2004). Following up from the initial control of the existing IAPs population, a follow-up is conducted where seedlings, root suckers and coppice growth are controlled and finally, maintenance control ensures continuity of the management system (Hobbs, 2004).

There are several areas (cultivated and non-cultivated) that are left without control measures due to lack of government funding and resources (Preston et al., 2018). The DEA spends about R6 billion every three years on this eradication programme, but not all areas infested with IAPs are targeted (Blignaut *et al.*, 2007). Other control measures employed to reduce the spread of IAPs are the prevention of IAPs entering a country, as well as preventing them from escaping from cultivation (Vilà et al., 2011). Research efforts need to guide these approaches by reducing the spread of IAPs through identification of alien species that pose serious threats to the environment at early stages, to learn more about these species to prevent them from expanding, to understand how they are able to invade new areas, to create new management techniques that can assist in reducing invasions and to maximize the use of these alien plants in certain areas for their beneficial properties (Pradeepa et al., 2013).

2.2 Ways to control IAPs in a horticultural green industry

2.2.1 Control methods for IAPs

Controlling and managing IAPs is of utmost importance to ensure that the plants do not distribute in an uncontrolled manner (Caplat et al., 2012). It is more difficult to manage and control an area infested with IAPs once it has been left for too long without any control (Culliney, 2005). The indigenous flora will have to compete for nutrients and water and the natural food reserves with IAPs (Blossey and Notzold, 1995). Control and management of IAPs have in the past been achieved through various systems (Potgieter *et al.,* 2019). These mechanisms or systems, including mechanical control, chemical control, biological control and habitat management, have certain advantages and disadvantages, depending on the method applied (Hussner *et al.*, 2017).

Mechanical control is more environmentally friendly to implement compared to chemical control techniques which cause harm to the other natural plants as well as the chemicals that find their way to rivers and waterways which kill water life (De Lange and van Wilgen, 2010). The government spends in the region of R6-6.5 billion per annum on IAP control which is 0.3% of South Africa GDP of the total R2,000 billion. If the IAP reach their full potential on growth, the government will have to allocate 5% of the GDP which will be detrimental in the management of the country (Van Wilgen and De Lange, 2011).

Mechanical control is associated with uprooting, tree felling, ring-barking and slashing unwanted IAPs (Hussner *et al.*, 2017), while chemical control tries to eradicate by applying herbicides directly to the problem plants or the soil around these plants *(*Marais *et al.*, 2004). These herbicides are either selective (only targeting a discrete group of species), or non-selective herbicides (Simmons et al., 2007). The advantage of chemical control is that it is effective and fast and, therefore, reduces the invasion quickly, but is expensive and labour-intensive (Potgieter *et al*., 2019). Certain safety precautions also need to be put in place, as these chemicals can present a danger to humans, animals and indigenous plants, therefore it is advisable to implement biological control which safeguards the natural environment (Raj and Syriac, 2016).

Biological control uses natural agents, such as mites, fungi or bacteria and a diverse range of insects, to target IAPs (Moran *et al*., 2013). Some of these natural agents do not kill the mother plant that needs to be controlled, but its reproduction is reduced, with the biological agent attacking flower buds, flowers or seeds, thereby preventing further distribution into neighbouring areas (Raj and Syriac, 2016). Natural agents can also bear certain disadvantages, such that IAPs become resistant to the biological control agent and, thus, the agent becomes inefficient (Van Vuuren, 2008). Some of the chemical applications are also not effective enough to control IAPs and, therefore, people and organisations are moving away from the chemical control system (Simberloff et al., 2013). The chemicals employed can be harmful to natural waterways and underground water leading to rivers and streams, which affects water and animal life that consumes the water, in turn, impacting on human life consuming these animals (Flory and Clay, 2009). Some IAPs are becoming resistant to chemicals used in the eradication which is a serious problem to the environment concerning the control and eradication of IAPs (Diggle et al., 2003). New agents will be required to combat IAPs, which leads to an even higher cost of eradication (van Wilgen *et al.*, 2012).

Habitat management is an IAP control method that includes animal grazing and controlled burning (Zimmermann *et al.*, 2004). Planning and monitoring are implemented in relation to the intensity of encroachment in certain areas (van Wilgen *et al.*, 2012). For quick control, farmers use animals they rear to feed on certain IAPs that are safe to eat, while government departments related to IAP control put burning schedules in place to prevent the natural environment being taken over by these IAPs (Foxcroft *et al.*, 2003).

2.2.2 Using IAPs to make compost

Compost is used on a commercial scale in many forms of plant agriculture, landscaping and the production of ornamental plants (Houot et al., 2002). Recycling 'plant waste' as compost, commonly carried out in nurseries and home gardens reduces the quantity of organic refuse (Hyatt and Richard, 1992). Composting requires the activity of different organisms: bacteria and fungi, as well as insects and earthworms. In China, the upper parts of the composted crofton weed (*Eupatorium adenophorum*) (stems, leaves, flowers and seed) are used in the manufacturing process of organic fertilizer (Li et al., 2008).

The requirements for an effective composting system are a certain moisture level, temperature, aeration, including particle size and carbon-to-nitrogen ratio of the nutrients to be composted to ensure efficient break-down/degradation of the material (Handreck and Black, 1984). About 40 to 50% of the entire composting pile/heap should be water so that microbes can thrive (Görgens and van Wilgen, 2004). The compost heap also needs ample aeration to ensure the movement of oxygen required by the microbes (Rosenberg and Linders, 2004). Mixing of the heap in intervals suited for the materials is important to allow speed and efficiency of oxygen to enter and fill up air spaces within the compost heap (Sommer and Dahl, 1999). The speed and efficiency of breakdown of the material composted are determined by the size of the particles as well as the temperature of the compost (Taghipour et al., 2008). For best decomposition, the composted material should be in the range of 40-50˚C to destroy any plant pathogens and germinating seeds from surviving the composting process (Adediran et al., 2003). Small particle size is important to allow quick breakdown, as microbes have a larger surface area to attack (Kariaga et al., 2012). The size of the material should also not be too small, for instance, sawdust has low aeration and, thus, the break-down process is hampered (Mor et al., 2006).

Plant compost can be derived from a multitude of materials. One of the most commonly form of compost used in South Africa is pine bark. This medium is mixed with other soil media which are mostly used in the agricultural and horticultural sectors for the production of herbs, vegetables and ornamental plants which includes flower seedlings.

2.3 Use of *Litsea glutinosa* as composting material

2.3.1 Botanical description of *Litsea glutinosa*-a prominent weed species on the East Coast of South Africa

Litsea glutinosa belongs to the Lauraceae family; it is an evergreen shrub/tree that can reach a height of 6 to10 m with an appearance similar to the avocado tree (*Persea americana*), also a member of Lauraceae (Perumal, 2014). The upper side of the leaf is lush green in colour, with a velvety appearance and thin hairs on the underside of the leaf (Agrawal et al., 2011). The leaves have leathery, acute/pointed tips and are about 70-150 mm long with 10-50 mm petioles (Yasunaga and Schuh, 2013). Flowers of the tree are insect-pollinated which are orange-yellow and are borne in small, axillary umbels. In South Africa *Lg* flowers from October to May (Chen et al., 2007). The fruit appears black and single-seeded with a shiny appearance, especially when the sun shines on the tree (You et al., 2009). Seeds are pea-sized so they are easily dispersed by birds (Choudhury et al., 1996). The plant is invasive in certain areas but threatened in parts of the natural habitat mainly after flowering (Pandey and Mandal, 2012). These photos were captured during seeding in the Queensburg area, Durban.

Picture 1: *Litsea glutinosa* (Anumanthoo, 2019)

2.3.2 Medicinal and industrial uses of *Litsea glutinosa*

There are many beneficial uses of *Lg*, such as to treat and cure certain medical conditions naturally by use of different parts of the tree, in different mixes and forms, like powder, pastes, liquid solutions and crushed pieces (Kong et al., 2015). The consistency in the ratios of the bark, leaves, seeds and roots is important to achieve the best results for the specific application (Mandal et al., 2000). Roots, bark and leaves of *Lg* are used to treat various ailments and sicknesses (Devi and Meera, 2010). The bark is used as an anti-inflammatory agent to reduce fever and swelling and has the potential to combat diarrhoea (Son et al., 2014). The leaves, in crushed form, are used as an ingredient to kill intestinal parasites (Das et al., 2013). The bark is also traditionally used to arouse sexual power (Lohitha et al., 2009) and also has the ability to relieve pain and calm the body following injury, in such instance ground bark is supplied as a paste made out of water and powdered bark to the area of concern (Devi and Meera, 2010). Bark in the powdered form is also used to manufacture incense sticks due to their effective characteristics (Mandal *et al.*, 2000). The bark is odourless, ensuring that the fragrance of the incense sticks is maintained when burnt (Lohitha et al., 2009). The seeds of *Lg*, when crushed, are used externally on boils and sores, removing any bacterial infections that may occur in those areas (Kotoky et al., 2007). Crushed parts of bark and seeds made into a soup are also used to reduce urinary tract infections and can decrease the occurrence of sexually transmitted diseases (Hossan et al., 2010). Essential oils extracted from the berries of *Lg* are used to relieve rheumatism (Choudhury *et al.*, 1996). A variety of anti-oxidants can be extracted from the leaves, bark, seeds and the roots of *Lg* (Devi and Meera, 2010). All these extracts prepared from different parts of the plant are considered safe to use for humans (Ghosh et al., 2016).

The seed of *Lg* comprises 50% of oils which can be used in the manufacturing of various soaps and candles due to high gluten content (Liu *et al.*, 2017). Root fibres of *Lg* are used in various countries of the world to make ropes and paper pulp (Franco and Narasimhan, 2009), whilst the tree trunks are used extensively in the manufacturing of furniture (Choudhury *et al.*, 1996).

2.3.3 Natural propagation of *Litsea glutinosa*

Propagation of *Lg* can be carried out via seed. Only about 85% of the seeds will germinate within 3-6 weeks from sowing (Haque et al., 2014). In South Africa, the fruit that is produced by *Lg* attracts indigenous bird species and is, thus, dispersed causing the high occurrence of this tree (Dlamini et al., 2018). Some of the birds, dispersing *Litsea glutinosa* seeds in South Africa are louries, starlings, bulbuls, barbets, hornbills, pigeons and doves (Hugel, 2012). Seeds are also dispersed naturally in South Africa by high winds and during extensive floods (Haque *et al.*, 2014).

2.3.4 Distribution and origin of *Litsea glutinosa*

Litsea glutinosa (Indian laurel) is indigenous to parts of India, China, Malaysia, the Pacific Islands and Australia (Yang et al., 2005). The trees are also dispersed throughout the Philippines, Vietnam and Thailand (Higgins, 2017). In the Philippines *Lg* is commercially produced, however, it is now an endangered species in the wild (Haque *et al.*, 2014). The plant grows at altitudes between 500-1900 m,a,s,l, and is mainly found in undisturbed forests in shaded areas (Sun *et al.*, 2017). In Bangladesh, *Lg* is not commonly found in the wild due to mismanagement in commercial harvesting as the bark was used for medicine (Uddin and Hassan, 2014). Indian laurel was first introduced to South Africa as an ornamental plant in the 1980s (Pradeepa *et al.*, 2013). Currently, it occurs in localised pockets throughout KwaZulu-Natal, where it is declared an alien invasive plant, a category one weed (Nel et al., 2004). Such plants are not allowed to be propagated and must be controlled or eradicated where applicable (Pimentel et al., 2005). The plant must also be removed from any land or water areas in South Africa (Preston *et al.*, 2018). Its long taproot makes it difficult to remove manually (Sitthithaworn et al., 2018). Once the tree is established in its habitat, it is difficult to eradicate or control with foliar applications due to this vigorous, strong root system (Richardson and van Wilgen, 2004). Eradication of a fully established plant can only be achieved by removing the entire plants with high powered machinery or cut stump for it to expose live tissue, thereafter apply a triclon herbicide in a solution mixed with diesel (100 ml herbicide: 1-litre diesel) (Higgins, 2017). Triclon is a systemic solution which will translocate throughout the plant when absorbed by the roots and foliage parts (Sun *et al.,* 2017).

2.3.5 Impact of *Litsea glutinosa*

The presence of *Lg* affects habitats by competing with indigenous plants for water, nutrients, space and sunlight (Xu et al., 2007). They absorb ample water and thus reduce the amount of water available to indigenous plants, thereby being detrimental to indigenous plants in that area (Gigord et al., 1999). By making the soil dryer, the ground also can become prone to soil erosion (Irwin et al., 2010). The germination percentage of *Lg* seeds is very high in that 50% of seeds will germinate when dispersed by birds eating the seeds or even through self-propagation methods which disperse the plants in different areas within the range of dispersal agents (Gosper and Vivian-Smith, 2009). The tree also produces suckers which create thick bushes and displace the natural vegetation (Mohammad et al., 2016). Seedlings of *Lg* are also very difficult to remove due to their strong taproot systems, and when pulled the root pieces below the ground level will again grow into a full tree (Somashekhar and Manju, 2002).

Due to the negative impact on natural resources, the eradication and control of this species are of high priority to ensure the sustainability of the environment (van Wilgen, 2012).

The National Environmental Management: Biodiversity Act (No. 10 of 2004) (NEMBA), aims to provide the framework, norms, and standards for the conservation, sustainable use, and equitable benefit-sharing of South Africa's biological resources (Republic of South Africa Department of Environmental Affairs, 2014).

Litsea glutinosa is a category 1a/1b invasive species. This means that it is a South African invader plant species which therefore must not be grown but rather controlled. The DEA regulation stipulates that in category 1a and 1b listed invasive species, the following should be considered: according to the DEA, invasive alien plant species must either be controlled or eradicated (category 1a species) or controlled and managed (category 1b species) (Republic of South Africa Department of Environmental Affairs, 2014).

2.3.6 Potential of *Litsea glutinosa* as a source of biodiesel

According to Perumal (2014), seeds and fruit of *Litsea glutinosa* can be used as a source of biodiesel. The properties and characteristics of *Lg* meet the requirements in terms of the American Society for Testing and Materials (ASTM) standards to manufacture biodiesel. This production process has not yet been commercialised because of the low availability and quantities of *Lg* found throughout the world *(*Perumal, 2014).

2.4 Conclusions

Various parts of *Lg* plant have potential commercial use. It is recommended that people are made more aware of the benefits of *Lg*, which will control the spread due to the communities mechanically removing the plants in their different distributions throughout South Africa. The cost to control the spread of *Lg* in South Africa is becoming more expensive, therefore eradication plans should be implemented to ensure that the natural habitat is safe and managed effectively through all stakeholders involved.

CHAPTER 3: EFFECTS OF COMPOSTED *LITSEA GLUTINOSA* AS PART OF THE GROWING MEDIUM ON THYME (*THYMUS VULGARIS*) AND ROCKET (*ERUCA SATIVA*) GROWTH PARAMETERS

3.1 Introduction

The growth of plants is not only genetically controlled but is also dependent on environmental factors (De Molina, 2002). Leafy vegetables and herbs are dependent on environmental conditions such as temperature, humidity and soil moisture (Dumas et al., 2003). Additionally, the growing medium is also important, as the composition of the medium can also determine the growth of herbs (Zhang et al., 2002). Leafy green plants thrive in well-drained rich media that contain required nutrients in optimum proportions (Lawlor et al., 2001). Reduced growth of leafy herbs can also be due to the reduction in the growing period, caused by lower temperatures, a reduction in day length, as well as limited supply of water and nutrients to the roots and upper parts of the plant (Zhang et al., 2002).

The production of herbs plays an important role in the health sector, in medicinal, therapeutic and curative processes as well as adding taste and flavours to the foods that are consumed (Tapsell et al., 2006). Some herbs are used to treat diseases as well as maintaining good health (Matthews et al., 1999). The majority of ingredients in medicine used to treat and cure people are extracted from plants (Panda, 1999). Research has shown that most of the plants used in the manufacturing process of medicines and therapeutic applications are gathered by the indigenous people from the old traditional harvesting methods, despite the advancement in technology and scientific methods (Yao et al., 2004). Herbal medication is still the main remedy for traditional applications of medicine (Kumar et al., 2012). It is, therefore, very important to grow herbs using natural, organic compost as a growing composition of the general population demands organic foods which ensure that the produce is safe to use (Sahota, 2009).

The application and impact of using a growing medium containing composted *Lg* on the growth of herbs have never been investigated. As herbs are easy to grow in pots, data collection on the effect of control as model crops to gain an understanding of the plants and their mechanisms to be measured accurately was experimented which provides new research that could be investigated. Composted *Lg* as part of a medium was used to grow thyme and rocket. Thyme and rocket are herbs commonly used throughout the world for their healing properties as well as culinary purposes (Hüsnü Can Baser, 1999). Thyme and rocket are grown throughout the year and are required in large quantities for exports as well as for consumption within South Africa (Cheifitz, 2009).

3.2 Materials and methods

3.2.1 Composting of *Litsea glutinosa*

The composting of this species was using all above-ground parts of *Lg* which included, stems, bark and leaves. The material was harvested before flowering and during June-September so that no seeds of *Lg* would sprout in the medium later. The collected plant material was put in a chipper that broke it down into small wooden chips of 3-5 cm in length to allow for easier and quicker composting. These small wood chips were left between five to six months in a 2 x 2 square structure constructed with poles, slates, shade cloth and nails. The pile was turned every 1-2 weeks and slightly watered once a week to keep it moist. This material was used in the experiment.

Thyme and rocket plants were used as experimental species, as they can be easily confined to pots while being popular as cooking (thyme) and salad (rocket) herbs. The compost produced from *Lg* to grow thyme and rocket herbs was the main experimental growing mix and, its suitability as a medium was compared with Gromor® Potting Soil.

The plant material was obtained as plugs which included large leaf-producing *Eruca sativa* (rocket) and small leaf-producing *Thymus vulgaris* (thyme) supplied by Sunshine Seedlings in Pietermaritzburg.

The experiment was carried out at the Durban University of Technology, Horticultural nursery (practical centre) location (-29.8521115/31.0089852). *Eruca sativa* and *Thymus vulgaris* plugs were grown in three-litre virgin plastic plant bags. Data on plants for thyme plugs were used from six week, 8-12 cm height specimens and rocket plugs were used from four week 5-8 cm height specimens. Herbs were planted into three media, either Gromor® Potting Soil (PS) as the (control), composted *Lg* (EM) as well as a combination of Gromor® Potting Soil plus the composted *L*g (PSEM) in a 1:1 ratio. Plants were grown over a two-month period (eight weeks) and measurements were taken weekly. Plants were irrigated with borehole water every second day. No fertilizer was added to any of the treatments. On *Eruca sativa,* leaf diameter of all leaves and plant height were recorded weekly, while on the *Thymus vulgaris,* plant height, as well as the length of side shoots, were measured at weekly intervals.

This study had a significant amount of raw data which was aggregated and averaged out to make the statistics more practical to conclude. The results for the leaf diameter of rocket, plant heights in rocket and thyme, as well as the length of side shoots in thyme, were measured every seven days on a Friday for an eight-week growing period. Rocket and thyme were grown in the three different soil media which was PS, EM and PSEM.

3.3 Results: Eight-week growth and development of rocket and thyme growth in three media

3.3.1 Measurements on rocket and thyme herbs

Table 1 Leaf diameter and plant height of rocket and length of side shoots and plant height of thyme grown in the three different media, PS, EM, PSEM

Leaf diameter / Plant height / Length of side shoot – averages			PS2	EM2	PSE M2	PS4	EM4	PSE M4	PS6	EM6	PSE M6	PS8	EM8	PSE M8
Leaf diameter	1	Mean	3.68	3.15	3.31	4.22	4.13	4.90	4.32	4.19	4.69	5.00	5.44	4.03
		N	5	5	5	5	5	5	5	5	5	5	5	5
		Std. Deviation	0.43	0.49	0.59	0.20	0.45	0.90	0.33	0.44	0.63	0.44	4.42	0.47
	Total	Mean	3.68	3.15	3.31	4.22	4.13	4.90	4.32	4.19	4.69	5.00	5.44	4.03
		N	5	5	5	5	5	5	5	5	5	5	5	5
		Std. Deviation	0.43	0.49	0.59	0.20	0.45	0.90	0.33	0.44	0.63	0.44	4.42	0.47
Plant height	1	Mean	22.00	12.26	14.13	30.53	21.60	23.83	40.33	28.66	31.00	44.46	32.16	31.96
		N	5	5	5	5	5	5	5	5	5	5	5	5
		Std. Deviation	2.52	2.47	1.38	2.67	5.64	3.05	3.88	2.24	1.61	4.29	4.74	2.05
	2	Mean	16.33	18.53	19.73	23.26	22.26	24.13	24.33	24.53	27.66	28.60	23.73	28.66
		N	5	5	5	5	5	5	5	5	5	5	5	5
		Std. Deviation	1.54	1.42	1.29	2.17	1.83	1.80	1.02	0.29	0.97	1.58	2.48	1.33
	Total	Mean	19.16	15.40	16.93	26.90	21.93	23.98	32.33	26.60	29.33	36.53	27.95	30.31
		N	10	10	10	10	10	10	10	10	10	10	10	10
		Std. Deviation	3.58	3.81	3.21	4.46	3.97	2.37	8.84	2.65	2.16	8.90	5.70	2.38
Length of side shoots	2	Mean	9.80	9.13	10.80	11.33	11.83	12.26	13.26	14.00	13.80	14.33	15.33	15.80
		N	5	5	5	5	5	5	5	5	5	5	5	5
		Std. Deviation	0.76	1.50	1.77	0.97	0.83	1.73	1.25	2.05	1.12	1.97	1.26	2.38
	Total	Mean	9.80	9.13	10.80	11.33	11.83	12.26	13.26	14.00	13.80	14.33	15.33	15.80
		N	5	5	5	5	5	5	5	5	5	5	5	5
		Std. Deviation	0.76	1.50	1.77	0.97	0.83	1.73	1.25	2.05	1.12	1.97	1.26	2.38

LIST OF ABBREVIATIONS	
PS2	Data collected on potting soil in the second week of growth
EM 2	Data collected on enriched medium in the second week of growth

PSEM 2	Data collected on potting soil + enriched medium in the second week of growth
The same goes for PS 4 which will denote the fourth week of data collection	

3.3.2 One sample Kolmogorov-Smirnov test

Table 2 One – sample Kolmogorov-Smirnov Test used to calculate mean values, standard deviation, absolute values as well as positive and negative differences in variables between the growth parameters of rocket and thyme plants

One-Sample Kolmogorov-Smirnov Test

Averages		**PS2**	**EM2**	**PSEM 2**	**PS4**	**EM4**	**PSEM4**	**PS6**	**EM6**	**PSEM 6**	**PS8**	**EM8**	**PSEM 8**
N		5	5	5	5	5	5	5	5	5	5	5	5
Normal Parameters[a,b]	Mean	3.686667	3.153333	3.316667	4.226667	4.133333	4.906667	4.320000	4.193333	4.693333	5.006667	5.446667	4.033333
	Std. Deviation	.4311483	.4953114	.5906682	.2086997	.4539946	.9074996	.3304879	.4412105	.6339471	.4443472	4.4252181	.4766783
Most Extreme Differences	Absolute	.239	.216	.334	.239	.216	.307	.271	.296	.244	.205	.442	.199
	Positive	.239	.158	.200	.223	.170	.232	.172	.296	.225	.166	.442	.164
	Negative	-.229	-.216	-.334	-.239	-.216	-.307	-.271	-.207	-.244	-.205	-.277	-.199
Test Statistic		.239	.216	.334	.239	.216	.307	.271	.296	.244	.205	.442	.199
Asymp. Sig. (2-tailed)		.200[c,d]	.200[c,d]	.072[c]	.200[c,d]	.200[c,d]	.140[c]	.200[c,d]	.174[c]	.200[c,d]	.200[c,d]	.002[c]	.200[c,d]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. This is a lower bound of the true significance.

3.3.3 Mauchly's test of sphericity

Table 3 Mauchly's Test of Sphericity to test the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix

Mauchly's Test of Sphericity[a]

Measure: TIME (WEEKS)

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
factor1	.105	3.887	5	.620	.584	1.000	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Measurement

Within Subjects Design: factor1

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

3.3.4 Pairwise comparisons to measure significant differences of plants over the eight week growing period

Table 4 Significant differences measurement using the Pairwise Comparisons test

Pairwise Comparisons

Measure: TIME (WEEKS)

(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-.540*	.122	.021	-.929	-.151
	3	-.633*	.159	.028	-1.140	-.127
	4	-1.320*	.149	.003	-1.796	-.844
2	1	.540*	.122	.021	.151	.929
	3	-.093	.080	.327	-.348	.161
	4	-.780*	.142	.012	-1.231	-.329
3	1	.633*	.159	.028	.127	1.140
	2	.093	.080	.327	-.161	.348
	4	-.687*	.211	.047	-1.359	-.014
4	1	1.320*	.149	.003	.844	1.796
	2	.780*	.142	.012	.329	1.231
	3	.687*	.211	.047	.014	1.359

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

There were significant differences in growth between the different time periods ($p < 0,05$), except between time periods 2 and 3 ($p = 0,327$).

The four measurements (every two weeks), that were taken during the eight-week experiment was compared with the other three measurements (six weeks data) to showcase significant differences.

3.3.5 Post Hoc Test comparing the three media, (PS, EM and PSEM) for every two week measurement over the eight-week experiment, indicating least significant differences

Table 5 Post Hoc Test indicating least significant differences between the three media (PS, EM and PSEM) on the measurements collected in the first two weeks of the experiment (week 0-2)

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	EM2_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-12.246667*	1,5765636	0,000	-16,291115	-8,202218
	Length of side shoot	-5.980000*	1,8204589	0,012	-10,650127	-1,309873
Plant height	Leaf diameter	12.246667*	1,5765636	0,000	8,202218	16,291115
	Length of side shoot	6.266667*	1,5765636	0,003	2,222218	10,311115
Length of side shoot	Leaf diameter	5.980000*	1,8204589	0,012	1,309873	10,650127
	Plant height	-6.266667*	1,5765636	0,003	-10,311115	-2,222218
Based on observed means. The error term is Mean Square(Error) = 8.285.						
*. The mean difference is significant at the 0.05 level.						

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	PS2_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-15.480000*	1,4460168	0,000	-19,189550	-11,770450
	Length of side shoot	-6.113333*	1,6697164	0,005	-10,396752	-1,829915
Plant height	Leaf diameter	15.480000*	1,4460168	0,000	11,770450	19,189550
	Length of side shoot	9.366667*	1,4460168	0,000	5,657117	13,076216
Length of side shoot	Leaf diameter	6.113333*	1,6697164	0,005	1,829915	10,396752
	Plant height	-9.366667*	1,4460168	0,000	-13,076216	-5,657117
Based on observed means. The error term is Mean Square(Error) = 6.970.						
*. The mean difference is significant at the 0.05 level.						

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	PSEM2_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-13.616667*	1,3729602	0,000	-17,138800	-10,094534
	Length of side shoot	-7.483333*	1,5853578	0,001	-11,550342	-3,416324
Plant height	Leaf diameter	13.616667*	1,3729602	0,000	10,094534	17,138800
	Length of side shoot	6.133333*	1,3729602	0,001	2,611200	9,655466
Length of side shoot	Leaf diameter	7.483333*	1,5853578	0,001	3,416324	11,550342
	Plant height	-6.133333*	1,3729602	0,001	-9,655466	-2,611200
Based on observed means. The error term is Mean Square(Error) = 6.283.						
*. The mean difference is significant at the 0.05 level.						

Table 6 Post Hoc Test indicating least significant differences between the three media (PS, EM and PSEM) on the measurements collected in the second two weeks of the experiment (week 2-4)

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	PSEM4_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-19.076667*	1,0789183	0,000	-21,844477	-16,308856
	Length of side shoot	-7.360000*	1,2458275	0,000	-10,555992	-4,164008
Plant height	Leaf diameter	19.076667*	1,0789183	0,000	16,308856	21,844477
	Length of side shoot	11.716667*	1,0789183	0,000	8,948856	14,484477
Length of side shoot	Leaf diameter	7.360000*	1,2458275	0,000	4,164008	10,555992
	Plant height	-11.716667*	1,0789183	0,000	-14,484477	-8,948856
Based on observed means. The error term is Mean Square(Error) = 3.880.						
*. The mean difference is significant at the 0.05 level.						

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	PS4_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-22.673333*	1,7996013	0,000	-27,289953	-18,056714
	Length of side shoot	-7.106667*	2,0780005	0,009	-12,437480	-1,775853
Plant height	Leaf diameter	22.673333*	1,7996013	0,000	18,056714	27,289953
	Length of side shoot	15.566667*	1,7996013	0,000	10,950047	20,183286
Length of side shoot	Leaf diameter	7.106667*	2,0780005	0,009	1,775853	12,437480
	Plant height	-15.566667*	1,7996013	0,000	-20,183286	-10,950047
Based on observed means. The error term is Mean Square(Error) = 10.795.						
*. The mean difference is significant at the 0.05 level.						

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	EM4_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-17.800000*	1,6039290	0,000	-21,914651	-13,685349
	Length of side shoot	-7.700000*	1,8520577	0,002	-12,451189	-2,948811
Plant height	Leaf diameter	17.800000*	1,6039290	0,000	13,685349	21,914651
	Length of side shoot	10.100000*	1,6039290	0,000	5,985349	14,214651
Length of side shoot	Leaf diameter	7.700000*	1,8520577	0,002	2,948811	12,451189
	Plant height	-10.100000*	1,6039290	0,000	-14,214651	-5,985349
Based on observed means. The error term is Mean Square(Error) = 8.575.						
*. The mean difference is significant at the 0.05 level.						

Table 7 Post Hoc Test indicating least significant differences between the three media (PS, EM and PSEM) on the measurements collected in the third two weeks of the experiment (week 4-6)

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	PSEM6_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-24.640000*	0,9263760	0,000	-27,016485	-22,263515
	Length of side shoot	-9.106667*	1,0696869	0,000	-11,850796	-6,362538
Plant height	Leaf diameter	24.640000*	0,9263760	0,000	22,263515	27,016485
	Length of side shoot	15.533333*	0,9263760	0,000	13,156848	17,909819
Length of side shoot	Leaf diameter	9.106667*	1,0696869	0,000	6,362538	11,850796
	Plant height	-15.533333*	0,9263760	0,000	-17,909819	-13,156848
Based on observed means. The error term is Mean Square(Error) = 2.861.						
*. The mean difference is significant at the 0.05 level.						

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	PS6_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-28.013333*	3,5432156	0,000	-37,102946	-18,923720
	Length of side shoot	-8,946667	4,0913529	0,102	-19,442448	1,549114
Plant height	Leaf diameter	28.013333*	3,5432156	0,000	18,923720	37,102946
	Length of side shoot	19.066667*	3,5432156	0,000	9,977054	28,156280
Length of side shoot	Leaf diameter	8,946667	4,0913529	0,102	-1,549114	19,442448
	Plant height	-19.066667*	3,5432156	0,000	-28,156280	-9,977054
Based on observed means. The error term is Mean Square(Error) = 41.848.						
*. The mean difference is significant at the 0.05 level.						

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	EM6_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-22.406667*	1,1952586	0,000	-25,472932	-19,340402
	Length of side shoot	-9.806667*	1,3801658	0,000	-13,347285	-6,266049
Plant height	Leaf diameter	22.406667*	1,1952586	0,000	19,340402	25,472932
	Length of side shoot	12.600000*	1,1952586	0,000	9,533735	15,666265
Length of side shoot	Leaf diameter	9.806667*	1,3801658	0,000	6,266049	13,347285
	Plant height	-12.600000*	1,1952586	0,000	-15,666265	-9,533735
Based on observed means. The error term is Mean Square(Error) = 4.762.						
*. The mean difference is significant at the 0.05 level.						

Table 8 Post Hoc Test indicating least significant differences between the three media (PS, EM and PSEM) on the measurements collected in the fourth two weeks of the experiment (week 6-8)

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	PSEM8_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-26.283333*	1,1501108	0,000	-29,233778	-23,332888
	Length of side shoot	-11.766667*	1,3280336	0,000	-15,173547	-8,359786
Plant height	Leaf diameter	26.283333*	1,1501108	0,000	23,332888	29,233778
	Length of side shoot	14.516667*	1,1501108	0,000	11,566222	17,467112
Length of side shoot	Leaf diameter	11.766667*	1,3280336	0,000	8,359786	15,173547
	Plant height	-14.516667*	1,1501108	0,000	-17,467112	-11,566222
Based on observed means. The error term is Mean Square(Error) = 4.409.						
*. The mean difference is significant at the 0.05 level.						

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	PS8_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-31.526667*	3,5879723	0,000	-40,731097	-22,322237
	Length of side shoot	-9,326667	4,1430335	0,091	-19,955027	1,301694
Plant height	Leaf diameter	31.526667*	3,5879723	0,000	22,322237	40,731097
	Length of side shoot	22.200000*	3,5879723	0,000	12,995570	31,404430
Length of side shoot	Leaf diameter	9,326667	4,1430335	0,091	-1,301694	19,955027
	Plant height	-22.200000*	3,5879723	0,000	-31,404430	-12,995570
Based on observed means. The error term is Mean Square(Error) = 42.912.						
*. The mean difference is significant at the 0.05 level.						

Post Hoc Tests						
Leaf diameter / Plant height / Length of side shoot						
Multiple Comparisons						
Dependent Variable:	EM8_avg					
Tukey HSD						
(I) Leaf diameter / Plant height / Length of side shoot		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Leaf diameter	Plant height	-22.503333*	2,5808484	0,000	-29,124131	-15,882536
	Length of side shoot	-9.886667*	2,9801070	0,011	-17,531705	-2,241628
Plant height	Leaf diameter	22.503333*	2,5808484	0,000	15,882536	29,124131
	Length of side shoot	12.616667*	2,5808484	0,000	5,995869	19,237464
Length of side shoot	Leaf diameter	9.886667*	2,9801070	0,011	2,241628	17,531705
	Plant height	-12.616667*	2,5808484	0,000	-19,237464	-5,995869
Based on observed means. The error term is Mean Square(Error) = 22.203.						
*. The mean difference is significant at the 0.05 level.						

Table 9Averages of the different media over the eight week growing period

Measurement		PS2_avg	EM2_avg	PSEM2_avg	PS4_avg	EM4_avg	PSEM4_avg	PS6_avg	EM6_avg	PSEM6_avg	PS8_avg	EM8_avg	PSEM8_avg
Rocket	N	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	3,7	3,2	3,3	4,2	4,1	4,9	4,3	4,2	4,7	5,0	5,4	4,0
	Std. Deviati	0,4	0,5	0,6	0,2	0,5	0,9	0,3	0,4	0,6	0,4	4,4	0,5

a. Leaf diameter / Plant height / Length of side shoot = Leaf diameter

Report[a]

Measurement		PS2_avg	EM2_avg	PSEM2_avg	PS4_avg	EM4_avg	PSEM4_avg	PS6_avg	EM6_avg	PSEM6_avg	PS8_avg	EM8_avg	PSEM8_avg
Rocket	N	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	22,0	12,3	14,1	30,5	21,6	23,8	40,3	28,7	31,0	44,5	32,2	32,0
	Std. Deviati	2,5	2,5	1,4	2,7	5,6	3,1	3,9	2,2	1,6	4,3	4,7	2,1
Thyme	N	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	16,3	18,5	19,7	23,3	22,3	24,1	24,3	24,5	27,7	28,6	23,7	28,7
	Std. Deviati	1,5	1,4	1,3	2,2	1,8	1,8	1,0	0,3	1,0	1,6	2,5	1,3
Total	N	10	10	10	10	10	10	10	10	10	10	10	10
	Mean	19,2	15,4	16,9	26,9	21,9	24,0	32,3	26,6	29,3	36,5	28,0	30,3
	Std. Deviati	3,6	3,8	3,2	4,5	4,0	2,4	8,8	2,7	2,2	8,9	5,7	2,4

a. Leaf diameter / Plant height / Length of side shoot = Plant height

Report[a]

Measurement		PS2_avg	EM2_avg	PSEM2_avg	PS4_avg	EM4_avg	PSEM4_avg	PS6_avg	EM6_avg	PSEM6_avg	PS8_avg	EM8_avg	PSEM8_avg
Thyme	N	5	5	5	5	5	5	5	5	5	5	5	5
	Mean	9,8	9,1	10,8	11,3	11,8	12,3	13,3	14,0	13,8	14,3	15,3	15,8
	Std. Deviati	0,8	1,5	1,8	1,0	0,8	1,7	1,3	2,1	1,1	2,0	1,3	2,4

a. Leaf diameter / Plant height / Length of side shoot = Length of side shoot

3.3.6 Leaf diameter - rocket

The leaf diameter of rocket did not differ significantly between any of the treatments at any time. There were however certain tendencies. Leaf diameter of rocket grown in PS gradually increased from week 2 to 4 (3.67cm to 4.23cm), then remained constant from weeks 4 to 6 (4.23cm to 4.32cm) and showed a further increase from week 6 to 8 (4.32cm to 5.01cm) (Figure 1). Leaf diameter increased on rocket plants in EM from week 2 to 4 (3.15cm to 4.13cm), stayed fairly constant from week 4 to 6 (4.13cm to 4.19cm) and increased again from week 6 to 8 (4.19cm to 5.45cm). When growing PSEM an increase in leaf diameter from week 2 to 4 (3.32cm to 4.91cm), followed by a decline from week 4 to 8 (4.91cm to 4.03cm).

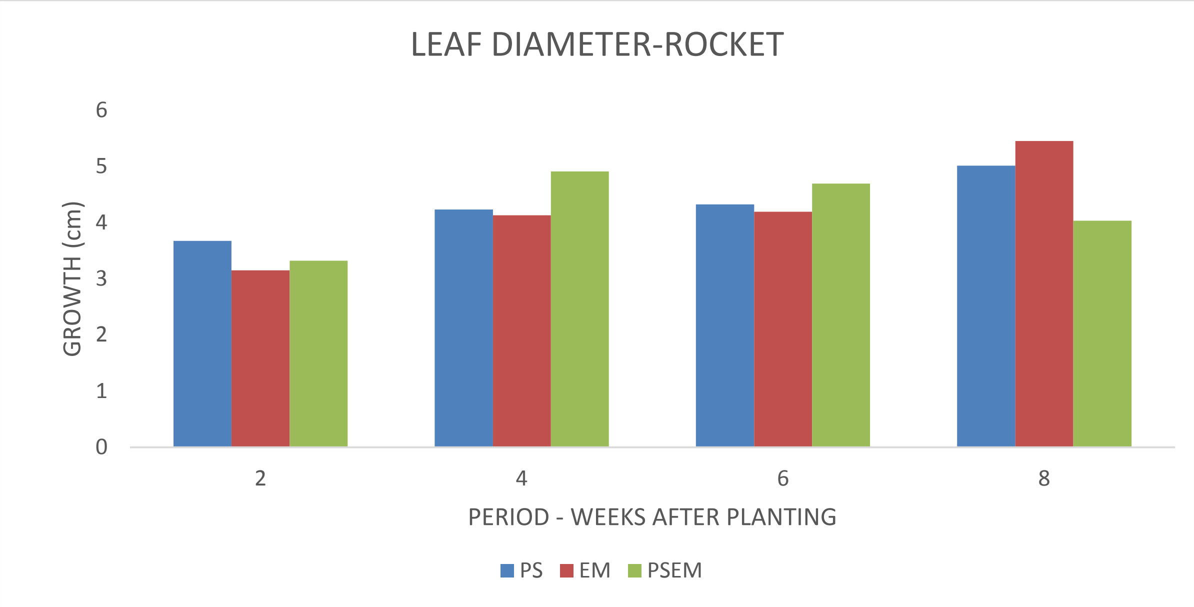

Figure 1 Leaf diameter of rocket plants over the eight-week growing period in the three media, (potting soil, enriched medium and potting soil + enriched medium).

Table 10 p – values of leaf diameter of rocket plants grown in the different media over an eight week period

	p - value			
Leaf diameter comparisons	Week 2	Week 4	Week 6	Week 8
PS vs EM	0,1189	0,6889	0,6666	0,8446
PS vs PSEM	0,25	0,128	0,2191	0,0082
EM vs PSEM	0,7819	0,1205	0,1596	0,4997

Means, standard deviation and number of plants from (Table 9) to calculating the p – value which shows significant differences between the different media.

3.3.7 Plant height of rocket

The plant height of rocket grown in PS increased consistently, from week 2 to 8 (22cm to 44,47cm) (Figure 2). Throughout the observation period, rocket plants grown in PS achieved a significantly greater height compared with plants grown in the other two media. Height of rocket grown in EM increased steadily from week 2 to 6 (12.27cm to 28.67cm) and gradually increased from week 6 to 8 (28.67cm to 32.13cm). Rocket height in PSEM increased considerably from week 2 to 6 (14.13cm to 31cm) and remained fairly constant from week 6 to 8 (31cm to 31.97cm).

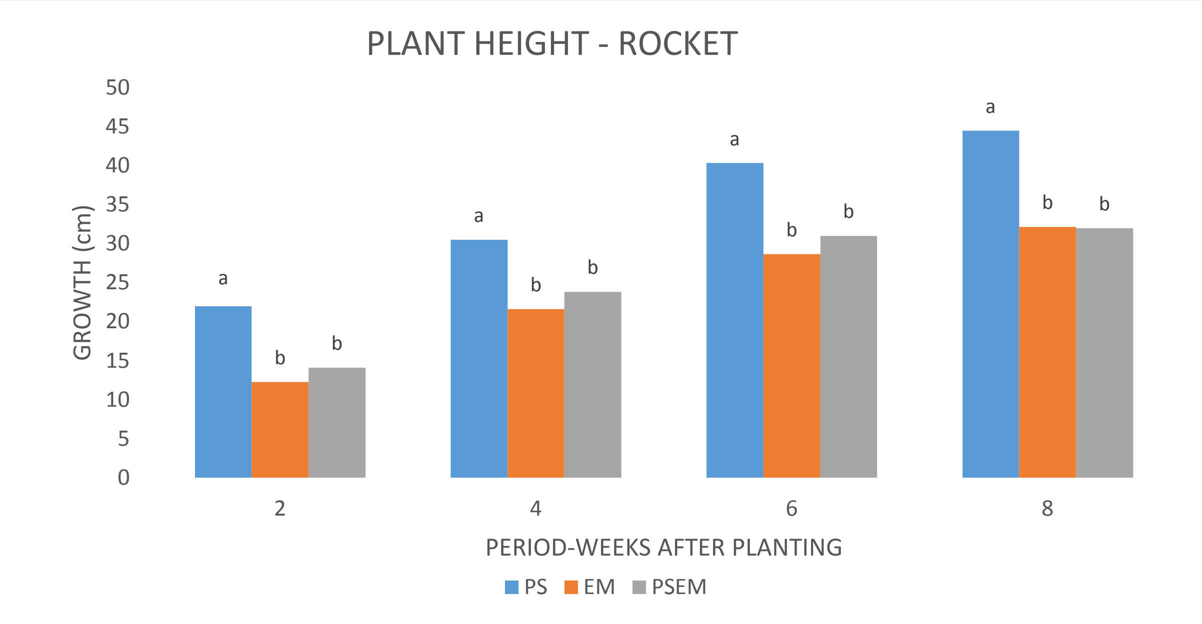

Figure 2 Plant height of rocket in three different media (potting soil, enriched medium and potting soil + enriched medium).

Table 11 p – values of rocket plant height in the different media over an eight week period

	p-value			
Rocket height comparisons	Week 2	Week 4	Week 6	Week 8
PS vs EM	0,0003 SD	0,0126 SD	0,0004 SD	0,0026 SD
PS vs PSEM	0,0003 SD	0,0065 SD	0,0011 SD	0,0004 SD
EM vs PSEM	0,1977	0,4642	0,0953	0,9329

Means, standard deviation and number of plants from (Table 9) to calculating the p – value which shows significant differences between the different media.

3.3.8 Plant height – thyme

Thyme grown in PS gradually increased in height from week 2 to 4 (16.33cm to 23.27cm), then remained fairly constant from week 4 to 6 (23.27cm to 24.33cm) and increase again from week 6 to 8 (24.33cm to 28.60cm) (Figure 3). Initially EM and PSEM outperformed PS, while no differences between treatments occurred in week four; however in week six, PSEM plants had the greatest height and in week eight, EM and PSEM differed significantly from each other in plant height. The height of thyme grown in EM had gradual and evenly increased from week 2 to 6 (18.53cm to 24.53cm) and declined slightly from week 6 to 8 (24.53cm to 23.73cm). Plant height of thyme grown in PSEM increased consistently throughout the eight-week growing period.

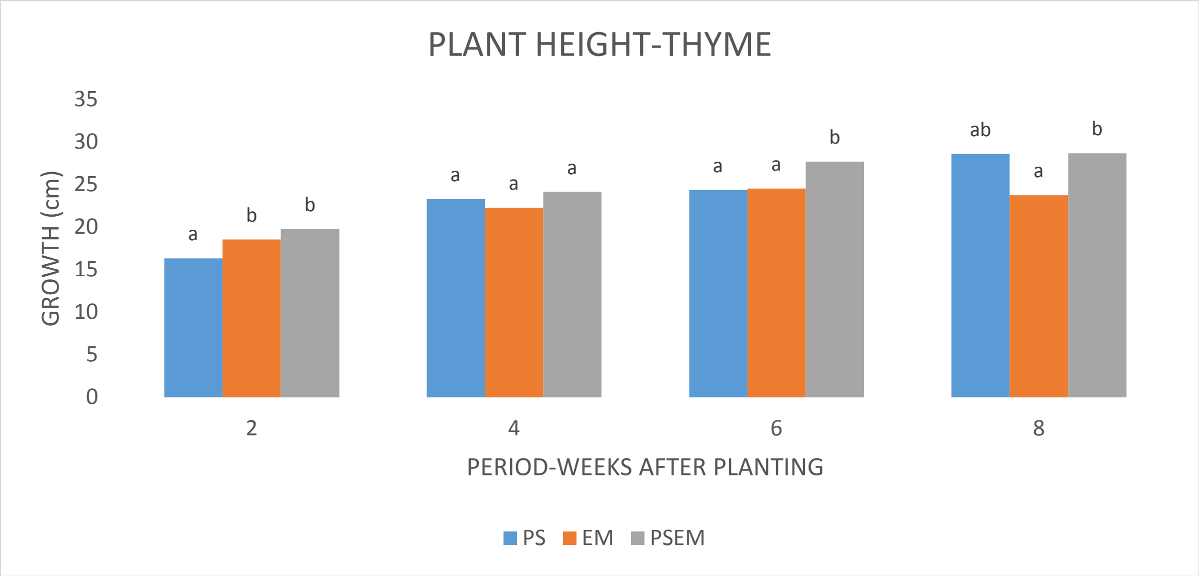

Figure 3 Plant height of thyme in three different media (potting soil, enriched medium and potting soil + enriched medium).

Table 12 p – values of thyme plant height in different media over an eight week period.

	p-value			
Thyme height comparisons	Week 2	Week 4	Week 6	Week 8
PS vs EM	0,0433 SD	0,4542	0,6797	0,3173
PS vs PSEM	0,0050 SD	0,5467	0,0007 SD	0,9163
EM vs PSEM	0,1978	0,1525	0,0001 SD	0,0041 SD

Means, standard deviation and number of plants from (Table 9) to calculating the p – value which shows significant differences between the different media.

3.3.9 Length of side shoots – thyme

The length of side shoots of thyme did not differ significantly between any of the treatments at any time (Figure 4). The side shoot length of thyme grown in PS increased from week 2 to 4 (9.8cm to 11.33cm), then a substantial increase from week 2 to 4 (11.33cm to 13.27cm) and a gradual increase from week 4 to 8 (11.33cm to 14.33cm). It was observed when grown in EM, a gradual increase from week 2 to 4 (9.13cm to 12.27cm), and a steady increase from week 4 to 6 (11.83cm to 14cm) and week 6 to 8 (14cm to 15.33) was observed. Thyme grown in PSEM displayed an increase of the length of side shoots from week 2 to 4 (10.8cm to 12.27cm), week 4 to 6 (12,27cm to 13.8 cm) and week 6 to 8 (13.8cm to 15.8cm). PSEM had the tallest measurements on the length of side shoots in thyme compared to PS and EM at the end of the eight-week growing period which was PSEM-15.8cm, EM-15.33cm and PS-14.33cm.

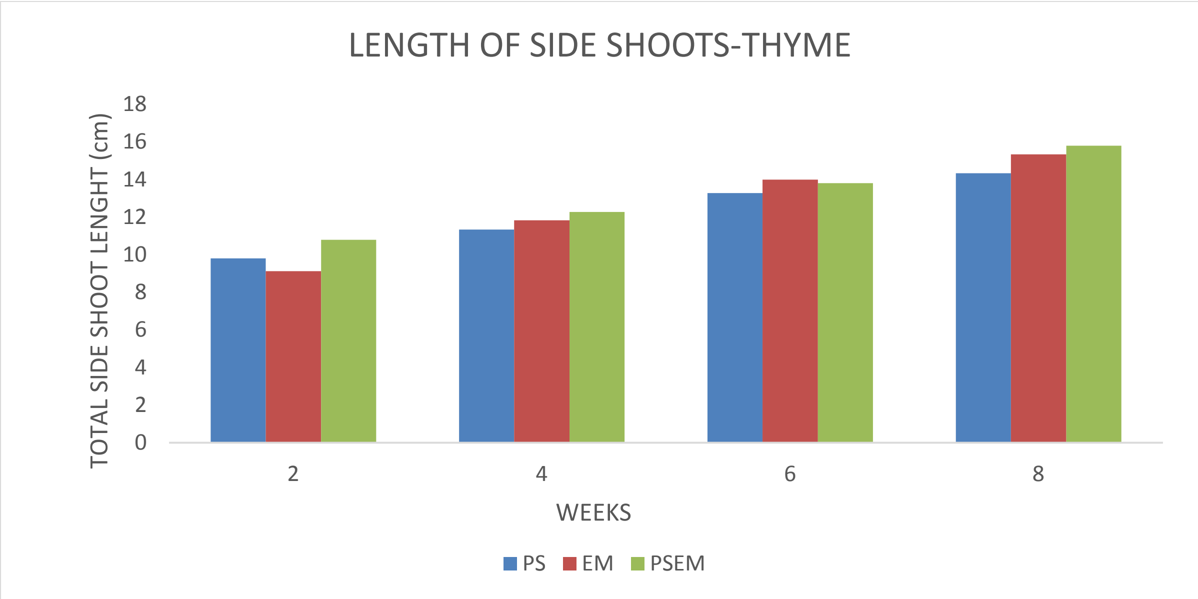

Figure 4 Comparison of length of side shoots of thyme between the three different soil media, PS, EM and PSEM

Table 13 p – values on thyme length of side shoot in different media over an eight week period

	p-value			
Thyme length of side shoot - comparisons	Week 2	Week 4	Week 6	Week 8
PS vs EM	0,3841	0,4081	0,5439	0,376
PS vs PSEM	0,2892	0,2897	0,5299	0,3143
EM vs PSEM	0,1434	0,5682	0,8551	0,6928

Means, standard deviation and number of plants from (Table 9) to calculating the p – value which shows significant differences between the different media.

3.4 Discussion

3.4.1 Leaf diameter rocket

When grown in PSEM leaf diameter increased initially rapidly (from weeks 2-4), but then a gradual decline for the next three measurements was recorded. Plants in PS had consistent growth over the eight-week observation period; PS and EM plants increased steadily throughout the eight-week growth phase. Rocket leaf diameter increased as the plant got older. EM plants increased leaf diameter growth throughout the eight-week growing period which indicates that EM had a positive effect on rocket growth. Leaf diameter is an important quality parameter in the market place (Koubaa et al., 2015). In rocket plants EM had the biggest and widest leaves and this could allow an increase in profits for the supplying of rocket leaves to grocery shops and restaurants that prefer larger sized leaves. Adding fertilizers to the EM will enhance growth in leaf diameter of rocket, thus increasing profits for the growers (Cefola and Pace, 2015).

Potting soil comprises most of the plant nutrients required for successful growth (Akoumianakis et al., 2008). Mixing PS with compost improves growth in herb plants, therefore by mixing PS to EM, the nutrition and water holding capacity will be improved as well as it will allow herb plants to grow for longer time periods in that mix (Cathey and Stuart, 1961). Rocket grown in EM showed improved growth from the second week period until the end of the experiment. Rainfall is also a major factor for leaf diameter in rocket as the composition of leaves are made up of at least half water, so as the plants get bigger, they absorb more water which is stored in the leaves (Lazzeri et al., 2004).

3.4.2 Plant height rocket

The plant height of rocket grown in PS indicated that it had the best growing conditions throughout the experimental growing period, probably because PS has high nutrient content available for plant uptake. EM and PSEM resulted in similar growth, with gradual, consistent inclines throughout the experiment period. The length of the leaf is vital when sold in a bunch as it will improve the ability to handle the product as well as making the saleable produce look lush and fresh as demanded by the purchasers (Barlas et al., 2011). Rocket leaves that are longer make salad bowls and garnishes more attractive. The market requires longer and wider rocket leaves for manufacturing of different spice mixes and for pharmaceutical uses (Barlas *et al.,* 2011). Plants grown in EM had the lowest height, indicating that EM can be used to bulk up the product (Nascimento et al., 2018). The consistency of growth for the entire eight weeks growing period of plants in PS recording the highest results compared to EM and PSEM. PS positively impacts on plant height in most herb plant species due to their nutritional contents (Nurzyńska-Wierdak, 2009). The older the rocket plants get the more effective the uptake of nutrients and water within the plants (Nicola et al., 2002). Rocket plants will also grow according to the medium that it is grown in, which will indicate the progress in growth over the experimental period (Hanafy Ahmed et al., 2002).

3.4.3 Plant height thyme

Plant size is an important parameter of plant height for the culinary and cosmetic industries using thyme (Zuazo et al., 2008). Growing thyme in PSEM resulted in the most consistent growth in height, despite plants in PS eventually displaying similar plant heights, PSEM produced the tallest plants. Growing thyme in PSEM at the end of the growing period, supported growth similar to PS growth.

The additional nutrition value of EM to the soil media could be used to positively enhance growth in thyme plants (Stahl-Biskup and Venskutonis, 2012). It will be important to evaluate how various media ratios vary with different applications of thyme. By adding EM to PS, thyme plant growth will be improved. This is important when thyme is required in a market as taller plants can be easily exported for spices and medicinal uses (Maftei, 1992b). Growth of thyme is dependent on the medium that it is grown in, as well as the water availability of the medium by the plant for uptake (Omidbaigi and Arjmandi, 2001).

3.4.4 Length of side shoots - thyme

All side shoots increased consistently over the eight-week growing period. PS had the lowest measurements compared to the other two media. EM and PSEM were dominant growth factors in these results. Composted *Lg* contributed to the growth of thyme on the measurement of the length of the side shoots. The PS had the lowest measurements in the results which did not have the impact that the EM had on the length of side shoots in thyme plants. Long side shoots in thyme plants are important in the market value, and sold as a spice or fresh thyme and also distributed to the pharmaceutical industry (Bąbelewski and Pancerz, 2014). EM is beneficial for the growing of thyme plants which can produce longer side shoots at a quicker pace to keep up with market demand. Thyme reacts well to compost as well as a combination of potting soil mixtures with compost (Bugbee, 2002).

3.5 Conclusions

In summary, this chapter presented data on the impact of composted *Lg* on the four growth parameters, which included leaf diameter and plant height in rocket as well as plant height and length of side shoots in thyme. PSEM combination was most beneficial to thyme development, producing the tallest plants. This feature is desirable to the commercial growers for enhanced growth of thyme. The demand of thyme in the industry is high, and the growth materials required to produce thyme plants is cheaper.

CHAPTER 4: FRESH AND DRY MASS OF ROCKET AND THYME GROWN IN DIFFERENT MEDIA

4.1 Introduction

Fresh mass/weight of any plant was measured with all the content of the plant, including the water that is stored in the plant (Dovie et al., 2007). Measuring of dry mass/weight is different to fresh mass/weight as in this case, all the water in that part of the plant must be removed by either freeze-drying or oven drying (Asekun et al., 2007). It is easier to calculate any traits of measure using dry mass because the water content of fresh mass is different in plants which are determined by the environmental conditions in that specific area (Shackleton, 2003). There are different plants used in a fresh and dry state which are determined by the application such as, garnishes, salads, spices and medicines (Springfield et al., 2005). The fresh mass of leaves in herbs and vegetables will determine the price it will be sold to the local markets and the restaurants (Shackleton, 2003).

4.2 *Thymus vulgaris* (thyme) - an important perennial herb species

Thyme and rocket were used as pilot herbs in this study. Due to the high demand by the consumers to use these two herbs, it was advantageous to investigate the required growth characteristics when dealing with the composted enriched *Lg.*

4.2.1 Origin and importance of *Thymus vulgaris*

Thyme, a member of the family of aromatic plants Lamiaceae, is native to Asia and Europe in an area extending from the western Mediterranean to south-eastern Italy (El-Qudah, 2014). This herb is used commercially and locally in a variety of dishes, soups and lotions as well as pharmaceutical products (Department of Agriculture Forestry and Fisheries, 2012). The name 'thyme' is derived from the word *thymos* 'fumigate' which refers to the use of thyme as incense due to its aromatic odour (De Rougemont, 1989, El-Qudah, 2014).

Thyme is produced in South Africa as an essential oil (Borugă et al., 2014, Chowdhury et al., 2008) and thereby forms part of the essential oil industry that uses thyme in fresh or dry forms (Du Preez, 2005). The South African population is growing by almost 2% annually from 49 million in 2009 with an expected population of 82 million by 2035 (Juliano, 2007). With these statistics of the population, the need and desire for food in different forms will have to be almost doubled with regards to growth (Forrester, 1973). The new generation of the population is expected to demand a higher quality crop of herbs which can be used for different aroma applications for the skin as well as spices and medicated products (Maftei, 1992a). Thyme has a wide spectrum of medicinal properties, as an antioxidant as well as an aromatic herb (El-Nekeety *et al.*, 2011). Under irrigation thyme will yield up to 15 tons of fresh matter per hectare annually (Runham, 1995). Thyme production is of importance in France, Switzerland, Spain, Italy, Bulgaria, Greece and Portugal (Stahl-Biskup and Venskutonis, 2012). Out of these countries, the highest thyme oil production occurs in Spain, which produces about 90% of the world trade (Department of Agriculture Forestry and Fisheries, 2012). France has the highest use of thyme in the perfume manufacturing process (Varlet, 1992), while Switzerland is the leading competitor in the thyme pharmaceutical field (Rey, 1992). India and Britain process thyme for flavouring ingredients and spices (De Rougemont, 1989). Thyme also contains anti-fungal and cytotoxicity properties making thyme oil an important product of the medicinal industry (Al-Shahrani et al., 2017).

4.2.2 Uses of thyme

Thyme is one of the spices that is exported by SA which constitutes 2.2% of the world's exports including ginger, saffron, turmeric and bay leaves. All above-ground parts of thyme are used for the essential oil (Al-Maqtari et al., 2011), which is an ingredient in pharmaceuticals, toiletries, spices and perfumes (El-Qudah, 2014). The fresh and dry parts of the plant are used as a spice for culinary purposes (Runham, 1995). The essential oil is used to keep processed meat and butter fresh, as well as in the manufacturing of chewing gum, ice-cream, liqueur and sweets (El-Nekeety et al., 2011). Certain properties of thyme assist in the combatting of chest infections, such as cough, pleurisy and bronchitis (Gurib-Fakim et al., 1996). They are also used as antiseptics, mouthwashes, fumigants and disinfectants (Gulec et al., 2013). Children who are diagnosed with worm infections can be treated with thyme extracts (Du Preez, 2005). Asthma and hay fever are also treated with prescribed medicines containing thyme ingredients (El-Qudah, 2014). Thyme is also used as an antibiotic in the poultry industry (Khan et al., 2012). The cosmetic industry relies on thyme as an ingredient of many products used to treat oily skin, sciatica, eczema, insect bites, acne and dermatitis (Department of Agriculture Forestry and Fisheries, 2012). Thyme is also grown as a companion plant to repel aphids and flies, but certain thyme species can also simply be used in the landscape industry (Varlet, 1992).

4.3 *Eruca sativa* (rocket) - an important annual, culinary herb species

4.3.1 Description, classification and distribution of *Eruca sativa*

Rocket belongs to the mustard family (Brassicaceae) and is commonly known as the salad rocket or garden rocket (Du Preez, 2005). These plants grow well during spring to autumn (Frescura et al., 2013). In cooler seasons, growth is not as quick as in warmer growing periods (Koocheki et al., 2008). *Eruca sativa* is grown intensively in Egypt, Turkey, Portugal and Italy to be used for its phytochemical and anti-bacterial properties (Padulosi, 1995). Currently, rocket is grown in many parts of Europe for processing into pre-packed plastic packets, enabling it to keep fresh for extended periods. Rocket is produced mainly for salads, spices and essential oils (Miyazawa et al., 2002).

Eruca sativa contains glycosides, vitamin C and mineral salts (Powling and Scanders, 1993), compounds that can assist with stomach cramps and pains (NurzyŃSka-Wierdak, 2015) and aid in stimulating body functions (Frescura *et al.*, 2013). Rocket also possesses anti-ulcer properties (Alqasoumi et al., 2009).

4.3.2 *Eruca sativa* used in manufacturing industries

In the last 20 years rocket has become a well-known herb in the commercial industry (DoleŽAlovÁ et al., 2013). The demands for this herb have risen worldwide (Akbulut and Bayramoglu, 2013). In many countries, rocket leaves are used for garnishing, in salads and as a herb spice in a dried form (Stevenson, 1986). Rocket is used in its fresh form as a garnish for salad and for cooking as a dried spice which contributes to the taste and aroma when in use (Al-Qurainy et al., 2010). The crushed seeds are used in many countries in the manufacturing process of soaps and cosmetics (Alam et al., 2007). Rocket plants can be easily grown in home hydroponic systems as well as in greenhouses for optimal growth and development and, therefore, high production (Rosenberg and Linders, 2004). Most of the local and subsistence farmers still grow rocket in home gardens or large open fields (Baiphethi and Jacobs, 2009). Rocket leaves last up to two weeks in storage and the quality of the leaves can be manipulated using a higher dosage of carbon dioxide and lower oxygen levels (Kim and Ishii, 2007). The essential oil aspect is essential due to the extracts from rocket leaves as these contain glucosinolates (Cataldi et al., 2007) that are extensively used in the pharmaceutical industries (Khoobchandani et al., 2010)

Fresh mass of thyme is used extensively in food dishes such as pastas, and especially for roasting meat and vegetables to bring out the tastiest foods with all the aromatic characteristics associated with the plant (Mudau et al., 2007). The shelf life for thyme plants in a fresh state without keeping in a refrigerator is between five and seven days and if kept in a refrigerator, the shelf life is between two to three weeks (Molins, 2001). The drier the thyme plants get naturally the lesser effective or the potency of it in terms of flavour will be reduced (Lubbe and Verpoorte, 2011). The leaves and stems of thyme are crushed in a fresh form and then oven-dried to keep the potency intact (Soysal et al., 2015). This dried crushed form is used in food additives and also used extensively in the manufacturing of soaps, incense sticks and medicinal applications (Maftei, 1992b). The market industry in South Africa exports more than 2% of the world's capacity of thyme (Crossman and Collingwood, 1991). Sustainable farming methods on thyme production is widely used throughout the world due to their hardiness and lifespan (Isman et al., 2011).

Rocket herbs are used in many methods of cooking, essential oils, garnishing and cosmetics (Hall et al., 2012). The fresh form of rocket determines the price of the leaves (Hardesty and Kusunose, 2009). The bigger the leaves are, the more it will cost to the salad market due to the weight (Fontana and Nicola, 2009). The smaller leaves are less expensive and also widely used for garnishing and preparations of pasta, pizzas and other pastry dishes (Pignone and Gómez-Campo, 2011). The shelf life of rocket is between thirteen and sixteen days depending on storage facilities to keep fresh (Pilone et al., 2017). Ethylene is a plant hormone that is used in the growth phase to extend the shelf life of vegetables, herbs and fruit (Cantwell and Reid, 1993).

4.4 Materials and methods

4.4.1 Fresh mass and dry mass determination

Fresh mass/weight of the thyme and rocket plants was measured at the end of each growing trial. Intermediate measurements were not done during the experimental trials due to the plants being put under stress if parts of the plants are removed. This is turn will affect the potential outputs. Fresh mass is all of the parts grown above the ground in rocket and thyme plants. The fresh parts of the rocket plant included the leaves, stems, flowers, seeds and roots which were measured in grams on a scale.

Steps in measuring fresh mass: Removed plants from soil were washed out for any soil medium still stuck on parts of the plant. Soft paper towels were used to absorb any water residual left on the plant. Separated roots, stems, leaves, flowers and seeds from each plant which was then ready to be measured. Each of the plants were cut evenly separating each other into the different parts ready for being weighed. Weighed the different parts of each plant on a scale to collect the required data. Measurement was in grams (g). This measurement was done eight weeks after growing the plugs of rocket and thyme.

Dry mass/weight of roots, stems, leaves, flowers and seeds of thyme and rocket plants were measured after fresh mass/weight measurements were complete.

Steps in measuring dry mass/weights: Each part of thyme and rocket plants were placed into pieces of foil. This was then placed into an oven set at 70 degrees for 72 hours. The mass/weights of each of the parts of the thyme and rocket were measured using a scale. Measurements were in grams (g).

4.5 Results - Fresh and dry mass of rocket and thyme grown in different media over three seasons

Results were measured using the five samples of the rocket and thyme plants. The rocket plant parts were weighed according to the leaves, stems, roots, flowers and seeds. Thyme plants were weighed in relation to the leaves and stems as one measurement and the roots as a separate measurement. Five fresh and five dry samples were weighed and an average of the results was indicated in the graphs at the end of this chapter.

4.5.1 Fresh and dry mass of rocket and thyme grown in PS, EM and PSEM over the three growing seasons

Table 14 Fresh and dry mass of rocket and thyme grown in PS, EM and PSEM, over the three growing season

Averages(cm) of rocket leaves grown in three media (PS, EM and PSEM) over the three growing seasons						
	SEASON 1		SEASON 2		SEASON 3	
	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
PS-ROCKET LEAVES	46,42	19,49	23,7	10,95	10,57	1,73
EM-ROCKET LEAVES	15,89	5,29	16,46	7,24	50,59	17,74
PSEM-ROCKET LEAVES	117,35	38,18	17,49	7,65	9,24	3,26
Averages(cm) of rocket stems grown in three media (PS, EM and PSEM) over the three growing seasons						
	SEASON 1		SEASON 2		SEASON 3	
	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
PS-ROCKET STEMS	91,85	36,35	12,94	3,12	3,36	0,54
EM-ROCKET STEMS	8,74	2,79	4,46	1,05	13,7	2,81
PSEM-ROCKET STEMS	62,76	20,29	10,18	2,14	2,66	0,8
Averages(cm) of rocket roots grown in three media (PS, EM and PSEM) over the three growing seasons						
	SEASON 1		SEASON 2		SEASON 3	
	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
PS-ROCKET ROOTS	8,06	2,96	2,38	0,57	1,23	0,48
EM-ROCKET ROOTS	2,71	0,78	0,64	0,15	2,82	0,8
PSEM-ROCKET ROOTS	7,96	2,34	0,6	0,15	0,5	0,17
Averages(cm) of rocket flowers grown in three media (PS, EM and PSEM) over the three growing seasons						
	SEASON 1		SEASON 2		SEASON 3	
	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
PS-ROCKET FLOWERS	0,52	0,19	0	0	0	0
EM-ROCKET FLOWERS	0,14	0,03	0,11	0,02	0,11	0,03
PSEM-ROCKET FLOWERS	0,06	0,01	0,04	0,005	0	0
Averages(cm) of rocket seeds grown in three media (PS, EM and PSEM) over the three growing seasons						
	SEASON 1		SEASON 2		SEASON 3	
	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
PS-ROCKET SEEDS	6,46	3,07	4,9	1,35	0,26	0,11
EM-ROCKET SEEDS	0,04	0,005	2,42	0,47	0	0
PSEM-ROCKET SEEDS	0	0	7,29	1,62	0	0
Averages(cm) of thyme leaves and stems grown in three media (PS, EM and PSEM) over the three growing seasons						
	SEASON 1		SEASON 2		SEASON 3	
	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
PS-THYME LEAVES AND STEMS	25,9	9,33	24,97	5,52	7,28	1,85
EM-THYME LEAVES AND STEMS	12,9	4,53	16,89	3,53	2,61	0,01
PSEM-THYME LEAVES AND STEMS	21,63	7,26	21,38	4,64	6,53	2
Averages(cm) of thyme roots grown in three media (PS, EM and PSEM) over the three growing seasons						
	SEASON 1		SEASON 2		SEASON 3	
	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
PS-THYME ROOTS	13,35	3,22	12,02	1,85	3,43	0,75
EM-THYME ROOTS	4,76	1,48	6,16	0,79	1,11	0,27
PSEM-THYME ROOTS	6,9	2,22	2,55	0,38	2,29	0,63

4.5.2 Statistical tests to determine significant difference between the different parts of rocket and thyme

Table 15 Significant differences in fresh and dry mass of rocket leaves, stems, roots, flowers, seeds and thyme leaves + stems and thyme roots grown in three different media using the Wilcoxon Signed Ranks Test

	FRESH AND DRY MASS STATISTICAL ANALYSIS								
Rocket Leaves									
Wilcoxon Signed Ranks Test									
Test Statistics[a]									
	PS2 - PS1	PS3 - PS1	PS3 - PS2	EM2 - EM1	EM3 - EM1	EM3 - EM2	PSEM2 - PSEM1	PSEM3 - PSEM1	PSEM3 - PSEM2
Z	-2.023[b]	-2.023[c]	-2.023[c]	-2.023[b]	-.135[c]	-2.023[c]	-2.023[b]	-2.023[b]	-2.023[c]
Asymp. Sig. (2-tailed)	0,043	0,043	0,043	0,043	0,893	0,043	0,043	0,043	0,043
a. Wilcoxon Signed Ranks Test									
b. Based on positive ranks.									
c. Based on negative ranks.									
NPAR TESTS									
PSEM3 (PAIRED)									
Rocket - Stems									
Wilcoxon Signed Ranks Test									
Test Statistics[a]									
	PS2 - PS1	PS3 - PS1	PS3 - PS2	EM2 - EM1	EM3 - EM1	EM3 - EM2	PSEM2 - PSEM1	PSEM3 - PSEM1	PSEM3 - PSEM2
Z	-2.023[b]	-2.023[b]	-2.023[b]	-2.023[b]	-1.753[b]	-.944[c]	-2.023[b]	-.944[b]	-2.023[c]
Asymp. Sig. (2-tailed)	0,043	0,043	0,043	0,043	0,08	0,345	0,043	0,345	0,043
a. Wilcoxon Signed Ranks Test									
b. Based on negative ranks.									
c. Based on positive ranks.									
NPAR TESTS									
PSEM3 (PAIRED)									

Rocket - Roots

Wilcoxon Signed Ranks Test

Test Statistics[a]

	PS2 - PS1	PS3 - PS1	PS3 - PS2	EM2 - EM1	EM3 - EM1	EM3 - EM2	PSEM2 - PSEM1	PSEM3 - PSEM1	PSEM3 - PSEM2
Z	-2.023[b]	-1.214[c]	-2.023[c]	-.944[b]	-.135[c]	-1.753[c]	-1.753[b]	-1.753[c]	-2.023[c]
Asymp. Sig. (2-tailed)	0,043	0,225	0,043	0,345	0,893	0,08	0,08	0,08	0,043

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

NPAR TESTS

PSEM3 (PAIRED)

Rocket Flowers

Wilcoxon Signed Ranks Test

Test Statistics[a]

	EM2 - EM1	EM3 - EM1	EM3 - EM2
Z	-1.342[b]	-.447[c]	-1.342[c]
Asymp. Sig. (2-tailed)	0,18	0,655	0,18

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

NPAR TESTS

PSEM3 (PAIRED)

Rocket - Seeds

Wilcoxon Signed Ranks

Test Statistics[a]					
	PS2 - PS1	PS3 - PS1	PS3 - PS2	EM2 - EM1	PSEM2 - PSEM1
Z	-.944[b]	-1.342[b]	-1.342[b]	-1.604[b]	-1.342[c]
Asymp. Sig. (2-tailed)	0,345	0,18	0,18	0,109	0,18

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

NPAR TESTS

PSEM3 (PAIRED)

Thyme Leaves+Stem

Wilcoxon Signed Ranks

Test Statistics[a]									
	PS2 - PS1	PS3 - PS1	PS3 - PS2	EM2 - EM1	EM3 - EM1	EM3 - EM2	PSEM2 - PSEM1	PSEM3 - PSEM1	PSEM3 - PSEM2
Z	-2.023[b]	-.405[b]	-1.214[c]	-2.023[b]	-1.753[b]	-.674[b]	-2.023[b]	-.674[b]	-2.023[c]
Asymp. Sig. (2-tailed)	0,043	0,686	0,225	0,043	0,08	0,5	0,043	0,5	0,043

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

NPAR TESTS

PSEM3 (PAIRED)

Thyme – Roots

Wilcoxon Signed Ranks

Test Statistics[a]									
	PS2 - PS1	PS3 - PS1	PS3 - PS2	EM2 - EM1	EM3 - EM1	EM3 - EM2	PSEM2 - PSEM1	PSEM3 - PSEM1	PSEM3 - PSEM2
Z	-1.753[b]	-.135[b]	-.674[c]	-2.023[b]	-1.483[b]	-2.023[c]	-2.023[b]	-.405[b]	-2.023[c]
Asymp. Sig. (2-tailed)	0,08	0,893	0,5	0,043	0,138	0,043	0,043	0,686	0,043

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

4.5.3 Summary of significant difference between the different measurements

Rocket leaves, stems and roots had significant differences between the measurements. Flowers and seeds of rocket had minimal or no significant differences between the measurements. Thyme (leaves and stems) and roots had nominal significant differences between the measurements.

Table 16 Significant differences summary of rocket leaves, stems, roots, flowers, seeds and thyme leaves + stems and thyme roots

	SUMMARY OF SIGNIFICANT DIFFERENCES BETWEEN THE DIFFERENT MEASUREMENTS								
	PS2 - PS1	**PS3 - PS1**	**PS3 - PS2**	**EM2 - EM1**	**EM3 - EM1**	**EM3 - EM2**	**PSEM2 - PSEM1**	**PSEM3 - PSEM1**	**PSEM3 - PSEM2**
Rocket - Leaves	0,043	0,043	0,043	0,043	0,893	0,043	0,043	0,043	0,043
Rocket - Stems	0,043	0,043	0,043	0,043	0,080	0,345	0,043	0,345	0,043
Rocket - roots	0,043	0,225	0,043	0,345	0,893	0,080	0,080	0,080	0,043
Rocket - flowers				0,180	0,655	0,180			
Rocket - seeds	0,345	0,180	0,180	0,109			0,180		
Thyme - leaves + stems	0,043	0,686	0,225	0,043	0,080	0,500	0,043	0,500	0,043
Thyme - roots	0,080	0,893	0,500	0,043	0,138	0,043	0,043	0,686	0,043
	ONLY VALUES < 0.05 ARE SIGNIFICANTLY DIFFERENT								

All highlighted $p \leq 0, 05$ implying that there is a significant difference between the time measurements for the various variables.

Statistical analysis of the fresh and dry mass of rocket and thyme explained in the tables and figures below;

Three growth media - PS, EM and PSEM.

The three different seasons in which the rocket and thyme plants were grown in;

The first season was from the 1st of April which continued for a two-month growing period until the 31st May 2016. This growth fell in the season of autumn moving overlapping into the beginning of winter. The second growing trial period was from the 1st of September to the 31st of October 2016 which showed seasonal results between winter and spring. The third growing trial period started on the 1st of February which continued until the 31st of March 2017 which indicated the season's summer and autumn.

4.5.4 Fresh and dry mass of rocket leaves from plants grown in the different growth media

Rocket leaves grown in PSEM had the highest results in the first season of 117,35 g of fresh mass and 38,18 g of dry mass compared to the 46,42 g in PS on fresh mass, 19,49 g on dry mass, and 15,89 g of fresh mass with a 5,29 g in dry mass of rocket grown in EM (Figure 5). The second season of rocket leaves grown in PS which recorded fresh mass of 23,7 g mass with a 10,95 g dry mass, EM showed a 16,46 g fresh mass with a 7,24 g dry mass and PSEM showed a 17,49 g fresh mass with a 7,65 g dry mass. The third season's growth of rocket leaves in the different growing medium indicated the following; EM having the highest fresh mass of 50,59 g with a 17,74 g dry mass, while PS showed a 10,57 g fresh mass with a 1,73 g dry mass and PSEM showing a 9,24 g fresh mass with a 3,26 g dry mass.

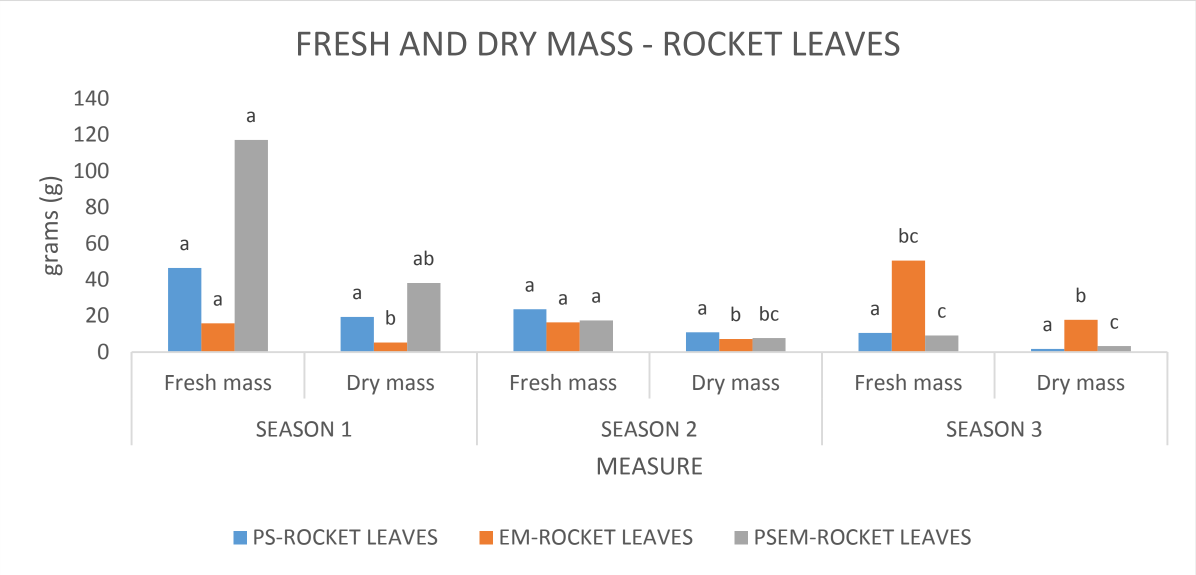

Figure 5 Comparison of fresh and dry mass of rocket leaves between the three growth media, PS, EM and PSEM. Letters above individual columns denote significant differences at p ≤ 0.05 (Table 17).

Table 17 p – values of fresh and dry mass of rocket leaves on plants grown in the different media over three seasons

p-value	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
Rocket leaves	**Season 1**	**Season 1**	**Season 2**	**Season 2**	**Season 3**	**Season 3**
PS - EM	0,5091	0,0451SD	0,0872	0,0040SD	0,0001SD	0,0001SD
PS - PSEM	0,0762	0,665	0,0669	0,0025SD	0,0001SD	0,0251SD
EM - PSEM	0,0965	0,3028	0,6605	0,904	0,0898	0,0013SD

	SUMMARY ON ROCKET LEAVES FOR SIGNIFICANT DIFFERENCES BETWEEN THE THREE GROWTH MEDIA AND THE THREE SEASONS								
	PS2 - PS1	**PS3 - PS1**	**PS3 - PS2**	**EM2 - EM1**	**EM3 - EM1**	**EM3 - EM2**	**PSEM2 - PSEM1**	**PSEM3 - PSEM1**	**PSEM3 - PSEM2**
Rocket - Leaves	0,043	0,043	0,043	0,043	0,893	0,043	0,043	0,043	0,043

Table 18 Significant difference of fresh and dry mass on rocket leaves grown in three growth media, (PS, EM and PSEM)

All highlighted values of p ≤ 0, 05 implying that there was a significant difference between the time measurements for the various variables.

Rocket leaves in EM in seasons three and one had no significant difference compared to all other comparisons in seasons with different media being significantly different.

4.5.5 Fresh and dry mass of rocket stems from plants grown in the three different growth media

Rocket stems grown in PS had the highest results in the first season of 91,85 g of fresh mass and 36,35 g of dry mass compared to the 62,76 g in PSEM on fresh mass, 20,29 g on dry mass, and 8,74 g of fresh mass with a 2,79 g in dry mass of rocket grown in EM (Figure 6). The second season of rocket stems grown in the following soil, PS fresh mass showed 12,94 g mass with a 3,12 g dry mass, while PSEM showed a 10,18 g fresh mass with a 2,14 g dry mass and EM showed a 1,05 g fresh mass with a 13,7 g dry mass. The third season's growth of rocket stems in the different growing medium indicated the following; EM having the highest fresh mass of 13,7 g with a 2,81 g dry mass, while PS showed a 3,36 g fresh mass with a 0,54 g dry mass and PSEM showing a 2,66 g fresh mass with a 0,8 g dry mass.

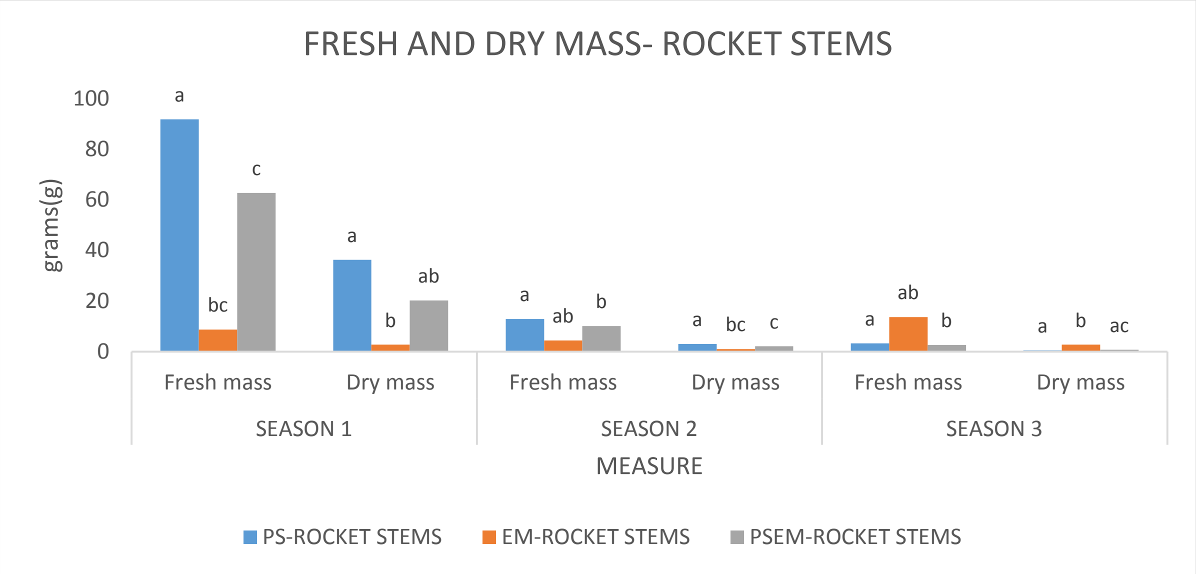

Figure 6 Comparison of fresh and dry mass of rocket stems between the three growth media, PS, EM and PSEM. Letters above individual columns denote significant differences at $p \leq 0.05$ (Table 19).

Table 19 p-values of fresh and dry mass of rocket stems on plants grown in the different media over three seasons

p-value	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
Rocket stems	Season 1	Season 1	Season 2	Season 2	Season 3	Season 3
PS - EM	0,0387SD	0,0189SD	0,0593	0,0286SD	0,0673	0,0022SD
PS - PSEM	0,0088SD	0,1777	0,0055SD	0,0328SD	0,0026SD	0,315
EM - PSEM	0,4412	0,3568	0,3378	0,4951	0,0593	0,0033SD

Table 20 Significant difference of fresh and dry mass on rocket stems grown in three growth media, (PS, EM and PSEM)

	SUMMARY ON ROCKET STEMS FOR SIGNIFICANT DIFFERENCES BETWEEN THE THREE GROWTH MEDIA AND THE THREE SEASONS								
	PS2 - PS1	**PS3 - PS1**	**PS3 - PS2**	**EM2 - EM1**	**EM3 - EM1**	**EM3 - EM2**	**PSEM2 - PSEM1**	**PSEM3 - PSEM1**	**PSEM3 - PSEM2**
Rocket - Stems	0,043	0,043	0,043	0,043	0,080	0,345	0,043	0,345	0,043

All highlighted values of $p \leq 0, 05$ implying that there was a significant difference between the time measurements for the various variables.

Rocket stems in seasons three and one on EM and PSEM which indicated no significant difference. EM in seasons three and two also had no significant difference. All the other seasonal comparison between three seasons of the three media indicated that they are significantly different.

4.5.6 Fresh and dry mass of rocket roots from plants grown in three different growth media

Rocket roots grown in PS had the greatest weight in the first season of 8.06 g of fresh mass and 2,96 g of dry mass compared to the 7,96 g in PSEM on fresh mass, 2,34 g on dry mass, and 2,71 g of fresh mass with a 0,78 g in dry mass of rocket grown in EM (Figure 7). The second season of rocket roots grown in PS showed fresh mass of 2.38 g mass with a 0,57 g dry mass, EM showed a 0,64 g fresh mass with a 0,15 g dry mass while PSEM showed a 0,6 g fresh mass with a 0,15 g dry mass. The third season's growth of rocket roots in the different growing medium indicated the following; EM having the highest fresh mass of 2.82 g with a 0,8 g dry mass, PS showed a 1,23 g fresh mass with a 0,48 g dry mass and PSEM showing a 0,5 g fresh mass with a 0,17 g dry mass.

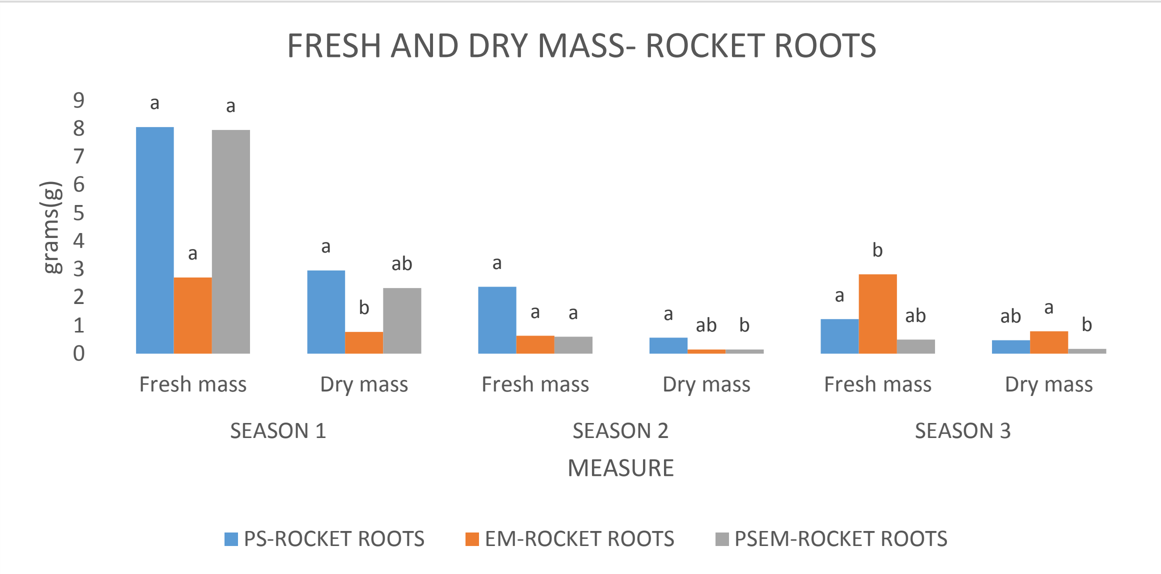

Figure 7 Comparison of fresh and dry mass of rocket roots between the three growth media, PS, EM and PSEM. Letters above individual columns denote significant differences at $p \leq 0.05$ (Table 21).

Table 21 p-values of fresh and dry mass of rocket roots on plants grown in the different media over three seasons

p-value	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
Rocket roots	Season 1	Season 1	Season 2	Season 2	Season 3	Season 3
PS - EM	0,2882	0,0058SD	0,8564	0,0834	0,0476SD	0,0521
PS - PSEM	0,2287	0,5709	0,4719	0,0152SD	0,8461	0,6369
EM - PSEM	0,5418	0,1492	0,7317	0,2514	0,0691	0,0057SD

Table 22 Significant difference of fresh and dry mass on rocket roots grown in three growth media, (PS, EM and PSEM)

	SUMMARY ON ROCKET ROOTS FOR SIGNIFICANT DIFFERENCES BETWEEN THE THREE GROWTH MEDIA AND THE THREE SEASONS								
	PS2 - PS1	**PS3 - PS1**	**PS3 - PS2**	**EM2 - EM1**	**EM3 - EM1**	**EM3 - EM2**	**PSEM2 - PSEM1**	**PSEM3 - PSEM1**	**PSEM3 - PSEM2**
Rocket - roots	0,043	0,225	0,043	0,345	0,893	0,080	0,080	0,080	0,043

All highlighted values of p ≤ 0, 05 implying that there was a significant difference between the time measurements for the various variables.

Rocket roots in seasons three and two of PS and PSEM showed significant differences and rocket roots in seasons two and one of PS indicating that they are significantly different. The other comparisons between seasons and different media showed no significant difference.

4.5.7 Fresh and dry mass of rocket flowers from plants grown in the three different growth media

Rocket flowers grown in PS had the greatest weight in the first season of 0,52 g of fresh mass and 0,19 g of dry mass compared to the 0,14 g in EM on fresh mass, 0,03 g on dry mass, and 0,06 g of fresh mass with a 0,01 g in dry mass of rocket grown in PSEM (Figure 8). The second season of rocket flowers grown in PS had no flowers while EM showed a 0,11 g fresh mass with a 0,02 g dry mass and PSEM showed a 0,04 g fresh mass with a 0,005 g dry mass. The third season's growth of rocket flowers in the different growing medium indicated the following; EM having the highest fresh mass of 0,11 g with a 0,03 g dry mass while PS and PSEM had no flowers. Flowers are dependent on the flowering season and also the appropriate nutrients that are required for flowering (Lazzeri et al., 2003).

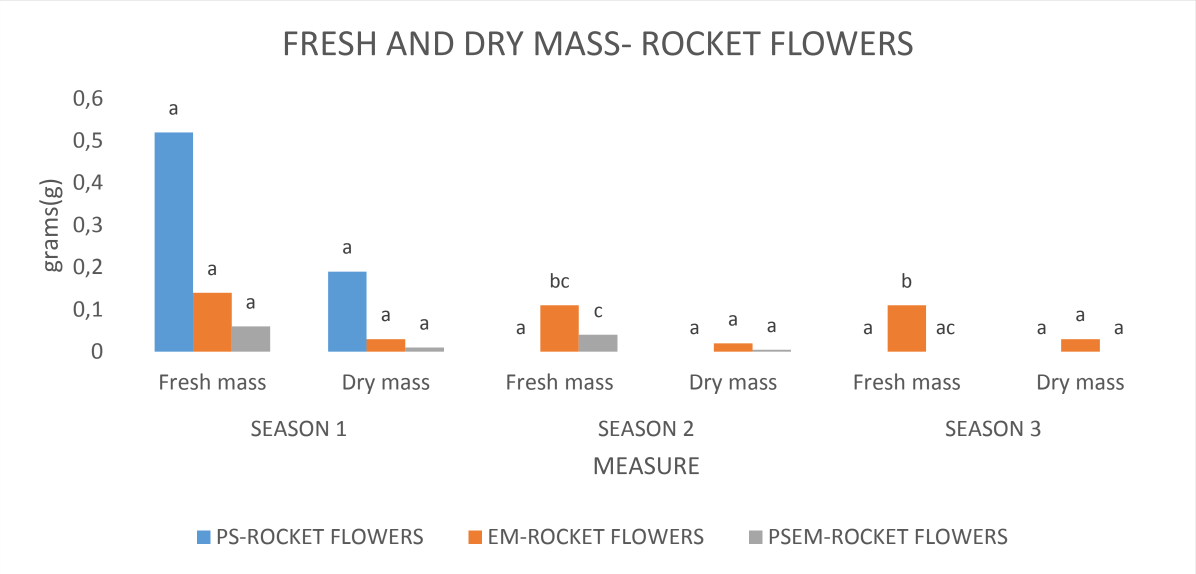

Figure 8 Comparison of fresh and dry mass of rocket flowers between the three growth media, PS, EM and PSEM. Letters above individual columns denote significant differences at p ≤ 0.05 (Table 23).

Table 23 p-values of fresh and dry mass of rocket flowers on plants grown in the different media over three seasons

p-value	**Fresh mass**	**Dry mass**	**Fresh mass**	**Dry mass**	**Fresh mass**	**Dry mass**
Rocket flowers	**Season 1**	**Season 1**	**Season 2**	**Season 2**	**Season 3**	**Season 3**
PS - EM	0,3349	0,8842	0,0001SD	0,2165	0,0001SD	0,2493
PS - PSEM	0,2568	0,1483	0,0001SD	0,296	0	0
EM - PSEM	0,5815	0,2313	0,1207	0,2472	0,0001SD	0,2493

Table 24 Significant difference of fresh and dry mass on rocket flowers grown in three growth media, (PS, EM and PSEM)

	SUMMARY ON ROCKET FLOWERS FOR SIGNIFICANT DIFFERENCES BETWEEN THE THREE GROWTH MEDIA AND THE THREE SEASONS								
	PS2 - PS1	**PS3 - PS1**	**PS3 - PS2**	**EM2 - EM1**	**EM3 - EM1**	**EM3 - EM2**	**PSEM2 - PSEM1**	**PSEM3 - PSEM1**	**PSEM3 - PSEM2**
Rocket - flowers	0	0	0	0,180	0,655	0,180	0	0	0

All highlighted values of p ≤ 0, 05 implying that there was a significant difference between the time measurements for the various variables.

Rocket flowers had no significant difference between the three seasons growth on different media.

4.5.8 Fresh and dry mass of rocket seeds from plants grown in the three different growth media

Rocket seeds grown in PS had the greatest weight in the first season of 6,46 g of fresh mass and 3,07 g of dry mass compared to the 0,04 g in EM on fresh mass, 0,005 g on dry mass, and 0,06 g of fresh mass with a 0,01 g in dry mass of rocket grown in PSEM (Figure 9). The second season of rocket seeds grown in the following soil, PSEM had the greatest weight of 7,29 g fresh mass with a 1,62 g dry mass while PS showed a 4,9 g fresh mass with a 1,35 g dry mass and EM showed a 2,42 g fresh mass with a 0,47 g dry mass. The third season's growth of rocket seeds in the different growing medium indicated the following; PS had the highest fresh mass of 0,26 g with a 0,11 g dry mass, EM and PSEM had no seeds.

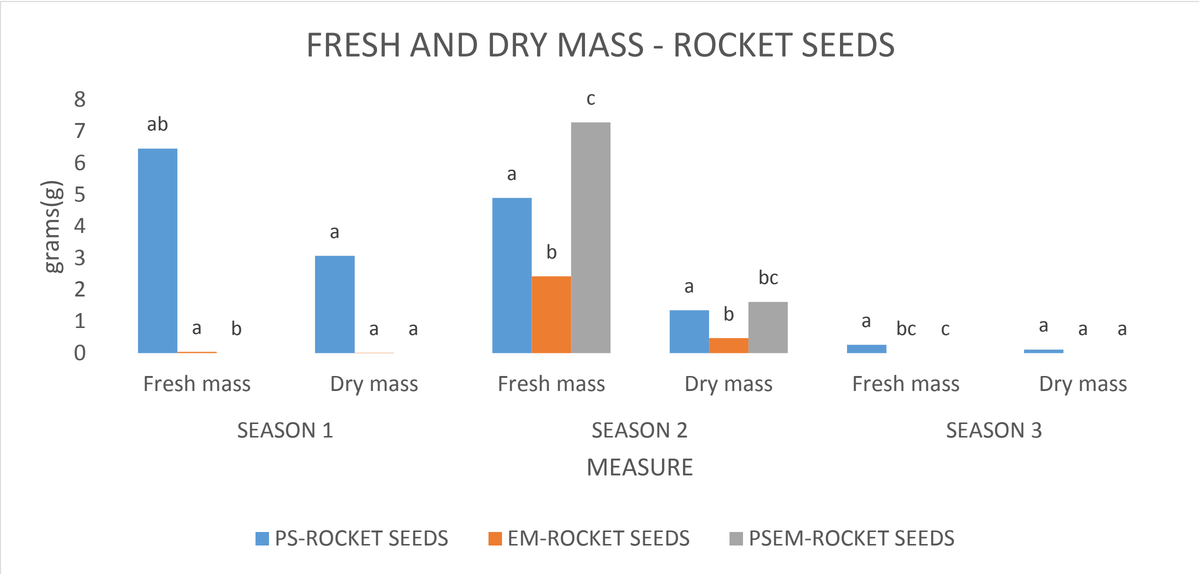

Figure 9 Comparison of fresh and dry mass of rocket seeds between the three growth media, PS, EM and PSEM. Letters above individual columns denote significant differences at $p \leq 0.05$ (Table 25).

Table 25 p- values of fresh and dry mass of rocket seeds on plants grown in the different media over three seasons

p-value	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
Rocket seeds	**Season 1**	**Season 1**	**Season 2**	**Season 2**	**Season 3**	**Season 3**
PS - EM	0,1120	0,1977	0,0226SD	0,0312SD	0,0001SD	0,1744
PS - PSEM	0,4887	0,2357	0,0291SD	0,3381	0,0001SD	0,1744
EM - PSEM	0,0001SD	0,175	0,0001SD	0,0468SD	0	0

Table 26 Significant difference of fresh and dry mass on rocket seeds grown in three growth media, (PS, EM and PSEM)

	SUMMARY ON ROCKET SEEDS FOR SIGNIFICANT DIFFERENCES BETWEEN THE THREE GROWTH MEDIA AND THE THREE SEASONS								
	PS2 - PS1	**PS3 - PS1**	**PS3 - PS2**	**EM2 - EM1**	**EM3 - EM1**	**EM3 - EM2**	**PSEM2 - PSEM1**	**PSEM3 - PSEM1**	**PSEM3 - PSEM2**
Rocket - seeds	0,345	0,180	0,180	0,109	0	0	0,180	0	0

All highlighted values of $p \leq 0, 05$ implying that there was a significant difference between the time measurements for the various variables.

Rocket seeds had no significant difference between the three seasons' growths on different media.

4.5.9 Fresh and dry mass of thyme leaves and stems from plants grown in the three different growth media

Thyme leaves and stems grown in PS had the greatest weight in the first season of 25,9 g of fresh mass and 9,33 g of dry mass compared to the 21,63 g in PSEM on fresh mass, 7,26 g on dry mass, and 12,9 g of fresh mass with a 4,53 g in dry mass of rocket grown in EM (Figure 10). The second season of thyme leaves and stems grown in PS showed fresh mass of 24,97 g mass with a 5,52 g dry mass while PSEM showed a 21,38 g fresh mass with a 4,64 g dry mass and EM showed a 16,89 g fresh mass with a 3,53 g dry mass. The third season's growth of thyme leaves and stems in the different growing medium indicated the following; PS having the highest fresh mass of 7,28 g with a 1,85 g dry mass, PSEM showed a 6,53 g fresh mass with a 2,0 g dry mass and EM showing a 2,61 g fresh mass with a 0,01 g dry mass.

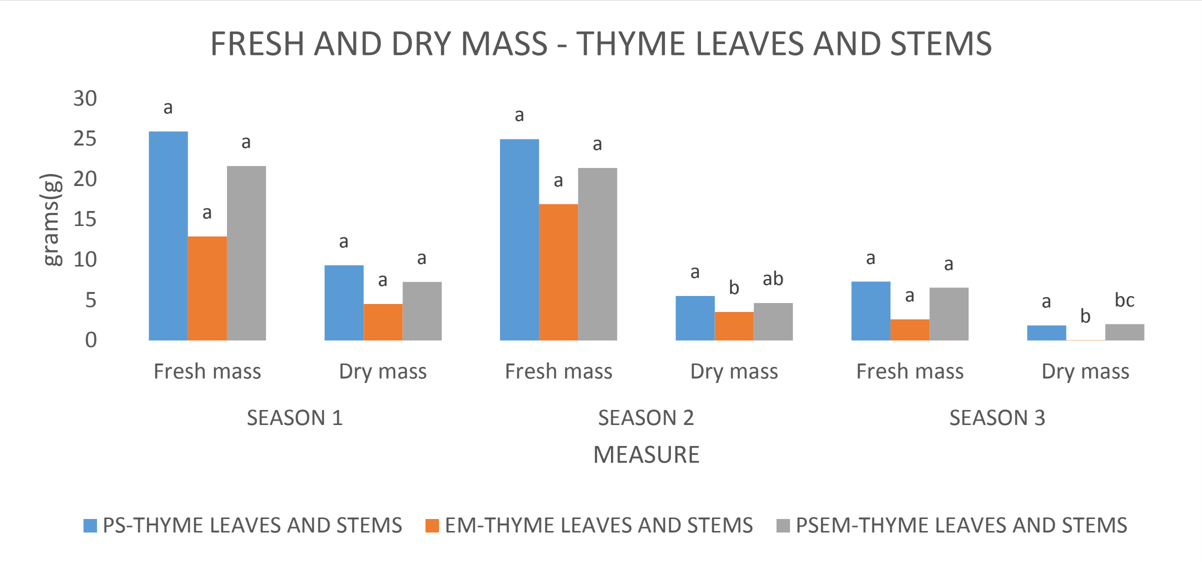

Figure 10 Comparison of fresh and dry mass of thyme leaves and stems between the three growth media, PS, EM and PSEM. Letters above individual columns denote significant differences at $p \leq 0.05$ (Table 27).

Table 27 p-values of fresh and dry mass of thyme leaves + stems on plants grown in the different media over three seasons

p-value	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
Thyme leaves + stems	Season 1	Season 1	Season 2	Season 2	Season 3	Season 3
PS - EM	0,3099	0,2179	0,1541	0,0255SD	0,2066	0,0120SD
PS - PSEM	0,8688	0,5021	0,7488	0,0647	0,8533	0,6474
EM - PSEM	0,3596	0,5639	0,6989	0,3332	0,1589	0,0124SD

Table 28 Significant difference of fresh and dry mass on leaves and stems of thyme grown in three growth media, (PS, EM and PSEM)

	SUMMARY ON THYME LEAVES + STEMS FOR SIGNIFICANT DIFFERENCES BETWEEN THE THREE GROWTH MEDIA AND THE THREE SEASONS								
	PS2 - PS1	**PS3 - PS1**	**PS3 - PS2**	**EM2 - EM1**	**EM3 - EM1**	**EM3 - EM2**	**PSEM2 - PSEM1**	**PSEM3 - PSEM1**	**PSEM3 - PSEM2**
Thyme - leaves + stems	0,043	0,686	0,225	0,043	0,080	0,500	0,043	0,500	0,043

All highlighted values of p ≤ 0, 05 implying that there was a significant difference between the time measurements for the various variables.

Thyme leaves and stems in seasons two and one of PS, EM and PSEM show significant differences and in seasons three and two of PSEM. All the other comparisons between seasons and different media indicates no significant differences.

4.5.10 Fresh and dry mass of thyme roots from plants grown in the three different growth media

Thyme roots grown in PS had the greatest weight in the first season of 13,35 g of fresh mass and 3,22 g of dry mass compared to the 6,9 g in PSEM on fresh mass, 2,22 g on dry mass, and 4,76 g of fresh mass with a 1,48 g in dry mass of rocket grown in EM (Figure 11). The second season of thyme roots grown in the following soil, PS showed fresh mass of 12,02 g mass with a 1,85 g dry mass, EM showed a 6,16 g fresh mass with a 0,79 g dry mass and PSEM showed a 2,55 g fresh mass with a 0,38 g dry mass. The third season's growth of thyme roots in the different growing media indicated the following; PS having the highest fresh mass of 3,43 g with a 0,75 g dry mass while PSEM showed a 2,29 g fresh mass with a 0,63 g dry mass and EM showing a 1,11 g fresh mass with a 0,27 g dry mass.

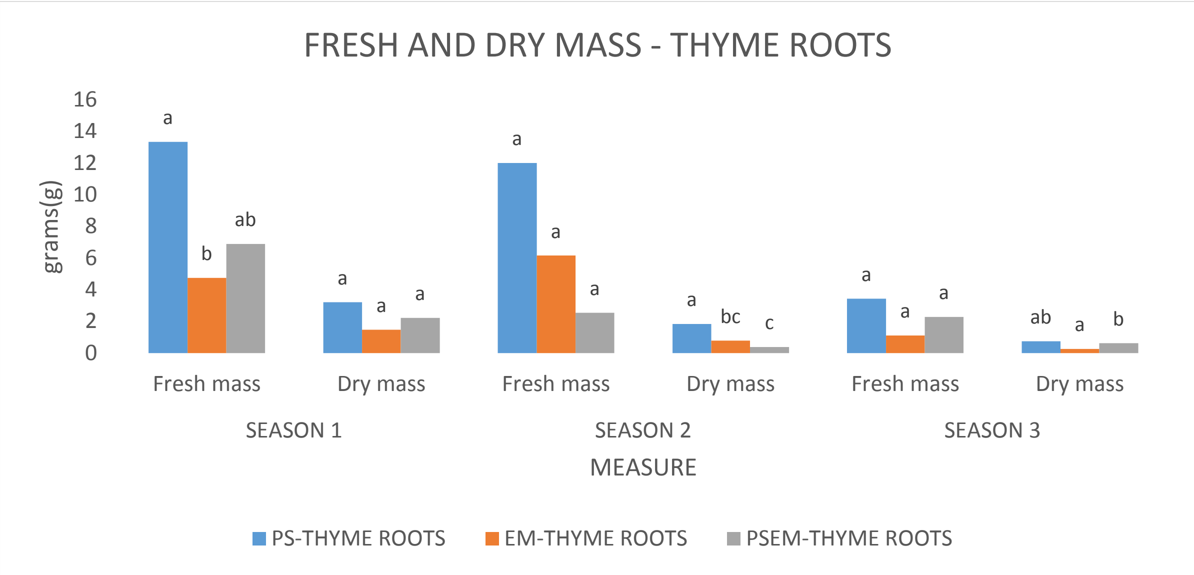

Figure 11 Comparison of fresh and dry mass of thyme roots between the three growth media, PS, EM and PSEM. Letters above individual columns denote significant differences at p ≤ 0.05 (Table 29).

Table 29 p-values of fresh and dry mass of thyme roots on plants grown in the different media over three seasons

p-value	**Fresh mass**	**Dry mass**	**Fresh mass**	**Dry mass**	**Fresh mass**	**Dry mass**	
Thyme roots	**Season 1**	**Season 1**	**Season 2**	**Season 2**	**Season 3**	**Season 3**	
PS - EM	0,0482SD	0,6137	0,0886	0,0136SD	0,6421	0,1829	
PS - PSEM	0,0649	0,4673	0,4773	0,0022SD	0,0919	0,832	
EM - PSEM	0,70010	0,75690	0,4367	0,4299	0,3132	0,0485SD	

Table 30 Significant difference of fresh and dry mass on thyme roots grown in three growth media, (PS, EM and PSEM)

	SUMMARY ON THYME ROOTS FOR SIGNIFICANT DIFFERENCES BETWEEN THE THREE GROWTH MEDIA AND THE THREE SEASONS								
	PS2 - PS1	**PS3 - PS1**	**PS3 - PS2**	**EM2 - EM1**	**EM3 - EM1**	**EM3 - EM2**	**PSEM2 - PSEM1**	**PSEM3 - PSEM1**	**PSEM3 - PSEM2**
Thyme - roots	0,080	0,893	0,500	0,043	0,138	0,043	0,043	0,686	0,043

All highlighted values of p ≤ 0, 05 implying that there was a significant difference between the time measurements for the various variables.

4.6 Discussion

4.6.1 Fresh and dry mass of rocket leaves

Rocket leaves grown in the first season in PSEM resulted in the greatest weight compared to the second and third seasons (Figure 5). This indicates that the mixture of PS and EM worked well in the autumn to winter months which produced larger yields in the rocket plants. EM had the lowest weight of fresh mass in the first season and the highest measurement in the third season which shows that the EM that was produced from the *Lg* showed promising results in the summer and autumn months. PSEM had the best results in the first season which indicated that rocket leaves were more productive. This is important to show that the rocket leaves stored more water in the first season's growth compared to the other two seasons. There was heavy rainfall in the first season's growth which encouraged the rocket leaves to grow effectively and also the mixture of PS and EM which was beneficial to the uptake of water due to the soil functions in terms of water holding capacity, nutrient availability and uptake, and drainage.

Season two of the growth of rocket leaves had minimal results of growth due to the season on growth in the winter to spring months of growing. This is an indication of the growth on rocket leaves which makes reference to poor growth in the winter months, therefore the results for the second season were poor. Rocket leaves grown in EM had the best fresh mass results in the third growing season which showed that there was a positive response from the EM on the growth of rocket leaves especially in the growing months of summer to autumn.

This is an indication that the rocket leaves reacted positively in the EM compared to the other two media. Rocket is dependent on the water availability to determine the size and freshness of leaves together with light intensities to indicate the photosynthetic rate of growing (Ashraf, 1994).

4.6.2 Fresh and dry mass of rocket stems

Fresh mass of rocket stems grown in PS had the greatest weight compared to all the other seasons' growth (Figure 6). This indicates that rocket stems liked the autumn to winter months to grow in PS. EM had the lowest fresh mass in the first season and the highest in the third season which shows that rocket stems liked the summer to autumn months to grow in EM. Rocket stems grew best in the first season's growth which showed that the PS and PSEM had positive results on fresh mass. This is due to the rainfall that occurred in the Durban area which improved and increased the growth of rocket stems in the first season's growth.

The PS and PSEM had the ability to hold water and bulk up rocket stems compared to the EM which had little impact on the growth of stems. The other two season's growth had minimal growth results on rocket stems between the three soil media which shows that there was not enough rainfall, including that the stems did not store lots of water in the second and third season's growth. The thickness and freshness of the stems are determined by the amounts of water available as well as the optimum growth period in which rocket is actively growing (Dolliver et al., 2007).

4.6.3 Fresh and dry mass of rocket roots

Rocket roots grown in PS and PSEM had similar fresh mass compared to EM which had the lowest results in the first season's growth (Figure 7). This implies that rocket roots grew well in the autumn to winter months in PS and PSEM compared to the lowest results in the third season which is from summer to autumn. Rocket roots had the greatest growth in PS of the second season compared to the EM and PSEM. Roots are reliant on good soil, aeration and nutrition that they can absorb and transport to the upper parts of the plant. The bigger and more vigorous the roots are, the more effective they are in absorbing water and nutrients (Kamran et al., 2016).

4.6.4 Fresh and dry mass of rocket flowers

Rocket flowers grown in PS in the first season had the greatest weight compared to the EM and PSEM for all the three seasons' growth (Figure 8). The rocket flowers' results for EM were fairly consistent in all three seasons which showed that they can flower in all the four seasons of the year. Rocket flowers grown in PSEM had the lowest results in most of the seasons' growth. The flowering of rocket in the three seasons of EM had similar results. Rocket flowers grown in PS had a rapid increase of mass in the first season compared to the second and third trial seasons. PSEM had fairly consistent growth mass between the seasons. Rocket flowering season is between May and August which is indicated in the results (Knobloch, 1972). The PS in the first season's growth showed positive results due to the rocket reacting to the preferred season for flowering.

4.6.5 Fresh and dry mass of rocket seeds

Rocket seeds grown in PS in the first season had the greatest weight compared to the other two growing mediums (Figure 9). PSEM had the highest results in the second season's growth between winter and spring. Rocket seeds had poor results of seeding in the first and third season's growth. Rocket seeds grown in EM only had positive results in the second trial together with PSEM compared to the other two growing seasons. The PSEM had positive growth in the second season which indicated that rocket plants seeded well. Rocket plants' most active growing season is in summer and therefore the highest seed-producing occurred in the second season (Nicola et al., 2005). Rocket seeds grown in PSEM in the second trial had the highest mass compared to EM and PS. PS had a steady incline in mass from seasons one and two. All three soil media used to grow rocket seeds had a low mass for the third season.

4.6.6 Fresh and dry mass of thyme leaves and stems

Thyme leaves and stems grown in PS and PSEM had consistent growth over the first two seasons compared to EM. PS results showed that thyme leaves and stems are positively grown in season's autumn to winter and winter to spring (Figure 10). Thyme leaves and stems grown in PS had the highest fresh mass for all the season compared to the EM and PSEM. EM had the lowest mass for all of the three growing seasons. PSEM had similar growth in the first two seasons and then a decline in the third season.

4.6.7 Fresh and dry mass of thyme roots

Thyme roots grew the best in PS in the first season between the summer and autumn months (Figure 11). Thyme roots in EM and PSEM had fairly similar results throughout the three seasons' growth. Thyme roots grown in PS had the best results for the entire three-season period. EM had a higher mass than PSEM in the second season compared to the first and third season which showed that PSEM was greater. Thyme roots are dependent on the availability of water and nutrients to absorb and transport to the upper parts of the plant when required. If plants are left without water, the plant will stress and become susceptible to drying out (Moradi et al., 2014).

4.7 Conclusions

The first trial/seasons’ growth for rocket leaves in PSEM had the highest measurements with regards to mass. This is a positive outcome in relation to this study due to the mass and size of the leaves grown in the PSEM which is the experimental medium and the control medium mixed in a 1:1 ratio. This shows that the market industry for rocket leaves will be interested in these findings to promote quicker plant characteristics of rocket leaves using the composted *Litsea glutinosa* to grow rocket plants. The growth of rocket for their leaves in the production of the salads as well as the spices industry would benefit from this research outputs for the timing of growth in different media and seasons for optimum production. Rocket grown in PS in the first trial/season in autumn to winter had the highest mass and PSEM having the highest in the second trial/season in winter-spring. This is important to growers of rocket for seed harvesting due to the differences of rocket grown in different media over different seasons. The relevance for seed production of rocket is required in large quantities for the manufacturing process of soaps and cosmetics. When using PS for growing thyme plants, the cost implicated is very high. Results has shown that PSEM had slightly similar growth compared to PS so it is feasible to use a cheaper medium PSEM that has optimum growth.

CHAPTER 5: CHLOROPHYLL CONCENTRATION IN ROCKET AND THYME LEAVES

5.1 Introduction

The importance of chlorophyll from the perception of the consumer is the main reason for them to buy any herbs (Paggi et al., 2013). The greener the leaves, the more chlorophyll the plant has developed, which shows the customer that the herbs are fresh and healthy (Sharma et al., 2008). Antioxidant compositions are more in herbs that are green and lush in appearance (Endo et al., 1985). This perception causes customers to buy greener herbs that contain antioxidants that can reduce oxidative stress and damage to mental health (Liu et al., 2008). Oxidative stress is one of the main causes of human mental health becoming unstable and weak (Aseervatham et al., 2013). The other aspect of chlorophyll playing a role is in the restaurant and salad industries which manufacture produce according to the quality and greenness of herb leaves to ensure customer satisfaction (Sledz and Witrowa-Rajchert, 2012). The pre-packaging of salad, be it leaves of lettuce, rocket, thyme, parsley, basil and coriander must be fresh and green when sold to increase revenue for the associated industry (Oberholtzer *et al.*, 2005).

The third unit of measurement to assess the impact of *Litsea glutinosa* on the growth of selected agricultural herbs (*Thymus vulgaris* and *Eruca sativa*) on leaf and stem growth was chlorophyll extract. Chlorophyll (green colour) is the most significant tetrapyrrole (possesses a central bound magnesium ion) (Gitelson et al., 2003). Chlorophyll is present in all higher plants (Gitelson and Merzlyak, 1997). The disadvantages of chlorophyll are that it is unstable in some foods that grow under diverse pH conditions (Muñoz-Huerta et al., 2013).

Chlorophyll extractions are experimented with to find out how effectively involved a plant can be in photosynthesis due to one of the main requirements being the chlorophyll content (Wang et al., 2014). The content of chlorophyll in recent research has become important due to the properties in antioxidants (Prochazkova et al., 2001). Chlorophyll is insoluble in water and therefore a type of solvent is required to extract it from plants efficiently (Suzuki and Ishimaru, 1990). It is vital to choose the right solvent for extraction to differentiate between pigment tissue treatments for experimentation (Holm-Hansen and Riemann, 1978).

The content of plants consists of nutrients such as chlorophyll, carotenoids, flavonoids etc. Of these, the most important component is chlorophyll for my study. The aim of my study was to investigate growth using enriched composted *Litsea glutinosa* on selected herb species. Due to chlorophyll being the active ingredient for photosynthesis in plants, I, therefore, can justify that chlorophyll is the most important measure for my study.

5.2 Materials and methods

5.2.1 Steps to analyse chlorophyll concentration in thyme and rocket leaves

There were 18 samples that were taken of 5 g each for the different measurements of study. Samples were then left to freeze-dry for 3 days. The rocket and thyme plants were separated from their leaves and fresh mass weighed for each of the plants in 5 gram lots. These were then put into zip-lock plastic packets. Liquid nitrogen was then added to the leaves to freeze cells. The zip-lock plastics were then sealed into a beaker covered with foil to prevent photosynthesis from occurring.

One g of fresh mass was added to a solution of 80% acetone. Four ml was used on 1 g fresh mass. One g fresh mass was weighed using a scale. The IKA T25 Digital Ultra – Turrax was used to mix the fresh mass and the 80% acetone for 1 minute x 1000. 80% acetone = 100% acetone + 20% distilled. Three g fresh mass was mixed in mortar with 4ml of 80% acetone and a pinch of acid-washed sand. Two ml acetone was used to wash the mortar (LICHTENTHALER and Wellburn, 1983). The mixture was added to 18 centrifuge tubes. Two ml of acetone was used to wash the Ultra-Turrax. Then the mixed samples were put into centrifuge tubes and put into the centrifuge PLC series for 5mins at full speed. After the samples were removed from the centrifuge PLC a small piece of foil was used to cover the top of the tube which was then placed in dry ice. The samples were then taken to do the chlorophyll and carotenoid tests. Zero point zero two ml of the samples was added to 0.18 ml of 80% acetone and put into the tubes for calculations.

5.2.2 Seasons and timeframes of experiments

Despite conducting the experiment in a semi-controlled environment, seasonal differences in plant growth were expected. Hence, the experiment was carried out in three growing seasons. Three seasons were considered when implementing the trials of growth using potting soil (PS) which is the control, composted *Litsea glutinosa* (EM) and potting soil, plus the composted *Litsea glutinosa* (PSEM) being the experiment. The first season was from the 1st of April which continued for a two-month growing period until the 31st of May 2016. This growth fell in the season of autumn overlapping into the beginning of winter. The second growing trial period was from the 1st September to the 31st of October 2016 which showed seasonal results between spring moving into summer.

The third growing trial period started on the 1st of February which continued until the 31st of

March 2017, thus showing seasonal growth between summers going to autumn. The thyme and rocket herbs showed variations in growth between each growing trial periods. Temperature and climate conditions were justifications for the different growth patterns between thyme and rocket.

5.3 Results-chlorophyll concentration in rocket and thyme over the three seasons

The results will be presented with a sequence of tables that will specify the chlorophyll content of thyme and rocket herbs species in the three arms of the study (experiment, control, experiment + control).

5.3.1 Chlorophyll concentrations in rocket and thyme over three seasons

It was important to investigate the chlorophyll content in these two herbs in all three seasons over the growth period. This is to determine how dependent chlorophyll is on light requirements which are determined by day lengths. The first season’s growth was observed from the beginning of April to the end of May. The season’s growth was between autumn overlapping into winter. The day length for this season’s growth was the shortest. The second season’s growth was between the beginning of September to the end of October.

This showed the day lengths increasing due to the season changing from winter moving into early spring. The third season’s growth started from the beginning of February until the end of March. This showed the longest day length in the entire study due to the season being summer moving into autumn.

Table 31 One-Sample Kolmogorov-Smirnov Test used to measure means and standard deviation of thyme grown in PS

THYME-PS-One-Sample Kolmogorov-Smirnov Test

		Chlorophyll A	Chlorophyll B
N		9	9
Normal Parameters[a,b]	Mean	6.122965	3.273926
	Std. Deviation	3.6658053	1.0652031
Most Extreme Differences	Absolute	.164	.215
	Positive	.164	.163
	Negative	-.128	-.215
Test Statistic		.164	.215
Asymp. Sig. (2-tailed)		.200[c,d]	.200[c,d]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. This is a lower bound of the true significance.

Table 32 Significant difference between multiple comparisons of Thymus valgaris grown in PS using the Bonferroni Test

Multiple Comparisons

Bonferroni

Dependent Variable	(I) Date	(J) Date	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Chlorophyll A	1.00	2.00	-3.4021281*	1.0156049	.046	-6.740884	-.063373
		3.00	-8.0595323*	1.0156049	.001	-11.398288	-4.720777
	2.00	1.00	3.4021281*	1.0156049	.046	.063373	6.740884
		3.00	-4.6574042*	1.0156049	.011	-7.996160	-1.318649
	3.00	1.00	8.0595323*	1.0156049	.001	4.720777	11.398288
		2.00	4.6574042*	1.0156049	.011	1.318649	7.996160
Chlorophyll B	1.00	2.00	1.7823527	.5715833	.062	-.096702	3.661407
		3.00	.0630090	.5715833	1.000	-1.816045	1.942063
	2.00	1.00	-1.7823527	.5715833	.062	-3.661407	.096702
		3.00	-1.7193437	.5715833	.071	-3.598398	.159711
	3.00	1.00	-.0630090	.5715833	1.000	-1.942063	1.816045
		2.00	1.7193437	.5715833	.071	-.159711	3.598398

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

Chlorophyll A: An examination of the p-values (sig.) indicates that there are significant differences in the means between the trial measurement periods. The directions of the differences are indicated in the means tables.

Chlorophyll B: It is observed that the differences are not significant between the trials ($p > 0.05$).

THYME-EM

Table 33 One-Sample Kolmogorov-Smirnov Test used to measure means, standard deviations and absolute values of thyme grown in EM

One-Sample Kolmogorov-Smirnov Test

		Chlorophyll A	Chlorophyll B
N		9	9
Normal Parameters[a,b]	Mean	6.391482	2.960739
	Std. Deviation	6.7184273	2.6633995
Most Extreme Differences	Absolute	.343	.179
	Positive	.343	.179
	Negative	-.218	-.126
Test Statistic		.343	.179
Asymp. Sig. (2-tailed)		.003[c]	.200[c,d]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. This is a lower bound of the true significance.

Test Statistics[a,b]

1 vs 2

	Chlorophyll A	Chlorophyll B
Chi-Square	3.857	3.857
df	1	1
Asymp. Sig.	.050	.050

a. Kruskal Wallis Test

b. Grouping Variable: Date

Test Statistics[a,b]

1 vs 3

	Chlorophyll A	Chlorophyll B
Chi-Square	7.200	7.200
df	2	2
Asymp. Sig.	.027	.027

a. Kruskal Wallis Test

b. Grouping Variable: Date

Test Statistics[a,b]

	Chlorophyll A	Chlorophyll B
Chi-Square	3.857	3.857
df	1	1
Asymp. Sig.	.050	.050

a. Kruskal Wallis Test

b. Grouping Variable: Date

2 vs 3

Table 34 One-Sample Kolmogorov-Smirnov Test used to measure mean values, standard deviations and absolute values of thyme grown in PSEM

THYME-PS+EM

One-Sample Kolmogorov-Smirnov Test

		Chlorophyll A	Chlorophyll B
N		9	9
Normal Parameters[a,b]	Mean	7.456261	4.130034
	Std. Deviation	6.1933655	1.4796606
Most Extreme Differences	Absolute	.216	.221
	Positive	.216	.221
	Negative	-.172	-.212
Test Statistic		.216	.221
Asymp. Sig. (2-tailed)		.200[c,d]	.200[c,d]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. This is a lower bound of the true significance.

Table 35 Significant difference between multiple comparisons of PSEM using the Bonferroni Test

Multiple Comparisons

Bonferroni

Dependent Variable	(I) Date	(J) Date	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Chlorophyll A	1.00	2.00	-4.1539544*	1.0393716	.021	-7.570842	-.737067
		3.00	-13.7229327*	1.0393716	.000	-17.139820	-10.306045
	2.00	1.00	4.1539544*	1.0393716	.021	.737067	7.570842
		3.00	-9.5689783*	1.0393716	.000	-12.985866	-6.152091
	3.00	1.00	13.7229327*	1.0393716	.000	10.306045	17.139820
		2.00	9.5689783*	1.0393716	.000	6.152091	12.985866
Chlorophyll B	1.00	2.00	-1.4271937	.7871091	.359	-4.014780	1.160392
		3.00	-2.8211990*	.7871091	.035	-5.408785	-.233613
	2.00	1.00	1.4271937	.7871091	.359	-1.160392	4.014780
		3.00	-1.3940053	.7871091	.381	-3.981591	1.193581
	3.00	1.00	2.8211990*	.7871091	.035	.233613	5.408785
		2.00	1.3940053	.7871091	.381	-1.193581	3.981591

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

Table 36 One-Sample Kolmogorov-Smirnov Test to measure mean value, standard deviations and absolute values of rocket grown in PS

ROCKET-PS

One-Sample Kolmogorov-Smirnov Test

		Chlorophyll A	Chlorophyll B
N		9	9
Normal Parameters[a,b]	Mean	7.401118	7.543434
	Std. Deviation	9.6107378	13.4236999
Most Extreme Differences	Absolute	.341	.463
	Positive	.341	.463
	Negative	-.281	-.307
Test Statistic		.341	.463
Asymp. Sig. (2-tailed)		.003[c]	.000[c]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

Test Statistics[a,b]

	Chlorophyll A	Chlorophyll B
Chi-Square	3.857	3.857
df	1	1
Asymp. Sig.	.050	.050

a. Kruskal Wallis Test

b. Grouping Variable: Date

Test Statistics[a,b]

	Chlorophyll A	Chlorophyll B
Chi-Square	7.200	7.200
df	2	2
Asymp. Sig.	.027	.027

a. Kruskal Wallis Test

b. Grouping Variable: Date

Test Statistics[a,b]

	Chlorophyll A	Chlorophyll B
Chi-Square	3.857	3.857
df	1	1
Asymp. Sig.	.050	.050

a. Kruskal Wallis Test

b. Grouping Variable: Date

Table 37 One-Sample Kolmogorov-Smirnov Test used to measure mean values, standard deviations and absolute values of rocket grown in EM

ROCKET-EM

One-Sample Kolmogorov-Smirnov Test

		Chlorophyll A	Chlorophyll B
N		9	9
Normal Parameters[a,b]	Mean	4.794627	2.342513
	Std. Deviation	3.5133211	1.8019461
Most Extreme Differences	Absolute	.310	.230
	Positive	.310	.207
	Negative	-.172	-.230
Test Statistic		.310	.230
Asymp. Sig. (2-tailed)		.013[c]	.188[c]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

Test Statistics[a,b]

	Chlorophyll A	Chlorophyll B
Chi-Square	3.857	3.857
df	1	1
Asymp. Sig.	.050	.050

a. Kruskal Wallis Test

b. Grouping Variable: Date

Test Statistics[a,b]

	Chlorophyll A	Chlorophyll B
Chi-Square	7.200	5.956
df	2	2
Asymp. Sig.	.027	.051

a. Kruskal Wallis Test

b. Grouping Variable: Date

Test Statistics[a,b]

	Chlorophyll A	Chlorophyll B
Chi-Square	3.857	3.857
df	1	1
Asymp. Sig.	.050	.050

a. Kruskal Wallis Test

b. Grouping Variable: Date

Table 38 One-Sample Kolmogorov-Smirnov Test to measure mean values, standard deviations and absolute values of rocket grown in PSEM

ROCKET-PS+EM

One-Sample Kolmogorov-Smirnov Test

		Chlorophyll A	Chlorophyll B
N		9	9
Normal Parameters[a,b]	Mean	6.035792	2.616519
	Std. Deviation	4.9560669	2.2503531
Most Extreme Differences	Absolute	.236	.218
	Positive	.236	.109
	Negative	-.173	-.218
Test Statistic		.236	.218
Asymp. Sig. (2-tailed)		.161[c]	.200[c,d]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. This is a lower bound of the true significance.

Table 39 Significant difference between multiple comparisons of rocket grown in PSEM using the Bonferroni Test

Multiple Comparisons

Bonferroni

Dependent Variable	(I) Date	(J) Date	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Chlorophyll A	1.00	2.00	-2.5070646	1.6112088	.512	-7.803841	2.789712
		3.00	-10.3008741*	1.6112088	.002	-15.597651	-5.004098
	2.00	1.00	2.5070646	1.6112088	.512	-2.789712	7.803841
		3.00	-7.7938095*	1.6112088	.009	-13.090586	-2.497033
	3.00	1.00	10.3008741*	1.6112088	.002	5.004098	15.597651
		2.00	7.7938095*	1.6112088	.009	2.497033	13.090586
Chlorophyll B	1.00	2.00	2.8837770	1.0987069	.118	-.728173	6.495727
		3.00	-1.4884737	1.0987069	.673	-5.100423	2.123476
	2.00	1.00	-2.8837770	1.0987069	.118	-6.495727	.728173
		3.00	-4.3722507*	1.0987069	.022	-7.984200	-.760301
	3.00	1.00	1.4884737	1.0987069	.673	-2.123476	5.100423
		2.00	4.3722507*	1.0987069	.022	.760301	7.984200

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

5.3.2 Chlorophyll concentrations of rocket and thyme in three media in the first season

Table 40 Post Hoc Tests of chlorophyll concentration comparisons between rocket and thyme grown in the three media over the first season's growth

Post Hoc Tests						
Combination						
Multiple Comparisons						
Dependent Variable:	R1					
Tukey HSD						
(I) Combination		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
PS-THYME	EM-THYME	-0,019664	0,2731133	1,000	-0,830236	0,790907
	EM+PS-THYME	-0,124643	0,2731133	0,997	-0,935215	0,685928
	PS-ROCKET	-0,158109	0,2731133	0,992	-0,968680	0,652463
	EM-ROCKET	0,125059	0,2731133	0,997	-0,685513	0,935630
	EM+PS-ROCKET	0,014884	0,2731133	1,000	-0,795687	0,825456
EM-THYME	PS-THYME	0,019664	0,2731133	1,000	-0,790907	0,830236
	EM+PS-THYME	-0,104979	0,2731133	0,999	-0,915550	0,705593
	PS-ROCKET	-0,138444	0,2731133	0,996	-0,949016	0,672127
	EM-ROCKET	0,144723	0,2731133	0,995	-0,665848	0,955295
	EM+PS-ROCKET	0,034549	0,2731133	1,000	-0,776023	0,845120
EM+PS-THYME	PS-THYME	0,124643	0,2731133	0,997	-0,685928	0,935215
	EM-THYME	0,104979	0,2731133	0,999	-0,705593	0,915550
	PS-ROCKET	-0,033466	0,2731133	1,000	-0,844037	0,777106
	EM-ROCKET	0,249702	0,2731133	0,941	-0,560869	1,060274
	EM+PS-ROCKET	0,139528	0,2731133	0,996	-0,671044	0,950099
PS-ROCKET	PS-THYME	0,158109	0,2731133	0,992	-0,652463	0,968680
	EM-THYME	0,138444	0,2731133	0,996	-0,672127	0,949016
	EM+PS-THYME	0,033466	0,2731133	1,000	-0,777106	0,844037
	EM-ROCKET	0,283168	0,2731133	0,903	-0,527404	1,093739
	EM+PS-ROCKET	0,172993	0,2731133	0,988	-0,637578	0,983565
EM-ROCKET	PS-THYME	-0,125059	0,2731133	0,997	-0,935630	0,685513
	EM-THYME	-0,144723	0,2731133	0,995	-0,955295	0,665848
	EM+PS-THYME	-0,249702	0,2731133	0,941	-1,060274	0,560869
	PS-ROCKET	-0,283168	0,2731133	0,903	-1,093739	0,527404
	EM+PS-ROCKET	-0,110174	0,2731133	0,999	-0,920746	0,700397
EM+PS-ROCKET	PS-THYME	-0,014884	0,2731133	1,000	-0,825456	0,795687
	EM-THYME	-0,034549	0,2731133	1,000	-0,845120	0,776023
	EM+PS-THYME	-0,139528	0,2731133	0,996	-0,950099	0,671044
	PS-ROCKET	-0,172993	0,2731133	0,988	-0,983565	0,637578
	EM-ROCKET	0,110174	0,2731133	0,999	-0,700397	0,920746
Based on observed means. The error term is Mean Square(Error) = .336.						

5.3.3 Chlorophyll concentrations of rocket and thyme in three media in the second season

Table 41 Post Hoc Tests of chlorophyll concentration comparisons between rocket and thyme grown in the three media over the second season's growth

Post Hoc Tests						
Combination						
Multiple Comparisons						
Dependent Variable:	R2					
Tukey HSD						
(I) Combination		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
PS-THYME	EM-THYME	-0,203148	0,2878088	0,980	-1,057334	0,651038
	EM+PS-THYME	-0,112166	0,2878088	0,999	-0,966352	0,742021
	PS-ROCKET	-0,218742	0,2878088	0,973	-1,072928	0,635444
	EM-ROCKET	0,048830	0,2878088	1,000	-0,805356	0,903016
	EM+PS-ROCKET	-0,020113	0,2878088	1,000	-0,874300	0,834073
EM-THYME	PS-THYME	0,203148	0,2878088	0,980	-0,651038	1,057334
	EM+PS-THYME	0,090982	0,2878088	1,000	-0,763204	0,945168
	PS-ROCKET	-0,015594	0,2878088	1,000	-0,869781	0,838592
	EM-ROCKET	0,251978	0,2878088	0,951	-0,602208	1,106164
	EM+PS-ROCKET	0,183034	0,2878088	0,988	-0,671152	1,037221
EM+PS-THYME	PS-THYME	0,112166	0,2878088	0,999	-0,742021	0,966352
	EM-THYME	-0,090982	0,2878088	1,000	-0,945168	0,763204
	PS-ROCKET	-0,106577	0,2878088	0,999	-0,960763	0,747610
	EM-ROCKET	0,160996	0,2878088	0,993	-0,693191	1,015182
	EM+PS-ROCKET	0,092052	0,2878088	1,000	-0,762134	0,946238
PS-ROCKET	PS-THYME	0,218742	0,2878088	0,973	-0,635444	1,072928
	EM-THYME	0,015594	0,2878088	1,000	-0,838592	0,869781
	EM+PS-THYME	0,106577	0,2878088	0,999	-0,747610	0,960763
	EM-ROCKET	0,267572	0,2878088	0,937	-0,586614	1,121758
	EM+PS-ROCKET	0,198629	0,2878088	0,982	-0,655557	1,052815
EM-ROCKET	PS-THYME	-0,048830	0,2878088	1,000	-0,903016	0,805356
	EM-THYME	-0,251978	0,2878088	0,951	-1,106164	0,602208
	EM+PS-THYME	-0,160996	0,2878088	0,993	-1,015182	0,693191
	PS-ROCKET	-0,267572	0,2878088	0,937	-1,121758	0,586614
	EM+PS-ROCKET	-0,068943	0,2878088	1,000	-0,923130	0,785243
EM+PS-ROCKET	PS-THYME	0,020113	0,2878088	1,000	-0,834073	0,874300
	EM-THYME	-0,183034	0,2878088	0,988	-1,037221	0,671152
	EM+PS-THYME	-0,092052	0,2878088	1,000	-0,946238	0,762134
	PS-ROCKET	-0,198629	0,2878088	0,982	-1,052815	0,655557
	EM-ROCKET	0,068943	0,2878088	1,000	-0,785243	0,923130
Based on observed means. The error term is Mean Square(Error) = .373.						

5.3.4 Chlorophyll concentrations of rocket and thyme grown in three media in the third season

Table 42 Post Hoc Tests of chlorophyll concentration comparisons between rocket and thyme grown in the three media over the third season's growth

Post Hoc Tests						
Combination						
Multiple Comparisons						
Dependent Variable:	R3					
Tukey HSD						
(I) Combination		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
PS-THYME	EM-THYME	0,009902	0,1818451	1,000	-0,529795	0,549599
	EM+PS-THYME	-0,069386	0,1818451	0,999	-0,609083	0,470311
	PS-ROCKET	-0,236087	0,1818451	0,784	-0,775784	0,303610
	EM-ROCKET	0,072987	0,1818451	0,999	-0,466710	0,612684
	EM+PS-ROCKET	0,034108	0,1818451	1,000	-0,505589	0,573805
EM-THYME	PS-THYME	-0,009902	0,1818451	1,000	-0,549599	0,529795
	EM+PS-THYME	-0,079288	0,1818451	0,998	-0,618985	0,460409
	PS-ROCKET	-0,245989	0,1818451	0,754	-0,785686	0,293708
	EM-ROCKET	0,063084	0,1818451	0,999	-0,476613	0,602781
	EM+PS-ROCKET	0,024206	0,1818451	1,000	-0,515491	0,563903
EM+PS-THYME	PS-THYME	0,069386	0,1818451	0,999	-0,470311	0,609083
	EM-THYME	0,079288	0,1818451	0,998	-0,460409	0,618985
	PS-ROCKET	-0,166701	0,1818451	0,940	-0,706398	0,372996
	EM-ROCKET	0,142372	0,1818451	0,969	-0,397325	0,682069
	EM+PS-ROCKET	0,103493	0,1818451	0,993	-0,436204	0,643190
PS-ROCKET	PS-THYME	0,236087	0,1818451	0,784	-0,303610	0,775784
	EM-THYME	0,245989	0,1818451	0,754	-0,293708	0,785686
	EM+PS-THYME	0,166701	0,1818451	0,940	-0,372996	0,706398
	EM-ROCKET	0,309073	0,1818451	0,539	-0,230624	0,848770
	EM+PS-ROCKET	0,270194	0,1818451	0,675	-0,269503	0,809891
EM-ROCKET	PS-THYME	-0,072987	0,1818451	0,999	-0,612684	0,466710
	EM-THYME	-0,063084	0,1818451	0,999	-0,602781	0,476613
	EM+PS-THYME	-0,142372	0,1818451	0,969	-0,682069	0,397325
	PS-ROCKET	-0,309073	0,1818451	0,539	-0,848770	0,230624
	EM+PS-ROCKET	-0,038879	0,1818451	1,000	-0,578576	0,500818
EM+PS-ROCKET	PS-THYME	-0,034108	0,1818451	1,000	-0,573805	0,505589
	EM-THYME	-0,024206	0,1818451	1,000	-0,563903	0,515491
	EM+PS-THYME	-0,103493	0,1818451	0,993	-0,643190	0,436204
	PS-ROCKET	-0,270194	0,1818451	0,675	-0,809891	0,269503
	EM-ROCKET	0,038879	0,1818451	1,000	-0,500818	0,578576
Based on observed means. The error term is Mean Square(Error) = .149.						

Table 43 Chlorophyll concentrations in rocket and thyme – three seasons

DATE	PLANT AND SOIL MEDIA	663,2	470	646,8		Chlor A		Chloro B
02-06-2016								
1	PS-ROCKET	3,18961	2,91097	2,76434		31,36021		43,1663
2	PS-ROCKET	0,85788	0,87257	0,43848		9,285671		5,052132
3	PS-ROCKET	1,00885	1,04948	0,43634		11,14102		4,236175
4	EM-ROCKET	0,83857	0,81608	0,36049		9,266715		3,473828
5	EM-ROCKET	0,74538	0,79491	0,34049		8,180938		3,519097
6	EM-ROCKET	0,95782	0,92741	0,42337		10,55209		4,217573
7	EM+PS-ROCKET	0,92417	0,92799	0,40008		10,20486		3,888453
8	EM+PS-ROCKET	1,32349	1,24555	0,56819		14,6275		5,466286
9	EM+PS-ROCKET	1,02992	1,05005	0,44689		11,3697		4,355543
10	PS-THYME	0,82176	0,74586	0,34964		9,091064		3,326284
11	PS-THYME	0,98434	0,95015	0,42792		10,86427		4,180146
12	PS-THYME	1,00498	0,95969	0,42312		11,1305		3,971682
13	EM-THYME	1,18343	1,56945	0,54411		12,97895		5,662872
14	EM-THYME	1,72754	2,03125	0,76333		19,03267		7,601141
15	EM-THYME	1,17497	1,34406	0,51605		12,9536		5,102728
16	EM+PS-THYME	1,47735	1,34756	0,63547		16,32458		6,12812
17	EM+PS-THYME	1,42398	1,33047	0,60533		15,75488		5,752297
18	EM+PS-THYME	1,2249	1,13963	0,51032		13,58123		4,72489

DATE	PLANT AND SOIL MEDIA	663,2	470	646,8		Chlor A		Chloro B
10-11-2016								
1	EM+PS-ROCET	0,51086	0,0274	0,18083		5,753519		1,282459
2	EM+PS-ROCKET	0,0914	-0,08383	-0,08513		1,357163		-2,29644
3	EM+PS-ROCKET	0,51074	0,03519	0,19592		5,709948		1,607506
4	PS-ROCKET	0,25122	0,00073	0,09604		2,809493		0,783638
5	PS-ROCKET	0,27144	0,02304	0,15781		2,88485		2,008571
6	PS-ROCKET	0,28714	0,02872	0,16121		3,067689		2,001601
7	EM-ROCKET	0,23012	-0,0002	0,06763		2,630282		0,280433
8	EM-ROCKET	0,28674	-0,00143	0,06377		3,334647		-0,09132
9	EM-ROCKET	0,30104	-0,00194	0,06586		3,503991		-0,11931
10	EM+PS-THYME	0,61658	0,12967	0,37123		6,517373		4,836887
11	EM+PS-THYME	0,63377	0,11603	0,38753		6,682474		5,099668
12	EM+PS-THYME	0,35179	0,03331	0,19911		3,753911		2,486736
13	PS-THYME	0,45963	0,05342	0,18407		5,116912		1,613392
14	PS-THYME	0,701	0,09277	0,31078		7,720174		3,10667
15	PS-THYME	0,38696	0,03859	0,16621		4,276534		1,600019
16	EM-THYME	0,25092	-0,00111	0,06061		2,904668		0,023423
17	EM-THYME	0,194	-0,0119	0,04187		2,259683		-0,0892
18	EM-THYME	0,29674	0,02516	0,11679		3,309221		0,997611

DATE	PLANT AND SOIL MEDIA	663,2	470	646,8		Chlor A		Chloro B
04-04-2017								
1	PS-THYME	0,29351	0,47231	0,28925		2,78849		4,721974
2	PS-THYME	0,22636	0,40552	0,21711		2,167173		3,513429
3	PS-THYME	0,20684	0,39226	0,20868		1,951573		3,431736
4	EM-THYME	0,12222	0,3078	0,12502		1,148389		2,064608
5	EM-THYME	0,12745	0,30838	0,12902		1,201297		2,123935
6	EM-THYME	0,18509	0,36581	0,19086		1,734853		3,159531
7	EM+PS-THYME	0,17282	0,35329	0,17697		1,623299		2,923473
8	EM+PS-THYME	0,12988	0,31571	0,13371		1,217979		2,212377
9	EM+PS-THYME	0,1761	0,35439	0,18158		1,650617		3,00586
10	PS-ROCKET	0,19418	0,37225	0,1994		1,822379		3,296782
11	PS-ROCKET	0,25482	0,45026	0,25193		2,41866		4,116913
12	PS-ROCKET	0,19322	0,37123	0,19601		1,820077		3,228793
13	EM-ROCKET	0,25045	0,43235	0,24645		2,380417		4,02138
14	EM-ROCKET	0,15683	0,33585	0,15931		1,476693		2,625332
15	EM-ROCKET	0,1929	0,36807	0,19253		1,825866		3,155605
16	EM+PS-ROCKET	0,17391	0,35125	0,17727		1,635814		2,924364
17	EM+PS-ROCKET	0,17454	0,35102	0,1766		1,645401		2,906746
18	EM+PS-ROCKET	0,21239	0,38697	0,20916		2,018221		3,413751

Table 44 Averages of chlorophyll a and b concentrations on rocket and thyme grown in different media (PS, EM and PSEM) over the three season's growth

	Date	Chlorophyll A	Chlorophyll B		Date	Chlorophyll A	Chlorophyll B		Date	Chlorophyll A	Chlorophyll B
PS-THYME	N	3	3	PS-THYME	N	3	3	PS-THYME	N	3	3
	Mean	2,3	3,89		Mean	5,7	2,11		Mean	10,36	3,83
	Std. Deviation	0,43	0,72		Std. Deviation	1,8	0,87		Std. Deviation	1,11	0,45
	Minimum	1,95	3,43		Minimum	4,28	1,6		Minimum	9,09	3,33
	Maximum	2,79	4,72		Maximum	7,72	3,11		Maximum	11,13	4,18
	Range	0,84	1,29		Range	3,44	1,51		Range	2,04	0,85
EM-THYME	N	3	3	EM-THYME	N	3	3	EM-THYME	N	3	3
	Mean	1,36	2,45		Mean	2,82	0,31		Mean	14,99	6,12
	Std. Deviation	0,32	0,62		Std. Deviation	0,53	0,6		Std. Deviation	3,5	1,31
	Minimum	1,15	2,06		Minimum	2,26	-0,09		Minimum	12,95	5,1
	Maximum	1,73	3,16		Maximum	3,31	1		Maximum	19,03	7,6
	Range	0,59	1,09		Range	1,05	1,09		Range	6,08	2,5
EM+PS-THYME	N	3	3	EM+PS-THYME	N	3	3	EM+PS-THYME	N	3	3
	Mean	1,5	2,71		Mean	5,65	4,14		Mean	15,22	5,54
	Std. Deviation	0,24	0,44		Std. Deviation	1,65	1,44		Std. Deviation	1,45	0,73
	Minimum	1,22	2,21		Minimum	3,75	2,49		Minimum	13,58	4,72
	Maximum	1,65	3,01		Maximum	6,68	5,1		Maximum	16,32	6,13
	Range	0,43	0,79		Range	2,93	2,61		Range	2,74	1,4
PS-ROCKET	N	3	3	2,00 PS-ROCKET	N	3	3	3,00 PS-ROCKET	N	3	3
	Mean	2,02	3,55		Mean	2,92	1,6		Mean	17,26	17,48
	Std. Deviation	0,34	0,49		Std. Deviation	0,13	0,71		Std. Deviation	12,24	22,24
	Minimum	1,82	3,23		Minimum	2,81	0,78		Minimum	9,29	4,24
	Maximum	2,42	4,12		Maximum	3,07	2,01		Maximum	31,36	43,17
	Range	0,6	0,89		Range	0,26	1,22		Range	22,07	38,93
EM-ROCKET	N	3	3	EM-ROCKET	N	3	3	EM-ROCKET	N	3	3
	Mean	1,89	3,27		Mean	3,16	0,02		Mean	9,33	3,74
	Std. Deviation	0,46	0,7		Std. Deviation	0,46	0,22		Std. Deviation	1,19	0,42
	Minimum	1,48	2,63		Minimum	2,63	-0,12		Minimum	8,18	3,47
	Maximum	2,38	4,02		Maximum	3,5	0,28		Maximum	10,55	4,22
	Range	0,9	1,4		Range	0,87	0,4		Range	2,37	0,74
EM+PS-ROCKET	N	3	3	EM+PS-ROCKET	N	3	3	EM+PS-ROCKET	N	3	3
	Mean	1,77	3,08		Mean	4,27	0,2		Mean	12,07	4,57
	Std. Deviation	0,22	0,29		Std. Deviation	2,53	2,17		Std. Deviation	2,29	0,81
	Minimum	1,64	2,91		Minimum	1,36	-2,3		Minimum	10,2	3,89
	Maximum	2,02	3,41		Maximum	5,75	1,61		Maximum	14,63	5,47
	Range	0,38	0,51		Range	4,4	3,9		Range	4,42	1,58
Total	N	18	18	Total	N	18	18	Total	N	18	18
	Mean	1,81	3,16		Mean	4,09	1,4		Mean	13,21	6,88
	Std. Deviation	0,44	0,69		Std. Deviation	1,76	1,79		Std. Deviation	5,36	9,12
	Minimum	1,15	2,06		Minimum	1,36	-2,3		Minimum	8,18	3,33
	Maximum	2,79	4,72		Maximum	7,72	5,1		Maximum	31,36	43,17
	Range	1,64	2,66		Range	6,36	7,4		Range	23,18	39,84

5.3.5 Chlorophyll concentrations of thyme grown in three different media, over three seasons

All measurements are expressed in (µg x g FM^{-1})

The chlorophyll content on the first season's growth of thyme (autumn to winter) had the following results; in PS chlorophyll a was 2.3 and chlorophyll b was 3.89 µg x g FM^{-1} (Figure 12). EM showed results in chlorophyll a of 14.99 and chlorophyll b was 6.12. PSEM indicated results for chlorophyll a at 15.22 and chlorophyll b indicated a 2.71 measurement. Season two (winter to spring) of growing showed chlorophyll extracts of thyme grown in PS presented chlorophyll a results of 5.7 and chlorophyll b being 2.11. Thyme grown in EM results of chlorophyll a was 2.82 and chlorophyll b presented results of 0.31. Thyme grown in PSEM indicated results in chlorophyll a of 5.65 and 4.14 in chlorophyll b. The third season's growth (summer to autumn) of thyme grown in PS presented results of chlorophyll a of 10.38, chlorophyll b as 3.83, in EM result of chlorophyll a was 1.36 and in chlorophyll b 2.45, lastly in PSEM results of chlorophyll a being 15.22 and chlorophyll b measuring 5.54.

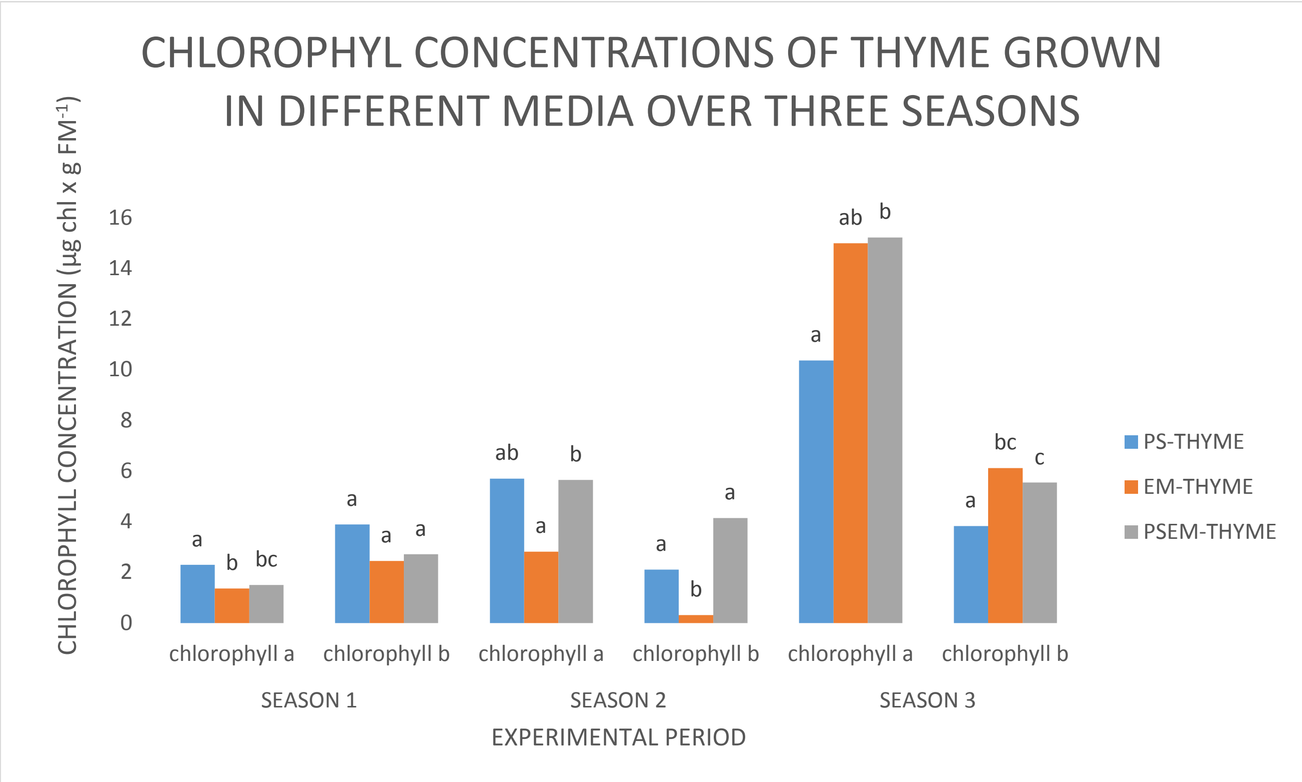

Figure 12 Chlorophyll a and chlorophyll b concentrations of thyme leaves from plants grown in the three different media, PS (potting soil), EM (enriched medium) and PSEM (potting soil + enriched medium) over three seasons(season one = autumn-winter, season two = spring - summer and season three = summer - autumn); different letters above chlorophyll concentration of one season denotes significant differences at p ≤ 0.05.

Table 45 Descriptive statistics for chlorophyll concentrations of thyme leaves over three season

p-value						
Chlorophyll concentration - Thyme	S1 Chlo a	S1 Chlo b	S2 Chlo	S2 Chlo b	S3 Chlo a	S3 Chlo b
PS - EM	0,0385 SD	0,0585	0,0565	0,0420 SD	0,0943	0,0458 SD
PS - PSEM	0,0481 SD	0,0726	0,9734	0,1048	0,0100 SD	0,0260 SD
EM - PSEM	0,5771	0,5855	0,0474 SD	0,0131 SD	0,9213	0,5396

Table 46 Descriptive statistics for chlorophyll concentrations of thyme leaves over three season of the different media

p - value				
Thyme	PS	EM	PSEM	chlo A vs chlo b
S1 vs S2	0,1911	0,1798	0,2874	PS - 0,0399 SD
S1 vs S3	0,0234 SD	0,1935	0,1082	EM - 0,1737
S2 vs S3	0,5031	0,8101	0,6468	PSEM - 0,1361

Thyme grown in PS in season one had a significantly different chlorophyll concentration compared with season three. Only for PS chlorophyll a and chlorophyll b were significantly different from each other.

5.3.6 Chlorophyll concentrations of rocket grown in the three different media, over three seasons

All measurements are expressed in (µg x g FM^{-1})

The first growing season (autumn to winter) of rocket grown in PS showed chlorophyll a results as 2.02 and chlorophyll b 3.55, EM presenting results of 1.89 chlorophyll a with 3.27 chlorophyll b, and in PSEM 1.77 in chlorophyll a and 3.08 in chlorophyll b (Figure 13). Season two (winter to spring) showed thyme grown in PS to have results of 2.92 of chlorophyll a and 1.6 of chlorophyll b, EM had results of chlorophyll a being 3.16 and in chlorophyll b 0.02, and PSEM presented results on chlorophyll a of 4.27 and 0.2 in chlorophyll b. The third season (summer to autumn) having results of rocket grown in PS indicating from (Figure 13) that chlorophyll a presented a 17.26 measurement and 17.48 measurement for chlorophyll b, EM had results of 9.33 of chlorophyll a and 3.74 of chlorophyll b, and PSEM presenting the following results, chlorophyll a 12.07 and chlorophyll b having a 4.57 measurement.

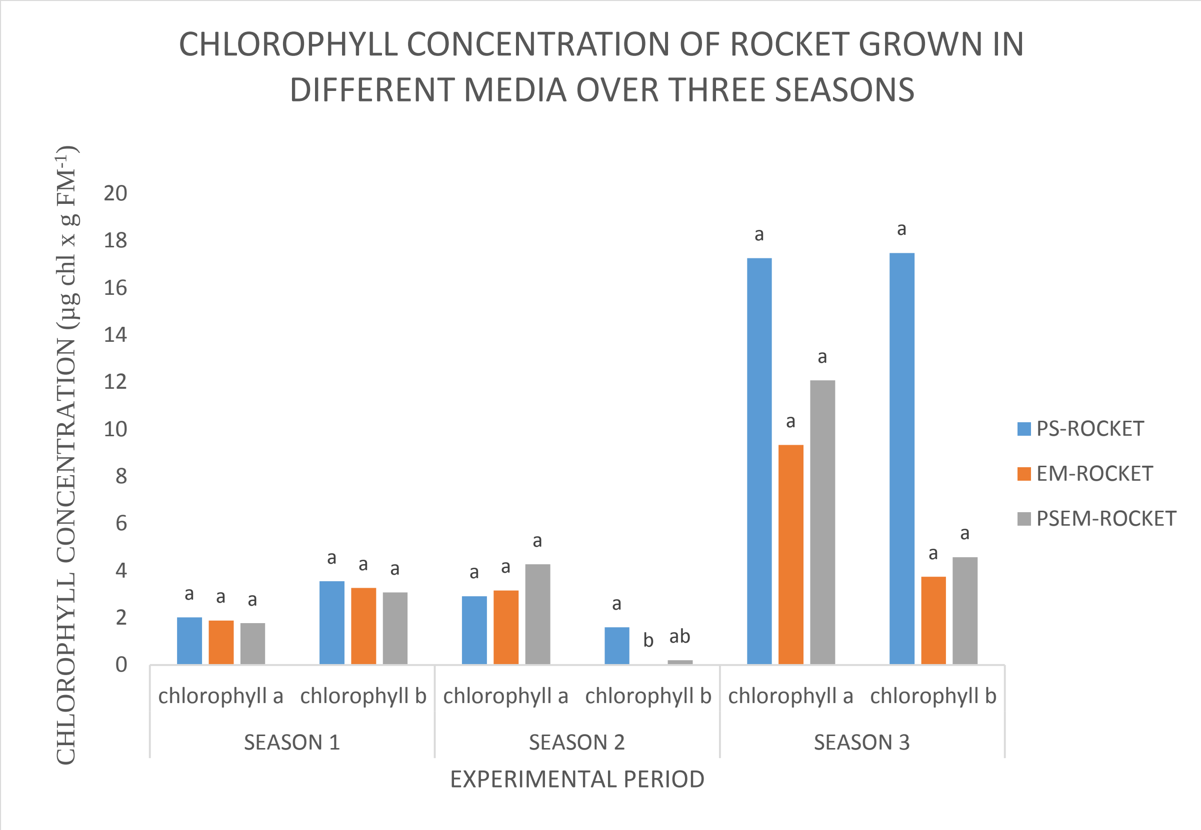

Figure 13 Chlorophyll a and chlorophyll b concentrations of rocket leaves from plants grown in the three different media, PS (potting soil), EM (enriched medium) and PSEM (potting soil + enriched medium) over three seasons(season one = autumn - winter, season two = spring - summer and season three = summer - autumn); different letters above chlorophyll concentration of one season denotes significant differences at p ≤ 0.05.

Table 47 Descriptive statistics for chlorophyll concentrations of rocket leaves over three season

p-value						
Chlorophyll concentration - Rocket	S1 Chlo a	S1 Chlo b	S2 Chlo a	S2 Chlo b	S3 Chlo a	S3 chlo b
PS - EM	0,7139	0,6007	0,4336	0,0212SD	0,3266	0,1284
PS - PSEM	0,3452	0,226	0,4082	0,3481	0,5103	0,1476
EM - PSEM	0,7044	0,6865	0,4962	0,8932	0,1398	0,1902

Table 48 Descriptive statistics for chlorophyll concentrations of rocket leaves over three season of the different media

p - value				
Rocket	PS	EM	PSEM	chlo A vs chlo b
S1 vs S2	0,7066	0,1489	0,2001	PS - 0,98
S1 vs S3	0,648	0,059	0,0788	EM - 0,0809
S2 vs S3	0,9296	0,8544	0,7512	PSEM - 0,0779

Rocket had no significant difference between the three season growths of different media.

5.4 Discussion

5.4.1 Chlorophyll concentration of thyme grown in different media (PS, EM and PSEM) over three seasons' growth

Thyme grown in EM in the first season had the highest measurement and then a decline in the next two seasons. Thyme grown in PS had a steady incline in measurement from the first season to the third season. The normal concentration ratio for chlorophyll A and B is 3:1 (Lichtenthaler, 1987). Thyme grown is PS and PSEM in the first season did not grow well due to the chlorophyll B being higher than chlorophyll A. This indicates that the thyme plants were growing with an unsuitable medium as well as in poor growing conditions which made the plants stress (Sehrawat et al., 2015). PSEM had the lowest measurement in the first season and a significant incline until the third season (Mimouni et al., 2016).

Thyme grown in the second season in the three different soil media had similar chlorophyll concentration results over the growing period which showed positive results because it is within the 3:1 ratio of chlorophyll A and B (Goufo et al., 2014). This indicates that the thyme plants had positive chlorophyll concentration results and the seasonal change has impacted to benefit the growing patterns (Neocleous and Ntatsi, 2018). Plants were growing well in the season of spring due to the increased day lengths and regular rainfall (Edwards et al., 1990). PSEM had the best results in the third season which was from February-March. The change in the growth of thyme between season one and three shows that thyme reacts positively to the EM mixed with PS as a result of the seasons with regards to chlorophyll concentration. The EM results on thyme in the summer to autumn seasons negatively affected growth. This indicates that chlorophyll concentration of thyme growing prefers the growth with EM in the autumn to winter months rather than summer to autumn. The adverse effect is reflected when EM is mixed with PS, where the best chlorophyll concentration is in the summer to autumn months and the lowest being in the autumn to winter months.

This is important for the farmers and local growers which indicates that it will be feasible and profitable to grow thyme in the summer and autumn months using the EM which is readily available as a medium for planting. The only cost will be labour to harvest the *Lg* trees and break it down either using natural break down methods or using chipping machinery and hasten the composting process. The chlorophyll concentration in herbs is vital due to customer demands. The greener the herb is to the consumer, the more in demand it will be. This comes with higher costs for higher end-users, like restaurants and grocery stores like Woolworths and Food Lovers' Market. Thyme is used extensively as garnishes for culinary processes, spices and pharmaceuticals which means the demand is high. If the local communities can be made aware of the wide uses of IAPs then they can also make a living through these manufacturing developments.

5.4.2 Chlorophyll concentrations of rocket grown different media (PS, EM and PSEM) over three seasons' growth

Rocket grown in the three soil media over the first two seasons had similar results. The third season had significant results between the growing media. Rocket grown in PS had the highest chlorophyll concentration followed by PSEM. Rocket grown in EM had the lowest chlorophyll content. Rocket plants had the highest chlorophyll contents in the summer months as well grown in PS.

PSEM and EM had lower chlorophyll concentration in rocket compared to the high chlorophyll concentration in thyme plants. Rocket had the best chlorophyll content grown in PS which is much more expensive to use in the growing processes. Growing rocket in EM is not feasible as shown from the results. The growth in terms of the chlorophyll concentration is very low which means minimal turnover and thus minimal or no profits will be made.

The normal concentration ratio for chlorophyll A and B is 3:1 (Lichtenthaler, 1987). This encourages growth and photosynthesis is at its peak (Porra, 2002). In season 1 it is evident that rocket plants were not growing successfully and did not grow at their peak due to autumn to winter months having shorter days and longer nights which means that the rocket plants grew at a minimum (Lichtenthaler et al., 1981). Season two had improved growth with the normal chlorophyll A:B ratio, which indicated that the plants were growing positively. Light intensity as becoming more available due to the season of spring which provided better conditions for photosynthesis (Lichtenthaler, 1985). Water was also increasing due to rainfall increases over the winter months which increased growth. The third season's concentrations of chlorophyll also indicated poor growth in PS as the ratio for chlorophyll A and B are the same. The chlorophyll concentrations in rocket grown in EM and PSEM were positive due to the chemical composition on the *Lg* which had more positive growth than the potting soil that plants are normally grown in (Fritschi and Ray, 2007). This is vital for this study, to show how rocket in certain seasons can successfully use the enriched medium for growing.

5.5 Conclusions

In this chapter, we have established that IAPs increase the chlorophyll content of thyme and rocket in different seasons and thus it can be recommended to be used in the yields of rocket and thyme. Rocket did not grow well due to seasonal changes in light which affected the photosynthetic rates in the plant. PS and PSEM had the best chlorophyll concentrations in the summer to autumn months. This means that EM can be used to add value to PS to save costs and have a better product with greener leaves in thyme plants which can be of an advantage for the market industry.

CHAPTER 6: CONSUMER EVALUATION

On taste and texture in rocket and thyme grown in different media

6.1 Introduction

Consumer evaluation of taste and texture of rocket and thyme was undertaken to assess the acceptability of these two herbs for human consumption. These are culinary herbs extensively used in restaurants and the retail markets. Consumer evaluations for thyme and rocket have been extensively experimented to look at compositions such as essential oils, aroma, flavonoids and carotenoids. The evaluations are based mainly on people's perspectives of the different categories of taste, texture and solidity vs. liquidity of the herb plants (Mani-Lopez et al., 2018). It is important that people who consume the herb plants are used to characterise the herbs into the different categories of taste and texture used to identify them and criticize when required. The measurements of antioxidants in herbs are dependent on environmental conditions as well as controlled greenhouse facilities which keep the herbs growing at optimum levels regardless of the outside climatic conditions (Wang, 2002). This is imperative to keep the produce fresh and green which are demanded by the consumers. The antioxidant levels in herbs were evaluated to measure the response of the consumers and to improve the production line and plant requirements (Neocleous and Ntatsi, 2018).

6.2 Methods: Evaluation of taste and texture in rocket and thyme leaves

A questionnaire was given to random staff at the Durban University of Technology to evaluate and give feedback on the taste and texture of rocket and thyme leaves that were grown in the three different growth mediums to further interrogate the results of this study. It was important to ensure that each participant had consistent leaf specimens to evaluate the taste and texture of rocket and thyme leaves. The leaves for this evaluation process were harvested at the end of the third growing season (01 February 2017-31st March 2017) - summer-autumn. Leaves were cut fresh and then given to the participants to assess and comment on in their questionnaire. Twenty participants were randomly chosen. Each participant had to answer on the following taste characteristics being; sweet, sour, bitter, pungent and other as well as on texture, evaluating the following traits - crisp, dry, moist, tender and other.

These 20 questionnaires were statistically analysed and recorded on bar graphs to illustrate the opinions of people concerning the taste and texture of rocket and thyme leaves.

6.3 Results

The results were statistically evaluated and analysed from the questionnaires and inserted into a bar graph to show the opinions and variations between taste and texture of thyme and rocket plants. The measurements of taste included the sweet, sour, bitter, pungent and other to analyse the consumer evaluation. The measurement of texture included the crisp, tender, dry, moist and other responses identified by the participants.

6.3.1 Consumer evaluation of rocket and thyme taste

The results for the taste of rocket and thyme plants were as follows; the consumer evaluation on the taste of rocket grown in PS showed thirty five percent of participants selected the sweet sensation compared to the EM which had the highest results of sixty percent of participants (Figure 14). The PSEM results showed forty five percent of participants preferred the sweet sensation of rocket. Thyme results for PSEM had fifteen percent of participants choosing the sweet sensation, five percent of participant chose the sweet sensation for rocket grown in EM and finally, ten percent of participants choose the sweet sensation on thyme grown in PS. The sour sensation in rocket grown in PS had fifteen percent of the participants' choice compared to ten percent of participants in EM and PSEM. Thyme grown in PS and PSEM had five percent of participants compared to EM which had no selection. The bitter sensation of rocket grown in PS had fifty percent of the electives, thirty percent of participants chose EM and forty percent selected the bitter sensation with rocket grown in PSEM. Half of the participants preferred the bitter sensation of thyme grown in PS compared to a smaller number of participants who choose the leaves grown in EM and PSEM which was fifteen percent and five percent respectively. Zero numbers of participants selected the leaves of rocket grown in PS and EM for the pungent sensation compared to the five percent choosing it grown in PSEM. The results for the pungent taste of thyme was indicated as follows; forty five percent grown in PS, sixty percent grown in EM and fifty percent chose the leaves of thyme grown in PSEM. No participants chose the other sensation with rocket leaves. Thirty percent PS, twenty percent EM and twenty five percent PSEM was the results for the other sensation with thyme leaves.

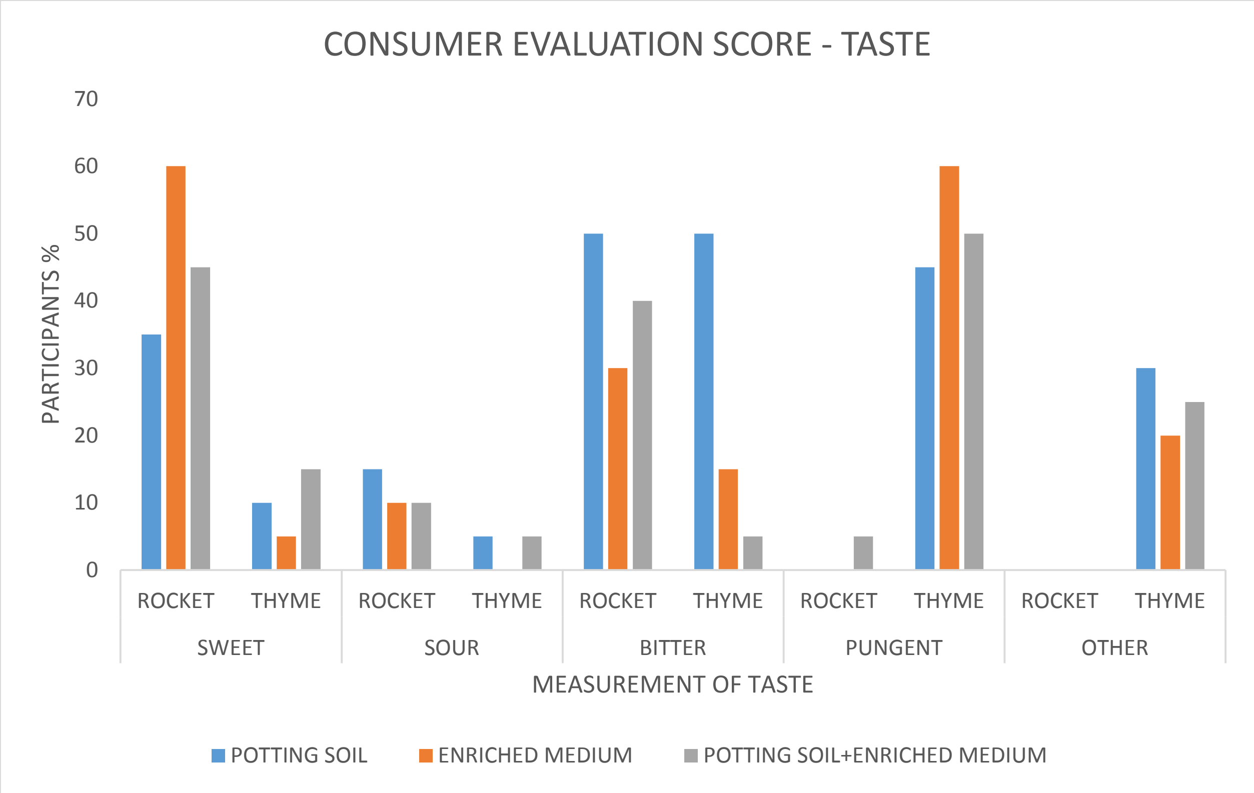

Figure 14 Percentage of participants scoring taste parameters of thyme and rocket grown in three different media.

6.3.2 Consumer evaluation of rocket and thyme texture

The results for the texture of rocket and thyme indicated the following; the crisp sensation of rocket leaves grown in PS had a thirty percent participant rate compared to rocket grown in EM which had a thirty five percent rate and PSEM a twenty five rate (Figure 15). Ten percent of the participants chose the crisp sensation of thyme grown in PS and fifteen percent rate for thyme grown in EM and PSEM. The tender sensation indicated rocket grown in PS which showed twenty percent of the participants, twenty five percent of participants choosing EM and thirty percent picking the PSEM mixture. Twenty five percent PS, fifteen percent EM and twenty percent PSEM indicated their choice of the tender sensation of thyme. All three media had five percent of participants choosing the dry aspect of rocket leaves. There were no participants choosing the dry sensation of thyme in the three growing media. Forty five percent PS, thirty five percent EM and forty percent PSEM of participants chose the moist aspect of rocket leaves. Forty five percent PS, fifty five percent EM and fifty percent PSEM of participants indicated that the thyme leaves were moist. Zero percent of participants chose the other sensation of texture on rocket leaves. Twenty percent of participants selected the other sensation with thyme grown in PS. EM and PSEM had fifteen percent participants preferring the other sensation of thyme leaves.

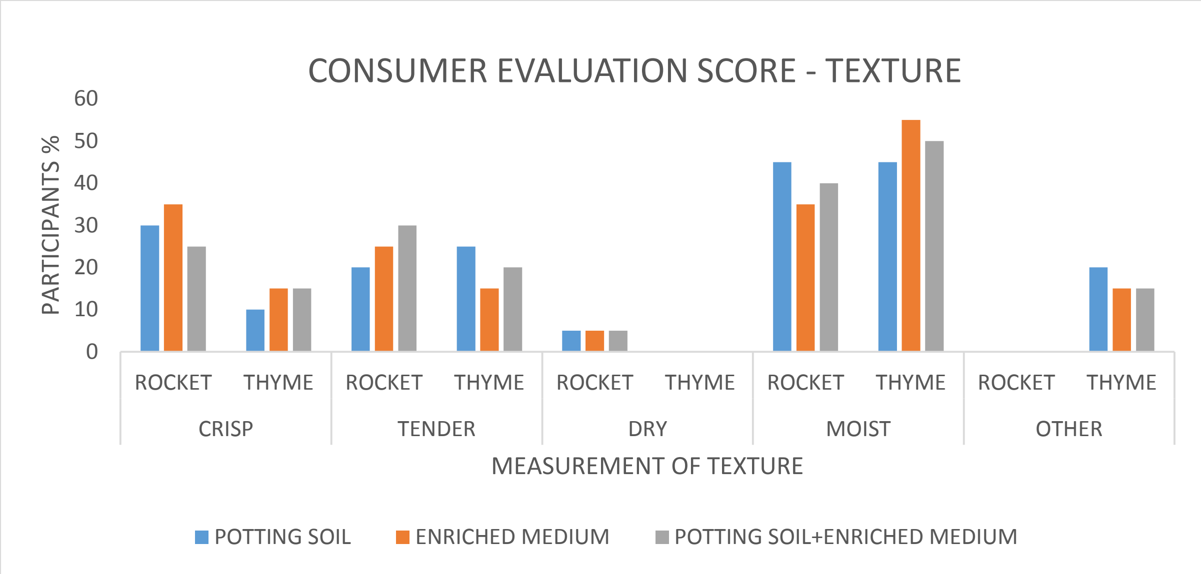

Figure 15 Percentage of participants scoring texture parameters of thyme and rocket grown in three different media.

6.4 Discussion

6.4.1 Evaluation of rocket and thyme taste

The trait of 'other' in the taste graph was due to participants having a minty sensation of thyme rather than the four other characteristics that were given. EM with the pungent taste had the highest result compared to thyme leaves grown in potting soil. The bitter sensation with regards to rocket grown in PS had the highest results compared to EM and PSEM. The percentage of participants was consistent between sour treatments of rocket and thyme leaves. The taste graph concludes that the plants grown in the different soil mediums were similar with slight variations between rocket and thyme leaves. Consumer evaluation of rocket was evident that the taste was similar and using EM in the growing of rocket and thyme is a natural way of adding value to the soil media. Nobody indicated a difference in taste between the samples. Consumers feel that using organic compost is a good way of improving the growing medium with natural compositions which has the same taste effect (Bell et al., 2017). Consumers also feel that a fresh quality leaf for tasting is a tasty leaf already due to appearance (Gutiérrez et al., 2015). The consumers became more positive in the evaluation and more knowledgeable in the scope of growing herbs with organic compost (Dahlin et al., 2017). Different media does play a role in the different taste of herbs (Yue et al., 2011).

6.4.2 Evaluation of rocket and thyme texture

The evaluation of texture in rocket and thyme grown in the three media had a minor difference. In most of the characteristics of the texture, the perceptions of the participants were fairly constant and plateaued through the three soil mediums. The choices of the participants of thyme and rocket in the moist and tender characteristic had the highest scores with the rocket and thyme grown in EM and PSEM. Only one participant chose the dry characteristic of rocket grown in all three soil mediums. Thyme had no participants choosing the dry trait and rocket had no participants choosing the ‘other’ trait. The statistically analysed data collected and interpreted in (Figure 15) for texture was evident that there were no major differences between the different texture characteristics. The texture of the sample rocket leaves was first looked at carefully by the consumers to assess the quality and how fresh the leaves were before sampling it (Løkke et al., 2012). Moisture in the leaves of rocket and thyme is dependent on rainfall and day length for photosynthesis (Wright and Westoby, 1999). The ‘other’ trait in thyme plants was the consumers’ indication of the oil composition that thyme comprises. Essential oils are a core ingredient that comes from thyme and is used extensively in the market industry (Angelovicova et al., 2013).

6.5 Conclusions

This chapter showed similar results between rocket and thyme grown in the three growing media. It can thus be concluded that using the EM to grow rocket and thyme herbs give similar taste and texture results which also indicates that it could be used in the commercial production of rocket and thyme plants. The recommendation in using the EM is that it is cheaper and available in most parts of South Africa for eradicating and using as compost which in this study is useful and beneficial to the outcomes of growing rocket and thyme.

CHAPTER 7: RECOMMENDATIONS AND CONCLUSIONS

The aim of this study was to widen the aspect of enriched medium generated from *Litsea glutinosa* to grow agricultural thyme and rocket plants. The subsequent growth potential of thyme and rocket herbs when grown in the three arms of study being; 1. The experiment (enriched medium), 2. The control (Gromor® Potting Soil) and 3. The experiment and the control mixed in a 1:1 ratio. The different seasons played a role in the variation of growth between the thyme and rocket herbs, the chlorophyll content in the thyme and rocket herbs was also different. Finally, the fresh mass/weight vs. the dry mass/weight which also showed weight variations.

7.1 Summary – impact of IAPs on rocket and thyme

The use of enriched composted *Litsea glutinosa* medium on the growth of rocket and thyme plants had a positive impact which was shown in the statistics and graphs of the three parameters of measure which included; growth, fresh and dry mass as well as chlorophyll extracts.

7.2 Limitations of this study

Beyond working with limited resources and time, there were different limitations to this study. Only two species of herbs were experimented on as well as the growing period of thyme can be much longer than eight weeks which did not reveal the full data of growth. The enriched composted medium generated from the *Litsea glutinosa* was not the only species worked on for this study. *Tithonia diversifolia* – Mexican sunflower was also composted but the texture of the compost was very soggy and moist which was not recommended for the purpose of this study. *Acacia podalyriifolia* – Pearl acacia was used in the form of biochar (charcoal produced from plant matter and stored in the soil which is beneficial in removing carbon dioxide from the atmosphere) which would have made the experiment very diverse and complex as a result of high costs and availability. A longer break down period of biochar would have prolonged data collection even further. The only concerns were the variations in temperature and humidity. This was only the pilot study of the research.

The questionnaire for the taste and texture sampling was restricted to the population of staff at the Durban University of Technology – using a convenience sample method. A larger population of skilled farmers may be able to give a better evaluation - because they are more experienced in the aspect of taste and texture of rocket and thyme leaves.

Only three growing trial periods were conducted over two years which included all season’s growth. Having an experimental study which included all season's growth within one year would have provided a more conclusive result. The composition of the enriched composted *Litsea glutinosa* which was composted at different seasons for this study may have provided seasonal variations.

7.3 Recommendations

7.3.1 Department of Environmental Affairs (DEA)

The government legislation and regulation on the eradication and control of IAPs has had a positive impact on the environment. It is recommended that certain IAPs should be composted and used for compost in agricultural uses in South Africa. Enriched composted *Litsea glutinosa* can be used to enhance the growth of rocket and thyme plants.

It is imperative that this study provides an important insight into the eradication of IAPs. This study contributes to communities to make use of natural resources that can at the same time reduce the quantities of IAPs. Local governments should provide education and training to communities on the ways and methods of eradicating and composting IAPs to benefit themselves as well as generate a usable product for different applications. Growth of these experimental trials should be done on a more commercial scale to get more accurate results.

7.3.2 Market industry

A business opportunity can arise for local communities where there are infestations of invasive alien plants that could be composted into a saleable product ready for the market. Different grades of compost can be produced to grow certain plants and also the leachate of this enriched medium can be used as an ingredient in certain fertilizers in either liquid, powder or granular forms.

Further interrogation into this study can be carried out using enriched *Litsea glutinosa* on different herbs and crop species. Different species of *Eruca* – rocket should be investigated to encourage bigger and smaller leaves for garnish and salads which are used extensively in restaurants and food industries as well as the manufacturing of cosmetics and pharmaceutical products throughout the world. Thyme plants should be left to grow for prolonged periods compared to the two-month trials in this study and measured for all the beneficial properties that they possess.

Cheaper materials should be made available which possess the same ingredients for optimum applications in the green industry. Therefore, it is vital that methods of using recycled material that are available can be amended and used to effectively contribute to cost-savings.

7.3.3 Nurseries and wholesalers

This study can also provide further potential to experiment on manufacturing compost that could be sold to nurseries, landscapers, farmers and sports turf organisations on a commercial basis. The idea behind this is to recycle materials that are eradicated by government departments that are associated with the control of invasive alien plant species using natural resources to make organic products that interest consumers.

Most nurseries and agricultural organisations use sterilized compost and fertilizers that are supplied by agricultural companies. These items are very expensive because they are used practically on a daily basis for different processes in the green industry. The main purpose of running any business is to make a substantial profit by cutting down costs and increasing turnover. Gromor® compost, farmyard and some of the other compost brands are used extensively to grow different herbs and crop species. These plants tend to grow well in these mediums, although other mediums are also available and still under research.

7.4 Further research

A possible oversight of this study was to measure the flavonoids, carotenoids and anti-oxidants from the thyme and rocket herbs. Growing these herbs on a larger scale in-situ rather than in bags and see the findings could be conducted in further research. The mineral analysis of this study could also be something to look into to benefit the pharmaceutical industry.

Future investigations and studies should be conducted on different invasive alien plant species to make compost that is highly nutritional and that could be used in all applications in the growing of horticulture and agricultural plants species.

Academic institutions should take advantage of the opportunities that this thesis has conveyed from its novel topic. The results of this research can also be beneficial to scientific sectors like Cedara and SASRI (South African Sugar Research Institute) which service a vast number of student projects.

7.5 Conclusions

In conclusion, the hypothesis of this study, namely enriched compost produced from *Litsea glutinosa,* is likely to induce equal or enhanced growth of thyme and rocket herbs, has been shown to be valid. Using a larger quantity of EM will definitely improve the soil composition for growing successfully rocket and thyme plants. Harvesting the materials at the right time is the key to the usage in soil mixture to prevent germination of seeds within the mixture of PS and EM. The use of *Litsea glutinosa* as an EM has been shown to be beneficial for the growth of rocket and thyme. Therefore, the recommendations of this study would benefit the three key stakeholders, DEA-Government, industry, nurseries and wholesalers, as well as further academic and scientific research.

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APPENDICES

APPENDIX A: CHLOROPHYLL EXTRACTION FROM ROCKET AND THYME – THREE SEASONS

DATE	PLANT AND SOIL MEDIA	663,2	470	646,8		Chlor A		Chloro B
02-06-2016								
1	PS-ROCKET	3,18961	2,91097	2,76434		31,36021		43,1663
2	PS-ROCKET	0,85788	0,87257	0,43848		9,285671		5,052132
3	PS-ROCKET	1,00885	1,04948	0,43634		11,14102		4,236175
4	EM-ROCKET	0,83857	0,81608	0,36049		9,266715		3,473828
5	EM-ROCKET	0,74538	0,79491	0,34049		8,180938		3,519097
6	EM-ROCKET	0,95782	0,92741	0,42337		10,55209		4,217573
7	EM+PS-ROCKET	0,92417	0,92799	0,40008		10,20486		3,888453
8	EM+PS-ROCKET	1,32349	1,24555	0,56819		14,6275		5,466286
9	EM+PS-ROCKET	1,02992	1,05005	0,44689		11,3697		4,355543
10	PS-THYME	0,82176	0,74586	0,34964		9,091064		3,326284
11	PS-THYME	0,98434	0,95015	0,42792		10,86427		4,180146
12	PS-THYME	1,00498	0,95969	0,42312		11,1305		3,971682
13	EM-THYME	1,18343	1,56945	0,54411		12,97895		5,662872
14	EM-THYME	1,72754	2,03125	0,76333		19,03267		7,601141
15	EM-THYME	1,17497	1,34406	0,51605		12,9536		5,102728
16	EM+PS-THYME	1,47735	1,34756	0,63547		16,32458		6,12812
17	EM+PS-THYME	1,42398	1,33047	0,60533		15,75488		5,752297
18	EM+PS-THYME	1,2249	1,13963	0,51032		13,58123		4,72489

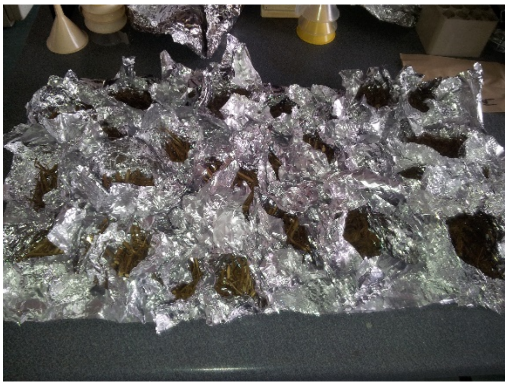
DATE	PLANT AND SOIL MEDIA	663,2	470	646,8		Chlor A		Chloro B
10-11-2016								
1	EM+PS-ROCET	0,51086	0,0274	0,18083		5,753519		1,282459
2	EM+PS-ROCKET	0,0914	-0,08383	-0,08513		1,357163		-2,29644
3	EM+PS-ROCKET	0,51074	0,03519	0,19592		5,709948		1,607506
4	PS-ROCKET	0,25122	0,00073	0,09604		2,809493		0,783638
5	PS-ROCKET	0,27144	0,02304	0,15781		2,88485		2,008571
6	PS-ROCKET	0,28714	0,02872	0,16121		3,067689		2,001601
7	EM-ROCKET	0,23012	-0,0002	0,06763		2,630282		0,280433
8	EM-ROCKET	0,28674	-0,00143	0,06377		3,334647		-0,09132
9	EM-ROCKET	0,30104	-0,00194	0,06586		3,503991		-0,11931
10	EM+PS-THYME	0,61658	0,12967	0,37123		6,517373		4,836887
11	EM+PS-THYME	0,63377	0,11603	0,38753		6,682474		5,099668
12	EM+PS-THYME	0,35179	0,03331	0,19911		3,753911		2,486736
13	PS-THYME	0,45963	0,05342	0,18407		5,116912		1,613392
14	PS-THYME	0,701	0,09277	0,31078		7,720174		3,10667
15	PS-THYME	0,38696	0,03859	0,16621		4,276534		1,600019
16	EM-THYME	0,25092	-0,00111	0,06061		2,904668		0,023423
17	EM-THYME	0,194	-0,0119	0,04187		2,259683		-0,0892
18	EM-THYME	0,29674	0,02516	0,11679		3,309221		0,997611

DATE	PLANT AND SOIL MEDIA	663,2	470	646,8		Chlor A		Chloro B
04-04-2017								
1	PS-THYME	0,29351	0,47231	0,28925		2,78849		4,721974
2	PS-THYME	0,22636	0,40552	0,21711		2,167173		3,513429
3	PS-THYME	0,20684	0,39226	0,20868		1,951573		3,431736
4	EM-THYME	0,12222	0,3078	0,12502		1,148389		2,064608
5	EM-THYME	0,12745	0,30838	0,12902		1,201297		2,123935
6	EM-THYME	0,18509	0,36581	0,19086		1,734853		3,159531
7	EM+PS-THYME	0,17282	0,35329	0,17697		1,623299		2,923473
8	EM+PS-THYME	0,12988	0,31571	0,13371		1,217979		2,212377
9	EM+PS-THYME	0,1761	0,35439	0,18158		1,650617		3,00586
10	PS-ROCKET	0,19418	0,37225	0,1994		1,822379		3,296782
11	PS-ROCKET	0,25482	0,45026	0,25193		2,41866		4,116913
12	PS-ROCKET	0,19322	0,37123	0,19601		1,820077		3,228793
13	EM-ROCKET	0,25045	0,43235	0,24645		2,380417		4,02138
14	EM-ROCKET	0,15683	0,33585	0,15931		1,476693		2,625332
15	EM-ROCKET	0,1929	0,36807	0,19253		1,825866		3,155605
16	EM+PS-ROCKET	0,17391	0,35125	0,17727		1,635814		2,924364
17	EM+PS-ROCKET	0,17454	0,35102	0,1766		1,645401		2,906746
18	EM+PS-ROCKET	0,21239	0,38697	0,20916		2,018221		3,413751

CHLOROPHYLL METHODOLOGY

OVEN SET AT 70DEGREES FOR 72 HOURS

TEMPERATURE SWITCH SET AT 70 DEGREES



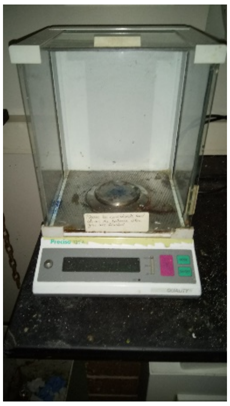
DRIED SAMPLES OF ROCKET AND THYME REMOVED FROM OVEN

Materials and methods

Steps to assess chlorophyll content in thyme and rocket plants:

1. Took 18 samples of 5g each for the different measurements of study.
2. Left samples in the freezer to freeze dry for 3 days.
    - Separated leaves from Rocket and Thyme plants.
    - Weighed fresh mass for 5grams.
    - Put the leaves in plastic packets.
    - Froze cells with liquid nitrogen by adding it to the plastic bags.
    - Placed plastics into a beaker that was put to freeze dry for 3 days.
    - Covered beaker with aluminium foil to prevent photosynthesis from occurring.

3. 1g of fresh mass was added to a solution of 80% acetone. 4ml was used on 1g fresh mass. 1 g fresh mass was weight using a scale.



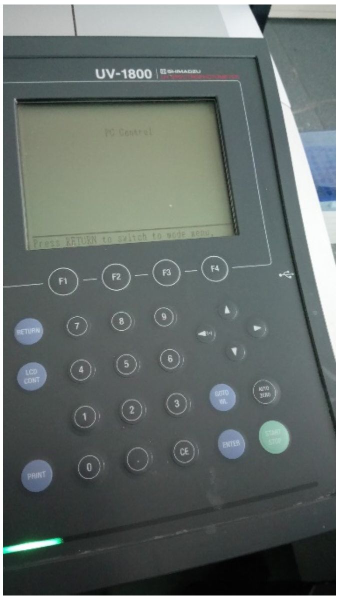
4. Used the IKA T25 Digital Ultra – Turrax to mix the fresh mass and the 80% acetone for 1 minute x 1000.

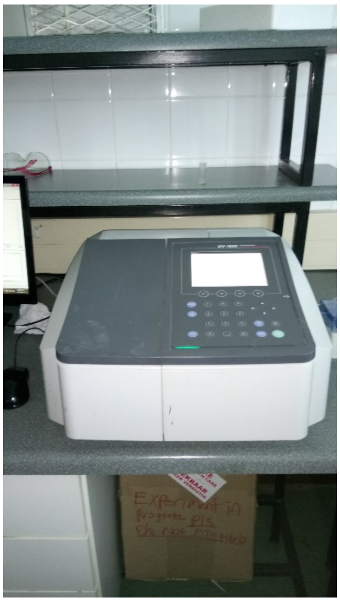
- 80% acetone = 100%acetone + 20% distilled
- 3g fresh mass mixed in mortar with 4ml of 80% acetone and pinch of acid-washed sand
- 2ml acetone used to wash mortar
- Mixture added to 18 centrifuge tubes

5. 2ml of acetone was used to wash Ultra-Turrax.
6. Then the mixed samples were put into centrifuge tubes and put into the Centrifuge PLC series for 5mins at full speed.

7. After the samples was removed from the centrifuge PLC then a small piece of foil was used to cover the top of the tube and that was placed in dry ice.

8. The samples were then taken to do the Chlorophyll and carotenoid tests.
9. 0.02 ml of the samples was added to 0.18 ml of 80% acetone and put into the tubes for calculations.






APPENDIX B: GROWTH DETERMINATION

RESULTS OF GROWTH OF ROCKET AND THYME PLANTS-DATA COLLECTED EVERY TWO WEEKS FOR A EIGHT WEEK PERIOD/TRIAL

Date: 01/04/2016 - 31/05/2016

Table 1 - 4

Results of leaf and stem growth of Thyme and Rocket plants

Five readings in each phase

Phase 1 (15/04/2016) **All measurements in Centimetres (cm)**

Table 1

	LEAF DIAMETER				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Rocket	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	5,6	1,5	3,9		20	6	14
MEASURE II	5,4	2	3,1		19	12	13
MEASURE III	4,8	2,2	2		17	7	15
MEASURE IV	4,6	1,7	2,9		15	9	12
MEASURE V	4,2	1,9	3,6		14	12	12
Total in cm.	**24,6**	**9,3**	**15,5**		**85**	**46**	**66**
Average	**4,92**	**1,86**	**3,1**		**17**	**9,2**	**13,2**

	LENGTH OF SIDE SHOOT				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Thyme	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	12	13	12		24	25	24
MEASURE II	14	6	19		26	22	22
MEASURE III	6	5	17		19	23	21
MEASURE IV	9	8	16		21	26	25
MEASURE V	10	9	14		20	24	25
Total in cm.	**51**	**41**	**78**		**110**	**120**	**117**
Average	**10,2**	**8,2**	**15,6**		**22**	**24**	**23,4**

PHASE 1 (30/04/2016)

	LEAF DIAMETER				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Rocket	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	5	2,2	3		24	17	15
MEASURE II	6	2,9	6		26	18	20
MEASURE III	7	3	5		22	14	22
MEASURE IV	5,5	2,7	4,5		19	13	18
MEASURE V	6,5	2,2	3,6		18	12	17,5
Total in cm.	**30**	**13**	**22,1**		**109**	**74**	**92,5**
Average	**6**	**2,6**	**4,42**		**21,8**	**14,8**	**18,5**

	LENGTH OF SIDE SHOOT				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Thyme	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASURE I	12	13	12		36	29	26
MEASURE II	15	12	15		29	26	25
MEASURE III	13	12	17		31	27	29
MEASURE IV	11	10,5	19		36	28	30
MEASURE V	13	11,5	17		28	27	27
Total in cm.	**64**	**59**	**80**		**160**	**137**	**137**
Average	**12,8**	**11,8**	**16**		**32**	**27,4**	**27,4**

PHASE 1 (15/05/2016)

	LEAF DIAMETER				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Rocket	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	4	3	3,5		28	15	17
MEASURE II	4,5	3	4,5		29	19	18
MEASURE III	6	4	5		30	14	23
MEASURE IV	6,9	3	6,5		32	15	19
MEASURE V	6,5	4	4,6		32	13	18
Total in cm.	**27,9**	**17**	**24,1**		**151**	**76**	**95**
Average	**5,58**	**3,4**	**4,82**		**30,2**	**15,2**	**19**

	LENGTH OF SIDE SHOOT				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Thyme	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASURE I	14	13	14		28	30	28
MEASURE II	15	12	15		29	26	29
MEASURE III	12	13	16		28	27	28
MEASURE IV	14	14	19		30	28	30
MEASURE V	13	14	20		30	28	31
Total in cm.	**68**	**66**	**84**		**145**	**139**	**146**
Average	**13,6**	**13,2**	**16,8**		**29**	**27,8**	**29,2**

RESULTS OF GROWTH OF ROCKET AND THYME PLANTS-DATA COLLECTED EVERY TWO WEEKS FOR A EIGHT WEEK PERIOD/TRIAL

Date: 01/04/2016 - 31/05/2016

PHASE 1 (31/05/2016)

	LEAF DIAMETER				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Rocket	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	8	3	5		28	15	17
MEASURE II	5	34	4		29	19,5	19
MEASURE III	7	4	7		30	14	23
MEASURE IV	6,5	4,2	6		33	15	21
MEASURE V	7	4	5		32	14	19,5
Total in cm.	**33,5**	**49,2**	**27**		**152**	**77,5**	**99,5**
Average	**6,7**	**9,84**	**5,4**		**30,4**	**15,5**	**19,9**

	LENGTH OF SIDE SHOOT				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Thyme	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASURE I	13	14	17		28	30	29
MEASURE II	15	13	21		32	27	29
MEASURE III	14	15	18		28	27	31
MEASURE IV	14	15	19		32	30	30
MEASURE V	15	16	21		30	28	31
Total in cm.	**71**	**73**	**96**		**150**	**142**	**150**
Average	**14,2**	**14,6**	**19,2**		**30**	**28,4**	**30**

APPENDIX C: QUESTIONNAIRE

ALIEN INVASIVE PLANT SPECIES (*Litsea glutinosa*-Indian Laurel)

Please take a few minutes to choose from the following options on taste and texture aspects of leaves from rocket and thyme plants. This questionnaire was prepared to see if there are any difference in taste and texture of rocket and thyme grown in the three different growing media.

These two herbs were grown in three different growing mediums;

1. Potting soil (Group1)
2. Composted *Litsea glutinosa* (Group2)
3. A combination of 1 and 2 above in a 1:1 ratio mixture (Group3)

CONSUMER EVALUATION OF TASTE AND TEXTURE ON ROCKET AND THYME LEAVES

1. CONSUMER EVALUATION OF TASTE ON ROCKET AND THYME LEAVES

1.	TASTE ANALYSIS	SWEET	SOUR	BITTER	PUNGENT	OTHER
ROCKET	Group1					
	Group 2					
	Group 3					
THYME	Group 1					
	Group 2					
	Group 3					

2. CONSUMER EVALUATION OF TEXTURE ON ROCKET AND THYME LEAVES

2	TEXTURE ANALYSIS	CRISP	TENDER	DRY	MOIST	OTHER
ROCKET	Group 1					

	Group 2					
	Group 3					
THYME	Group 1					
	Group 2					
	Group 3					

Thanks you for your participation in this questionnaire to assist the environment and agricultural sector, including market industry for future references

APPENDIX D: FRESH AND DRY MASS IN DIFFERENT MEDIA

The following pages contain details of growth performance over specific periods.

Fresh and Dry Mass for Rocket plants grown in the different soil media

01-04-2016/31-05-2016

Potting Soil + Enriched Media

All measurements in grams (g.)

Rocket	Leaves		Stems		Roots		Flowers		Seeds	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	214,35	71,31	115,25	37,2	12,85	3,78	0	0	0	0
2.	30,85	9,23	25,25	7,18	4,02	1,08	0,29	0,08	0,87	0,27
3.	17,78	5,79	8,65	2,78	3,98	1,1	0,09	0,01	0	0
4.	50,25	15,55	16,69	5,35	9,56	3,06	0,36	0,12	1,25	0,38
5.	20,36	5,06	10,27	3,38	3,08	0,9	0,12	0,03	0	0
Total in g.	333,59	106,94	176,11	55,89	33,49	9,92	0,86	0,24	2,12	0,65
Average	66,718	21,388	35,222	11,178	6,698	1,984	0,172	0,048	0,424	0,13

Enriched Media

All measurements in grams (g.)

Rocket	Leaves		Stems		Roots		Flowers		Seeds	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	24,56	8,41	8,25	2,63	3,85	1,08	0	0	0	0
2.	17,98	5,82	12,25	3,55	1,65	0,5	0,58	0,14	0,25	0,02
3.	12,36	4,71	10,52	3,72	2,89	0,84	0,92	0,3	0,31	0,04
4.	42,85	15,26	28,95	10,25	6,23	1,87	0,15	0,04	0	0
5.	7,23	2,18	9,23	2,96	1,58	0,49	0,29	0,07	0,08	0,01
Total in g.	104,98	36,38	69,2	23,11	16,2	4,78	1,94	0,55	0,64	0,07
Average	20,996	7,276	13,84	4,622	3,24	0,956	0,388	0,11	0,128	0,014

Potting Soil

All measurements in grams (g.)

Rocket	Leaves		Stems		Roots		Flowers		Seeds	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	32,56	12,74	52,85	20,81	5,85	2,71	0,29	0,14	10,56	5,44
2.	39,65	13,27	50,28	19,43	8,25	2,39	0,31	0,18	0,89	0,15
3.	34,56	11,48	38,95	12,21	7,25	2,07	0,12	0,02	3,85	0,84
4.	46,52	14,19	55,36	21,7	4,65	1,5	0,1	0,02	0,95	0,05
5.	60,28	26,25	130,85	51,89	10,28	3,21	0,75	0,25	2,36	0,71
Total in g.	213,57	77,93	328,29	126,04	36,28	11,88	1,57	0,61	18,61	7,19
Average	42,714	15,586	65,658	25,208	7,256	2,376	0,314	0,122	3,722	1,438

Fresh and Dry Mass for Thyme plants

Potting Soil + Enriched Media

All measurements in grams (g.)

Thyme	Leaves and Stems		Roots		Flowers	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	27,95	9,75	10,85	3,49	0	0
2.	6,98	2,91	1,58	0,39	0	0
3.	10,25	3,33	1,98	0,48	0	0
4.	12,58	4,32	1,35	0,39	0	0
5.	15,32	4,77	2,96	0,95	0	0
Total in g.	73,08	25,08	18,72	5,7	0	0
Average	14,616	5,016	3,744	1,14	0	0

Enriched Media

All measurements in grams (g.)

Thyme	Leaves and Stems		Roots		Flowers	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	9,58	3,81	2,25	0,7	0	0
2.	7,95	2,92	2,95	0,78	0	0
3.	4,21	1,74	1,28	0,3	0	0
4.	18,95	6,82	8,25	2,91	0	0
5.	16,23	5,25	7,28	2,27	0	0
Total in g.	56,92	20,54	22,01	0	0	0
Average	11,384	4,108	4,402	0	0	0

Potting Soil

All measurements in grams (g.)

Thyme	Leaves and Stems		Roots		Flowers	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	25,42	9,7	17,59	4,56	0	0
2.	17,25	5,61	5,26	0,95	0	0
3.	5,21	1,87	3,21	0,43	0	0
4.	15,29	5,46	4,95	1,44	0	0
5.	26,38	8,97	9,12	1,88	0	0
Total in g.	89,55	31,61	40,13	9,26	0	0
Average	17,91	6,322	8,026	1,852	0	0

Fresh and Dry Mass for Rocket plants grown in the different soil media

01/09/2016-31/10/2016

Potting Soil + Enriched Media

All measurements in grams (g.)

Rocket	Leaves		Stems		Roots		Flowers		Seeds	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	16,52	7,65	7,75	1,35	0,65	0,17	0,09	0,01	4,58	0,82
2.	19,65	8,65	15,52	3	0,86	0,2	0	0	6,83	1,6
3.	13,69	6,51	12,15	2,6	0,74	0,22	0	0	10,42	2,42
4.	13,24	5,25	8,71	1,85	0,84	0,21	0	0	7,48	1,8
5.	18,46	7,65	12,61	2,94	0,56	0,14	0	0	10,01	2,42
Total in g.	**81,56**	**35,71**	**56,74**	**11,74**	**3,65**	**0,94**	**0,09**	**0,01**	**39,32**	**9,06**
Average	**16,312**	**7,142**	**11,348**	**2,348**	**0,73**	**0,188**	**0,018**	**0,002**	**7,864**	**1,812**

Enriched Media

All measurements in grams (g.)

Rocket	Leaves		Stems		Roots		Flowers		Seeds	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	21,35	9,54	5,04	1,25	0,6	0,21	0	0	4,13	0,85
2.	12,65	5,35	8,93	2,27	1,05	0,29	0	0	5,73	1,64
3.	15,32	6,89	6,67	1,25	1,05	0,24	0	0	3,02	0,57
4.	17,25	8,35	17,68	3,85	2,28	0,55	0,91	0,12	5,89	1,24
5.	11,57	4,95	4,25	0,86	0,68	0,09	0,23	0,05	0,71	0,1
Total in g.	**78,14**	**35,08**	**42,57**	**9,48**	**5,66**	**1,38**	**1,14**	**0,17**	**19,48**	**4,4**
Average	**15,628**	**7,016**	**8,514**	**1,896**	**1,132**	**0,276**	**0,228**	**0,034**	**3,896**	**0,88**

Potting Soil

All measurements in grams (g.)

Rocket	Leaves		Stems		Roots		Flowers		Seeds	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	26,85	12,56	9,43	2,57	0,6	0,2	0	0	3,53	1
2.	24,65	11,85	15,21	3,8	2,29	0,54	0	0	5,97	2,26
3.	30,25	14,69	20,12	5,34	3,24	0,57	0	0	6,63	4,03
4.	28,65	16,51	12,69	3,45	2,24	0,48	0	0	7,88	3,2
5.	20,56	9,35	16,46	3,68	4,17	0,95	0	0	6,28	1,7
Total in g.	**130,96**	**64,96**	**73,91**	**18,84**	**12,54**	**2,74**	**0**	**0**	**30,29**	**12,19**
Average	**26,192**	**12,992**	**14,782**	**3,768**	**2,508**	**0,548**	**0**	**0**	**6,058**	**2,438**

Fresh and Dry Mass for Thyme plants

Potting Soil + Enriched Media

All measurements in grams (g.)

Thyme	Leaves and Stems		Roots		Flowers	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	13,82	3,89	1,92	0,3	0	0
2.	17,8	3,68	5,48	0,6	0	0
3.	24,12	4,84	7,51	1,1	0	0
4.	24,79	4,81	4,37	0,71	0	0
5.	28,94	5,39	3,18	0,46	0	0
Total in g.	**109,47**	**22,61**	**22,46**	**3,17**	**0**	**0**
Average	**21,894**	**4,522**	**4,492**	**0,634**	**0**	**0**

Enriched Media

All measurements in grams (g.)

Thyme	Leaves and Stems		Roots		Flowers	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	16,97	3,28	10,29	1,29	0	0
2.	28,24	5,74	7,26	0,96	0	0
3.	16,73	3,11	4,41	0,56	0	0
4.	16,96	3,8	6,55	0,95	0	0
5.	16,81	3,78	2,03	0,3	0	0
Total in g.	**95,71**	**19,71**	**30,54**	**4,06**	**0**	**0**
Average	**19,142**	**3,942**	**6,108**	**0,812**	**0**	**0**

Potting Soil

All measurements in grams (g.)

Thyme	Leaves and Stems		Roots		Flowers	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	24,61	5,49	11,16	1,92	0	0
2.	28,07	6,11	10,6	1,48	0	0
3.	21,18	4,44	8,59	1,23	0	0
4.	24	5,49	6,91	1,18	0	0
5.	25,34	5,56	12,89	1,78	0	0
Total in g.	**123,2**	**27,09**	**50,15**	**7,59**	**0**	**0**
Average	**24,64**	**5,418**	**10,03**	**1,518**	**0**	**0**

Fresh and Dry Mass for Rocket plants grown in the different soil media

01-02-2017 31/03/2017

Potting Soil + Enriched Media

All measurements in grams (g.)

Rocket	Leaves		Stems		Roots		Flowers		Seeds	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	10,23	3,65	2,86	0,85	0,45	0,12	0	0	0	0
2.	24,82	8,65	3,06	0,98	1,24	0,56	0	0	0	0
3.	14,56	5,26	1,72	0,52	0,7	0,26	0	0	0	0
4.	9,06	3,21	2,72	0,63	0,86	0,39	0	0	0	0
5.	8,26	2,87	2,46	0,75	0,56	0,22	0	0	0	0
Total in g.	**66,93**	**23,64**	**12,82**	**3,73**	**3,81**	**1,55**	**0**	**0**	**0**	**0**
Average	**13,386**	**4,728**	**2,564**	**0,746**	**0,762**	**0,31**	**0**	**0**	**0**	**0**

Enriched Media

All measurements in grams (g.)

Rocket	Leaves		Stems		Roots		Flowers		Seeds	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	44,98	16,52	8,67	1,98	2,75	0,96	0	0	0	0
2.	31,37	10,32	5,99	1,85	2,12	0,68	0	0	0	0
3.	32,92	10,95	10,64	2,31	1,56	0,52	0	0	0	0
4.	43,48	14,25	6,67	1,58	2,53	0,71	0,91	0,23	0	0
5.	56,2	18,96	18,74	3,65	2,89	0,65	0,23	0,06	0	0
Total in g.	**208,95**	**71**	**50,71**	**11,37**	**11,85**	**3,52**	**1,14**	**0,29**	**0**	**0**
Average	**41,79**	**14,2**	**10,142**	**2,274**	**2,37**	**0,704**	**0,228**	**0,058**	**0**	**0**

Potting Soil

All measurements in grams (g.)

Rocket	Leaves		Stems		Roots		Flowers		Seeds	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	15,62	2,9	3,8	0,77	2,12	0,84	0	0	0	0
2.	11,99	1,34	3,58	0,56	1,09	0,39	0	0	1,02	0,42
3.	10,48	1,76	3,78	0,91	0,96	0,31	0	0	0	0
4.	7,09	1,6	3,07	0,49	0,56	0,26	0	0	0	0
5.	5,52	0,56	2,92	0,31	0,34	0,12	0	0	0,52	0,22
Total in g.	**50,7**	**8,16**	**17,15**	**3,04**	**5,07**	**1,92**	**0**	**0**	**1,54**	**0,64**
Average	**10,14**	**1,632**	**3,43**	**0,608**	**1,014**	**0,384**	**0**	**0**	**0,308**	**0,128**

Fresh and Dry Mass for Thyme plants

Potting Soil + Enriched Media

All measurements in grams (g.)

Thyme	Leaves and Stems		Roots		Flowers	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	9,7	2,88	2,94	0,85	0	0
2.	1,77	0,62	0,54	0,21	0	0
3.	3,63	1,16	1,65	0,43	0	0
4.	4,11	1,52	1,28	0,31	0	0
5.	3,36	1,12	1,65	0,41	0	0
Total in g.	**22,57**	**7,3**	**8,06**	**2,21**	**0**	**0**
Average	**4,514**	**1,46**	**1,612**	**0,442**	**0**	**0**

Enriched Media

All measurements in grams (g.)

Thyme	Leaves and Stems		Roots		Flowers	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	3,26	0	1,56	0,26	0	0
2.	2,25	0	0,95	0,15	0	0
3.	1,15	0,75	0,45	0,09	0	0
4.	1,85	0	0,85	0,16	0	0
5.	1,96	0	0,67	0,28	0	0
Total in g.	**10,47**	**0,75**	**4,48**	**0**	**0**	**0**
Average	**2,094**	**0,15**	**0,896**	**0**	**0**	**0**

Potting Soil

All measurements in grams (g.)

Thyme	Leaves and Stems		Roots		Flowers	
Plant No.	Fresh mass	Dry mass	Fresh mass	Dry mass	Fresh mass	Dry mass
1.	9,2	1,86	4,21	0,65	0	0
2.	0,7	0,33	0,35	0,08	0	0
3.	3,6	0,75	1,52	0,15	0	0
4.	3,56	1,4	1,65	0,29	0	0
5.	5,36	1,84	2,65	0,86	0	0
Total in g.	**22,42**	**6,18**	**10,38**	**2,03**	**0**	**0**
Average	**4,484**	**1,236**	**2,076**	**0,406**	**0**	**0**

RESULTS OF GROWTH OF ROCKET AND THYME PLANTS-DATA COLLECTED EVERY TWO WEEKS FOR A EIGHT WEEK PERIOD/TRIAL

Date: 01/09/2016 - 31/10/2016

Table 1 - 4

Results of leaf and stem growth of Thyme and Rocket plants

Five readings in each phase

Phase 2 (15/09/2016) All measurements in Centimetres (cm)

Table 1

SPECIMEN	CONTROL	EXPERIMENT		CONTROL	EXPERIMENT	
	LEAF DIAMETER			PLANT HEIGHT		
Rocket	Potting Soil	Enriched Media	Enriched Media + Potting Soil	Potting Soil	Enriched Media	Enriched Media + Potting Soil
MEASURE I	3,2	2,5	2,5	25	9	19
MEASURE II	3,5	3	2,2	28	17	19
MEASURE III	3,6	2,6	2,1	27	12	10
MEASURE IV	3,4	2,5	1,8	26	6	15
MEASURE V	3,4	3	2,3	28	10	12
Total in cm.	**17,1**	**13,6**	**10,9**	**134**	**54**	**75**
Average	**3,42**	**2,72**	**2,18**	**26,8**	**10,8**	**15**

SPECIMEN	CONTROL	EXPERIMENT		CONTROL	EXPERIMENT	
	LENGTH OF SIDE SHOOT			PLANT HEIGHT		
Thyme	Potting Soil	Enriched Media	Enriched Media + Potting Soil	Potting Soil	Enriched Media	Enriched Media + Potting Soil
MEASURE I	10	9	4	20	15	14
MEASURE II	9	10	6	17	14	19
MEASURE III	10	8	7	16	13	18
MEASURE IV	9	6	8	18	14	16
MEASURE V	8	7	5	17	15	15
Total in cm.	**46**	**40**	**30**	**88**	**71**	**82**
Average	**9,2**	**8**	**6**	**17,6**	**14,2**	**16,4**

PHASE 2 (30/09/2016)

SPECIMEN	CONTROL	EXPERIMENT		CONTROL	EXPERIMENT	
	LEAF DIAMETER			PLANT HEIGHT		
Rocket	Potting Soil	Enriched Media	Enriched Media + Potting Soil	Potting Soil	Enriched Media	Enriched Media + Potting Soil
MEASURE I	4	4	5	54	52	25
MEASURE II	4,1	2,3	6,5	56	40	40
MEASURE III	3,8	2,8	5,3	52	32	42
MEASURE IV	4,2	3	6,2	56	17	36
MEASURE V	4,2	2,9	2,5	54	15	46
Total in cm.	**20,3**	**15**	**25,5**	**272**	**156**	**189**
Average	**4,06**	**3**	**5,1**	**54,4**	**31,2**	**37,8**

SPECIMEN	CONTROL	EXPERIMENT		CONTROL	EXPERIMENT	
	LENGTH OF SIDE SHOOT			PLANT HEIGHT		
Thyme	Potting Soil	Enriched Media	Enriched Media + Potting Soil	Potting Soil	Enriched Media	Enriched Media + Potting Soil
MEASURE I	14	15	10	15	22	24
MEASURE II	8	12	8	18	22	23
MEASURE III	9	9	8	29	21	27
MEASURE IV	11	9,5	7	21	18	19
MEASURE V	13	13	10	18	16	20
Total in cm.	**55**	**58,5**	**43**	**101**	**99**	**113**
Average	**11**	**11,7**	**8,6**	**20,2**	**19,8**	**22,6**

PHASE 2 (15/10/2016)

SPECIMEN	CONTROL	EXPERIMENT		CONTROL	EXPERIMENT	
	LEAF DIAMETER			PLANT HEIGHT		
Rocket	Potting Soil	Enriched Media	Enriched Media + Potting Soil	Potting Soil	Enriched Media	Enriched Media + Potting Soil
MEASURE I	4,5	4,8	4	70	60	60
MEASURE II	4,4	2,8	7	65	40	57
MEASURE III	3,6	4,2	6	63	55	61
MEASURE IV	4,5	1,5	3,5	62	46	52
MEASURE V	3,5	2	4	52	60	58
Total in cm.	**20,5**	**15,3**	**24,5**	**312**	**261**	**288**
Average	**4,1**	**3,06**	**4,9**	**62,4**	**52,2**	**57,6**

SPECIMEN	CONTROL	EXPERIMENT		CONTROL	EXPERIMENT	
	LENGTH OF SIDE SHOOT			PLANT HEIGHT		
Thyme	Potting Soil	Enriched Media	Enriched Media + Potting Soil	Potting Soil	Enriched Media	Enriched Media + Potting Soil
MEASURE I	13	10	15	17	20	24
MEASURE II	13	10	11	22	21	26
MEASURE III	23	20	14	22	25	33
MEASURE IV	14	17	14	21	25	26
MEASURE V	16	15	15	17	22	30
Total in cm.	**79**	**72**	**69**	**99**	**113**	**139**
Average	**15,8**	**14,4**	**13,8**	**19,8**	**22,6**	**27,8**

RESULTS OF GROWTH OF ROCKET AND THYME PLANTS-DATA COLLECTED EVERY TWO WEEKS FOR A EIGHT WEEK PERIOD/TRIAL

Date: 01/09/2016 - 31/10/2016

PHASE 2 (31/10/2016)

	LEAF DIAMETER				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Rocket	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	3,8	2	3,5		60	66	64
MEASURE II	4,1	1,5	3		65	73	59
MEASURE III	3,9	1,8	2,5		64	62	48
MEASURE IV	4,2	2,2	2,8		62	44	63
MEASURE V	4,6	2,5	2,4		70	60	55
Total in cm.	**20,6**	**10**	**14,2**		**321**	**305**	**289**
Average	**4,12**	**2**	**2,84**		**64,2**	**61**	**57,8**

	LENGTH OF SIDE SHOOT				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Thyme	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASURE I	12	11	18		30	21	36
MEASURE II	16	22	15		30	24	24
MEASURE III	22	15	18		26	18	32
MEASURE IV	17	18	2		22	11	26
MEASURE V	24	21	19		28	22	22
Total in cm.	**91**	**87**	**72**		**136**	**96**	**140**
Average	**18,2**	**17,4**	**14,4**		**27,2**	**19,2**	**28**

RESULTS OF GROWTH OF ROCKET AND THYME PLANTS-DATA COLLECTED EVERY TWO WEEKS FOR A EIGHT WEEK PERIOD/TRIAL

Date: 01/02/2017 - 31/03/2017

Table 1 - 4

Results of leaf and stem growth of Thyme and Rocket plants

Five readings in each phase

Phase 1 (15/02/2017) All measurements in Centimetres (cm)

Table 1

		LEAF DIAMETER				PLANT HEIGHT	
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Rocket	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	1.8	6	4		17	14	14
MEASURE II	2,4	4	5		27	17	13
MEASURE III	2,2	8.5	6		24	16	17
MEASURE IV	2,1	7	5.5		14	16	15
MEASURE V	2,5	5	6		29	21	12
Total in cm.	**9,2**	**22**	**21**		**111**	**84**	**71**
Average		**5,5**	**5,25**		**22,2**	**16,8**	**14,2**

		LENGTH OF SIDE SHOOT				PLANT HEIGHT	
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Thyme	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	8	13	8		8	18	25
MEASURE II	10	11	13		12	20	22
MEASURE III	12	10	11		12	17	15
MEASURE IV	11	12	10		9	21	18
MEASURE V	9	10	12		6	11	17
Total in cm.	**50**	**56**	**54**		**47**	**87**	**97**
Average	**10**	**11,2**	**10,8**		**9,4**	**17,4**	**19,4**

PHASE 1 (02/03/2017)

		LEAF DIAMETER				PLANT HEIGHT	
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Rocket	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	3	7	3,5		20	17	17
MEASURE II	2	5	5		15	18	12
MEASURE III	2,5	7	6		19	20	14
MEASURE IV	3	8	5,5		17	20	16
MEASURE V	2,6	7	6		6	19	17
Total in cm.	**13,1**	**34**	**26**		**77**	**94**	**76**
Average	**2,62**	**6,8**	**5,2**		**15,4**	**18,8**	**15,2**

		LENGTH OF SIDE SHOOT				PLANT HEIGHT	
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Thyme	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASURE I	9	11	7		20	23	28
MEASURE II	11	12	11		17	21	23
MEASURE III	8	14	14		19	19	22
MEASURE IV	11	12	15		15	19	20
MEASURE V	12	11	14		17	16	19
Total in cm.	**51**	**60**	**61**		**88**	**98**	**112**
Average	**10,2**	**12**	**12,2**		**17,6**	**19,6**	**22,4**

PHASE 1 (15/03/2016)

		LEAF DIAMETER				PLANT HEIGHT	
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Rocket	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	3	6,5	4,8		42	20	15
MEASURE II	3,5	6,1	4,5		20	21	18
MEASURE III	3,8	5,5	5		30	15	17
MEASURE IV	2,5	7	4		24	19	17
MEASURE V	3,6	5,5	3,5		26	18	15
Total in cm.	**16,4**	**30,6**	**21,8**		**142**	**93**	**82**
Average	**3,28**	**6,12**	**4,36**		**28,4**	**18,6**	**16,4**

		LENGTH OF SIDE SHOOT				PLANT HEIGHT	
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Thyme	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASURE I	9	13	8		23	24	27
MEASURE II	10	13	13		22	28	26
MEASURE III	11	16	12		25	21	23
MEASURE IV	12	14	11		25	20	30
MEASURE V	10	16	10		26	23	24
Total in cm.	**52**	**72**	**54**		**121**	**116**	**130**
Average	**10,4**	**14,4**	**10,8**		**24,2**	**23,2**	**26**

RESULTS OF GROWTH OF ROCKET AND THYME PLANTS-DATA COLLECTED EVERY TWO WEEKS FOR A EIGHT WEEK PERIOD/TRIAL

Date: 01/02/2017 - 31/03/2017

PHASE 1 (31/03/2016)

	LEAF DIAMETER				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Rocket	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASUTRE I	3	3,5	3		48	18	15
MEASURE II	4	4,5	3		26	22	14
MEASURE III	5	5	4		60	24	19
MEASURE IV	4	4,5	4,5		32	16	22
MEASURE V	5	5	4,8		28	20	21
Total in cm.	**21**	**22,5**	**19,3**		**194**	**100**	**91**
Average	**4,2**	**4,5**	**3,86**		**38,8**	**20**	**18,2**

	LENGTH OF SIDE SHOOT				PLANT HEIGHT		
SPECIMEN	**CONTROL**	**EXPERIMENT**			**CONTROL**	**EXPERIMENT**	
Thyme	**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**		**Potting Soil**	**Enriched Media**	**Enriched Media + Potting Soil**
MEASURE I	9	17	13		25	29	26
MEASURE II	11	14	14		32	25	30
MEASURE III	10	12	15		31	22	24
MEASURE IV	12	14	14		28	20	32
MEASURE V	11	13	13		27	22	28
Total in cm.	**53**	**70**	**69**		**143**	**118**	**140**
Average	**10,6**	**14**	**13,8**		**28,6**	**23,6**	**28**

Fresh and dry mass averages of rocket and thyme grown in PS, over the three growing seasons

		Fresh and dry mass(gm) of rocket and thyme grown in PS for 3 seasons					
PLANTS & CHARACTERISTICS	MEASUREMENT	Trial 1		Trial 2		Trial 3	
		Fresh	Dry	Fresh	Dry	Fresh	Dry
ROCKET-LEAVES	1	32,56	12,74	26,85	12,56	15,62	2,9
	2	39,65	13,27	24,65	11,85	11,99	1,34
	3	34,56	11,48	30,25	14,69	10,48	1,76
	4	46,52	14,19	28,65	16,51	7,09	1,6
	5	60,28	26,25	20,56	9,35	5,52	0,56
	AVERAGES	46,42	19,495	23,705	10,955	10,57	1,73
ROCKET-STEMS	1	52,85	20,81	9,43	2,57	3,8	0,77
	2	50,28	19,43	15,21	3,8	3,58	0,56
	3	38,95	12,21	20,12	5,34	3,78	0,91
	4	55,36	21,7	12,69	3,45	3,07	0,49
	5	130,85	51,89	16,46	3,68	2,92	0,31
	AVERAGES	91,85	36,35	12,945	3,125	3,36	0,54
ROCKET-ROOTS	1	5,85	2,71	0,6	0,2	2,12	0,84
	2	8,25	2,39	2,29	0,54	1,09	0,39
	3	7,25	2,07	3,24	0,57	0,96	0,31
	4	4,65	1,5	2,24	0,48	0,56	0,26
	5	10,28	3,21	4,17	0,95	0,34	0,12
	AVERAGES	8,065	2,96	2,385	0,575	1,23	0,48
ROCKET-FLOWERS	1	0,29	0,14	0	0	0	0
	2	0,31	0,18	0	0	0	0
	3	0,12	0,02	0	0	0	0
	4	0,1	0,02	0	0	0	0
	5	0,75	0,25	0	0	0	0
	AVERAGES	0,52	0,195	0	0	0	0
ROCKET-SEEDS	1	10,56	5,44	3,53	1	0	0
	2	0,89	0,15	5,97	2,26	1,02	0,42
	3	3,85	0,84	6,63	4,03	0	0
	4	0,95	0,05	7,88	3,2	0	0
	5	2,36	0,71	6,28	1,7	0,52	0,22
	AVERAGES	6,46	3,075	4,905	1,35	0,26	0,11
THYME- LEAVES AND STEMS	1	25,42	9,7	24,61	5,49	9,2	1,86
	2	17,25	5,61	28,07	6,11	0,7	0,33
	3	5,21	1,87	21,18	4,44	3,6	0,75
	4	15,29	5,46	24	5,49	3,56	1,4
	5	26,38	8,97	25,34	5,56	5,36	1,84
	AVERAGES	25,9	9,335	24,975	5,525	7,28	1,85
THYME-ROOTS	1	17,59	4,56	11,16	1,92	4,21	0,65
	2	5,26	0,95	10,6	1,48	0,35	0,08
	3	3,21	0,43	8,59	1,23	1,52	0,15
	4	4,95	1,44	6,91	1,18	1,65	0,29
	5	9,12	1,88	12,89	1,78	2,65	0,86
	AVERAGES	13,355	3,22	12,025	1,85	3,43	0,755
THYME-FLOWERS	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0

Fresh and dry mass averages of rocket and thyme grown in EM, over the three growing seasons

		Fresh and dry mass(gm) of rocket and thyme growin in EM for 3 seasons					
PLANTS & CHARACTERISTICS	**MEASUREMENT**	**Trial 1**		**Trial 2**		**Trial 3**	
		Fresh	**Dry**	**Fresh**	**Dry**	**Fresh**	**Dry**
ROCKET-LEAVES	1	24,56	8,41	21,35	9,54	44,98	16,52
	2	17,98	5,82	12,65	5,35	31,37	10,32
	3	12,36	4,71	15,32	6,89	32,92	10,95
	4	42,85	15,26	17,25	8,35	43,48	14,25
	5	7,23	2,18	11,57	4,95	56,2	18,96
	AVERAGES	15,895	5,295	16,46	7,245	50,59	17,74
ROCKET-STEMS	1	8,25	2,63	5,04	1,25	8,67	1,98
	2	12,25	3,55	8,93	2,27	5,99	1,85
	3	10,52	3,72	6,67	1,25	10,64	2,31
	4	28,95	10,25	17,68	3,85	6,67	1,58
	5	9,23	2,96	4,25	0,86	18,74	3,65
	AVERAGES	8,74	2,795	4,645	1,055	13,705	2,815
ROCKET-ROOTS	1	3,85	1,08	0,6	0,21	2,75	0,96
	2	1,65	0,5	1,05	0,29	2,12	0,68
	3	2,89	0,84	1,05	0,24	1,56	0,52
	4	6,23	1,87	2,28	0,55	2,53	0,71
	5	1,58	0,49	0,68	0,09	2,89	0,65
	AVERAGES	2,715	0,785	0,64	0,15	2,82	0,805
ROCKET-FLOWERS	1	0	0	0	0	0	0
	2	0,58	0,14	0	0	0	0
	3	0,92	0,3	0	0	0	0
	4	0,15	0,04	0,91	0,12	0,91	0,23
	5	0,29	0,07	0,23	0,05	0,23	0,06
	AVERAGES	0,145	0,035	0,115	0,025	0,115	0,03
ROCKET-SEEDS	1	0	0	4,13	0,85	0	0
	2	0,25	0,02	5,73	1,64	0	0
	3	0,31	0,04	3,02	0,57	0	0
	4	0	0	5,89	1,24	0	0
	5	0,08	0,01	0,71	0,1	0	0
	AVERAGES	0,04	0,005	2,42	0,475	0	0
THYME- LEAVES AND STEMS	1	9,58	3,81	16,97	3,28	3,26	0
	2	7,95	2,92	28,24	5,74	2,25	0
	3	4,21	1,74	16,73	3,11	1,15	0,75
	4	18,95	6,82	16,96	3,8	1,85	0
	5	16,23	5,25	16,81	3,78	1,96	0
	AVERAGES	12,905	4,53	16,89	3,53	2,61	0
THYME-ROOTS	1	2,25	0,7	10,29	1,29	1,56	0,26
	2	2,95	0,78	7,26	0,96	0,95	0,15
	3	1,28	0,3	4,41	0,56	0,45	0,09
	4	8,25	2,91	6,55	0,95	0,85	0,16
	5	7,28	2,27	2,03	0,3	0,67	0,28
	AVERAGES	4,765	1,485	6,16	0,795	1,115	0,27
THYME-FLOWERS	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0

Fresh and dry mass averages of rocket and thyme grown in PSEM, over the three growing seasons

		Fresh and dry mass (gm) of rocket and thyme grown in PSEM					
PLANTS & CHARACTERISTICS	MEASUREMENT	Trial 1		Trial 2		Trial 3	
		Fresh	Dry	Fresh	Dry	Fresh	Dry
ROCKET-LEAVES	1	214,35	71,31	16,52	7,65	10,23	3,65
	2	30,85	9,23	19,65	8,65	24,82	8,65
	3	17,78	5,79	13,69	6,51	14,56	5,26
	4	50,25	15,55	13,24	5,25	9,06	3,21
	5	20,36	5,06	18,46	7,65	8,26	2,87
	AVERAGES	117,355	38,185	17,49	7,65	9,245	3,26
ROCKET-STEMS	1	115,25	37,2	7,75	1,35	2,86	0,85
	2	25,25	7,18	15,52	3	3,06	0,98
	3	8,65	2,78	12,15	2,6	1,72	0,52
	4	16,69	5,35	8,71	1,85	2,72	0,63
	5	10,27	3,38	12,61	2,94	2,46	0,75
	AVERAGES	62,76	20,29	10,18	2,145	2,66	0,8
ROCKET-ROOTS	1	12,85	3,78	0,65	0,17	0,45	0,12
	2	4,02	1,08	0,86	0,2	1,24	0,56
	3	3,98	1,1	0,74	0,22	0,7	0,26
	4	9,56	3,06	0,84	0,21	0,86	0,39
	5	3,08	0,9	0,56	0,14	0,56	0,22
	AVERAGES	7,965	2,34	0,605	0,155	0,505	0,17
ROCKET-FLOWERS	1	0	0	0,09	0,01	0	0
	2	0,29	0,08	0	0	0	0
	3	0,09	0,01	0	0	0	0
	4	0,36	0,12	0	0	0	0
	5	0,12	0,03	0	0	0	0
	AVERAGES	0,06	0,015	0,045	0,005	0	0
ROCKET-SEEDS	1	0	0	4,58	0,82	0	0
	2	0,87	0,27	6,83	1,6	0	0
	3	0	0	10,42	2,42	0	0
	4	1,25	0,38	7,48	1,8	0	0
	5	0	0	10,01	2,42	0	0
	AVERAGES	0	0	7,295	1,62	0	0
THYME- LEAVES AND STEMS	1	27,95	9,75	13,82	3,89	9,7	2,88
	2	6,98	2,91	17,8	3,68	1,77	0,62
	3	10,25	3,33	24,12	4,84	3,63	1,16
	4	12,58	4,32	24,79	4,81	4,11	1,52
	5	15,32	4,77	28,94	5,39	3,36	1,12
	AVERAGES	21,635	7,26	21,38	4,64	6,53	2
THYME-ROOTS	1	10,85	3,49	1,92	0,3	2,94	0,85
	2	1,58	0,39	5,48	0,6	0,54	0,21
	3	1,98	0,48	7,51	1,1	1,65	0,43
	4	1,35	0,39	4,37	0,71	1,28	0,31
	5	2,96	0,95	3,18	0,46	1,65	0,41
	AVERAGES	6,905	2,22	2,55	0,38	2,295	0,63
THYME-FLOWERS	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0