EFFECTS OF DIFFERENT SOILLESS GROWING MEDIA ON SEEDLING QUALITY OF SOME SOLANACEAE VEGETABLES

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Master Thesis

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REPUBLIC OF TURKEY
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CONTROL OF TRANSPLANT HEIGHT IN TOMATO AND CABBAGE USING PLANT GROWTH REGULATOR PROHEXADIONE-CALCIUM

MASTER'S THESIS

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Department : HORTICULTURE

This master's thesis was accepted by the following committee on 17.05.2017 with the vote unity.

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PREFACE

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LIST OF SYMBOLS AND ABBREVIATIONS

%	: Percentage
°C	: Celsius degree
BD	: Bulk Density
Ca	: Calcium
CEC	: Cation exchange capacity
cm	: Centimeter
Cu	: Cupper
DMRT	: Duncan’s Multiple Range Test
EC	: Electrical conductivity
Fe	: Iron
g	: Gram
K	: Potassium
L	: Liter
LECA	: Lightweight Expanded Clay Aggregates
Mg	: Magnesium
$mg.L^{-1}$	: Milligram / liter
MGM	: Metoroloji Genel Müdürlüğü
mm	: Millimeter
Mn	: Manganese
MSWC	: Municipal Solid Waste Compost
NH_4	: Ammonium
NO_3–N	: Nitrate Nitrogen
OM	: Organic Mater
OP	: Old Peat
p	: Significance

PH	:	pH is the negative log of hydrogen ion concentration in a water-based solution. pH is an abbreviation for "power of hydrogen" where "p" is short for the German word for power, *potenz* and H is the element symbol for hydrogen
SMS	:	Spent Mushroom Substrate
SMS-AB	:	Spent Mushroom Substrate Agaricus Bisporus
SMS-PO	:	Spent Mushroom Substrate Pleurotus Ostreatus
SPAD	:	The Soil Plant Analysis Development
TP	:	Total Porosity
WHC	:	Water Holding Capacity
WP	:	White Peat
Zn	:	Zinc

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DEĞİŞİK TOPRAKSIZ YETİŞTİRME ORTAMLARININ BAZI SOLANACEAE SEBZELERİNDE FİDE KALİTESİ ÜZERİNE ETKİLERİ

ÖZET

Başarılı sebze üretiminde en önemli şeylerden birisi güçlü ve sağlıklı fideler yetiştirmektir. Kaliteli fidelerin üretiminde önemli olan fizyolojik olayların ayarlanması noktasında bitki yetiştirme ortamı önemli rol oynar. Bu çalışma bazı topraksız yetiştirme ortamlarının domates (*Lycopersicon esculentum* Mill.) ve biber (*Capsicum annuum* L.) fidelerinin gelişimi üzerine etkilerini belirlemek amacıyla yürütülmüştür. Organik bileşenler olarak torf ve kokopit, inorganik bileşenler olarak ise perlit, vermikulit, kaya yünü ve genişletilmiş kil agregaları kullanılarak on iki büyüme ortamı formüle edilmiştir. Farklı yetiştirme ortamlılarında yetiştirilen 6 haftalık fidelerde, fide boyu, gövde çapı, kök çapı, gerçek yaprak sayısı, göreceli yaprak klorofil içeriği, gövde yaş ağırlığı, gövde kuru ağırlığı, kök yaş ağırlığı ve kök kuru ağırlığı tespit edilmiştir. Çalışmanın sonuçları, farklı yetiştirme ortamlarının domates ve biberde fide gelişimi ve kalitesini önemli ölçüde etkilediğini göstermiştir. Fide gelişimi ve kalitesi bakımından en iyi sonuçlar torf ve vermikulitten karışımdan (1:1) elde edilmiştir.

Anahtar kelimeler: Domates, biber, fide gelişimi, sebze üretimi, topraksız.

EFFECTS OF DIFFERENT SOILLESS GROWING MEDIA ON SEEDLING QUALITY OF SOME SOLANACEAE VEGETABLES

ABSTRACT

One of the most important things in successful vegetable transplant production is to grow strong and healthy transplants. The role of plant growing media is become important in modulating physiological responses that will eventually lead to producing high quality seedlings. Aim of this thesis study was to evaluate tomato (*Lycopersicon esculentum* Mill.) and pepper (*Capsicum annuum* L) transplant growth in various soilless growing media. Twelve growing media were formulated using peat moss and coconut pith as the organic components, and perlite, vermiculite, rockwool, and expanded clay aggregates as the inorganic components. To facilitate interpretations, seedling height, stem diameter, number of true leaves, elative leaf chlorophyll content, stem fresh weight, stem dry weight, root fresh weight, and root dry weight of 6-week old transplant grown in different growing media were compared. The results of the study have shown that the use of different growing media significantly affected growth and quality of tomato and pepper transplants. The best mixture consisted of peat and vermiculite (1:1; v/v).

Key words: Tomato, pepper, growing media, transplant production, soilless

1. INTRODUCTION

The production of container-grown vegetables plants has expanded in recent years, due to the advantages of this method with respect to direct sowing techniques or the production of seedlings in traditional nurseries Castillo et al. (2004). One method of ensuring success in vegetable production is to establish healthy and vigorous seedlings that do not deteriorate in the new environment but immediately resume their growth. Growing quality transplants offers a number of benefits, such as shorter growing season and more efficient use of land, improved crop uniformity, more accurate prediction of harvest dates, facilitating the use of a wider range of herbicides, extends the growing season, more efficient use of expensive hybrid seed. By using transplants, producers can also insure a good stand of vegetable plants without the uncertainty of direct seeding or the added cost of field thinning (Hannan 2016).

The lack of appropriate cultural practices during growing season is one of the barriers to successful vegetable production. Mistakes, which made during transplant production, are multiplied through the rest of the season and will significantly affect yield and quality. Production could be much higher than the amount above if we can reduce the losses due to poor growing media and poor seedlings.

The growth medium used in vegetable transplants is a determining factor given its close correlation with plant development. Growing media influences seed germination, seedling emergence, seedling growth and quality of seedlings in a nursery (Corti et al. 1998; Wilson et al. 2001; Baiyeri 2004; Sahin et al. 2005; Agbo and Omaliko 2006; Baiyeri and Mbah, 2006; Bulut and Demir 2007; Aklibasinda et al. 2011; Unal 2013).

Growing media or substrates are described as all those solid resources other than soil which only or in combinations can guarantee improve situations than agricultural soil. Media of different source take on the function of soil and provide port for the root system, provide water and nutrients for the plant, and maintain satisfactory aeration within the root zone (Gruda et al. 2006).

Various ingredients have been used to produce growing media for vegetable production all over the world; the raw materials which are used differ depending on their availability (Schmilewski 2009). Such raw materials can be inorganic or organic, but growing media are often formulated from a mix of various raw materials to achieve the correct balance of air and water holding capacity for the plants to be grown as well as for the long-term stability of the medium (Bilderback et al. 2005; Nair et al. 2011). Physically, growing media can improve texture, structure, aggregate stability, drainage, and aeration and enhance water- holding capacity (Jim 1996).

Numerous materials can be used to produce substrates for vegetable transplants, and mixtures are often used to achieve the appropriate characteristics required for transplant development (Handreck and Black 2002). At present, sphagnum peat from Central and Northern Europe is used in the majority of commercial substrates due to its excellent chemical, physical and biological properties. Besides peat, there are other products that can potentially supplement compost in the growing medium. These can include organic materials such as bark coconut (*Cocos nucifera* L.) coir, poultry feathers, or inorganic materials such as vermiculite, clay, perlite, and mineral wool (Grunert et al. 2008; Vaughn et al. 2011) or mixes such as peat and perlite; coir and peat and pelleted clay and peat Nair et al. (2011). Moreover, sometimes these materials are used in the system of organized cubes such as Rockwool cubes for seedling and transplant production, bags and slabs peat- based substrates and rock wool, correspondingly, mats (polyurethane foam), and troughs rock wool, the last three are can be used for vegetable production in soilless culture systems. The progress is extremely country related; historically the development of growing media can be exhibited in separate stages (Gruda 2012).

In recent years, research has focused on substitute and/or alternative materials to traditional peat (Handar et al. 1985; Raviv et al. 1986; Verdonck 1988). Since its availability has diminished. One of the alternative products is coco fiber. Coco fiber is a waste product of the coconut palm husk industry that offers a reliable, economical and absorbent growing medium alternative (Evans and Stamps 1996). Peat [70% peat + 30%

vermiculite (v/v/)] has long been the primary growing medium in standard vegetable transplant production. However, interest has increased in the use of coir (coconut pith), as an alternative vegetable transplant medium because of favorable physico-chemical properties such us high water holding capacity, low bulk density and high potassium content (Arenas and Vavrina 1998). Sixteen different transplant media formulations (v/v) were tested in a mixture component experiment with tomato, using coir and peat as organic components and vermiculite and perlite as inorganic components. Coir - medium compared well with the standard peat vermiculite medium based on the transplant quality parameters of stem diameter, root growth and height when used in the following mixtures: 50% peat/25% coir/25% vermiculite and 50% peat/25% coir /25% perlite (Arenas and Vavrina 1998).

The growth medium varied widely from country to country and there is no such thing as one perfect mix for all types of plants. Therefore, selecting the best substrate among the various materials is imperative to the plant productivity. With so many mixes to choose from it can be confusing. Replacing soil with other growing media for growing vegetables especially, pepper and tomatoes resulted better control of plant nutrition and plant diseases that caused by soil (Olympios 1995).

Growers have used many different combinations of components in a growing medium for tomato seedling production in Turkey. However there is no standard growing media, which was developed or standardized in Turkey up to date. The aim of this thesis study was determine the influence of growing media types and mixture on the quality of tomato and pepper seedlings under greenhouse conditions.

2. LITERATURE REVIEW

2.1. Growing Media

Uniform seedling emergence and rapid growth are essential for efficient transplant production Herrera et al. (2008). To this end the nature, components and properties of the growing media are critical. Growing media is defined as the mean where the roots of cultivated plants grow properly (Kamp 2000). The suitable growing medium would provide enough support to the plant, serve as reserve for nutrients and water; also allow exchanging oxygen diffusion to the roots and permitting gaseous exchange between the roots and atmosphere outside the root substrate (Argo 1998; Abad et al. 2002). However, different substrates have different materials and structure which could have direct and/or indirect impact on plant growth and development. While these substrates can be utilized alone, mixtures of the substrates such as peat moss and perlite, coconut and pelleted clay (Grunert et al. 2008; Nair et al. 2011; Vaughn et al. 2011; Bhat et al. 2014) are also be used widely. Therefore, choosing the suitable substrate among the various substrates is important to the plant productivity (Olympios 1995).

Soil was conventionally used as a growth medium in the agriculture practices to produce ornamental and commercial plant yield. However, the maintenance of soils as potting mixes proved to be problematic. Top soil supply, uniformity and quality are difficult to maintain and soil must be pasteurized or fumigated. Pasteurization of some soils at high temperatures creates additional problems such as manganese toxicity and an imbalance between ammonifying and nitrifying bacteria.

The high bulk density of a soil medium increases handling labor and cost of shipping plants. There was also insufficient access to a supply of appropriate soil for growing plants. It soon became known that potting soil mixes with more than 30% soil resulted in poor aeration and less water availability (Handreck and Black, 2002; Boodley and Newman 2009).

Although there is not an ideal growth medium suitable for all growing potted plants a growth medium should incorporate physical, chemical, and biological requirements for good plant growth along with the requirements of practical plant production (to be readily available, easy to handle, lightweight and to produce uniform plant growth) (Heiskanen 1993; Reinikainen 1993; Tsakaldimi 2001; Jacobs et al. 2009; Landis and Morgan 2009).

Growing medium also needs some essential requirements such as permeability and strength to support the plant and maintain plant growth (Chang and Shang 2007). And the growing medium ability to hold water and exchange gasses might be of importance for keeping the quality of plants (Dresboll 2010). The above factors have to be taken into account when selecting and mixing media.

Criteria which should be considered for use of a material in a potting mixture include (Matkin et al. (1957) :

Effective in producing good drainage and aeration
Biologically and chemically stable when pasteurized
Low in soluble salts
Readily available in uniform grade
Economical
Capable of retaining moisture and nutrients to meet plant requirements
Light in weight
Easily incorporated into mixture
Acceptable pH

Constituents such as natural soil, peat, sand, perlite and vermiculite are commonly used as substrates for container plant production. Nevertheless, these materials might be fully or partially replaced by various organic or inorganic wastes, such as rock wool, expanded clay, pumice, glass wool, peat moss, coconut, coir rice hulls, bark and composted plant materials, thus achieving environmental and economic benefits (Hochmuth and Hochmuth 2003; Surrage et al. 2010; Tsakaldimi and Ganatsas 2016).

In recent years, many innovative cultivation procedures using new growing media methods have been developed, including systems without solid medium, as well as aggregate systems in which inorganic or organic substrates are used (Gruda 2009). Different materials can be used as growing media offering numerous advantages.

2.1.1. Peat Moss

Peats are organic materials formed by accumulation of specific plant species which are partially decomposed by aerobic conditions. The type of plant material and its degree of decomposition determine the value for use in growing media. Peat is classified into four distinct types (1) sphagnum moss peat; (2) hypnaceous moss peat; (3) reed and sedge peat; and (4) humus peat or muck (Mastalerz 1977). The most common substrate is based on Sphagnum peat due to its high physical and chemical stability and low degradation rate. Peat moss is a basic component for potting media in vegetable growth (Molitor and Bruckner 1997).

Sphagnum peat has been provided the base material for the majority of commercial substrates used in nurseries; its excellent physical, chemical, and biological properties make it ideal for growing horticultural seedlings (Abad et al. 2001; Diaz-Perez and Camacho-Ferre 2010).

Peat moss is the most vital medium because of its desirable physical characteristics and high cation exchange capacity (CEC) Raviv et al. (1986). And contain special properties which peat moss retains a lot of water and is extremely stable and it decomposes very slowly (Molitor and Bruck 1997). It is also acidic and has no nutrient value. However, the availability of peat moss is becoming limited since peat is harvested from wetlands and in recent years there has been increasing environmental opposition against peat harvesting (Robertson 1993; Barkham 1993; Buckland 1993). However, the peat is expensive and searching to find replacing materials Mami et al. (2008). Other advantages for peat such as better environmental protection with closed systems and improved the quality of product through precise dosage of nutrients such as for vegetables (Schnitzler and Gruda 2002). Recently, culturing plant in greenhouses with controlling the conditions have been developed which is caused increased of plant growing in various climates. The methods are effective for increasing yield and production especially in developed countries.

Unfortunately, the high demand for peat in horticulture has led to constant exploitation of peat lands, the consequent depletion of this resource, and the ecosystem degradation (Raviv 1998; Sterrett 2001).

Because of the declining availability of peat in the near future due to environmental constraints Di Benedetto et al. (2006), the European Union has issued directives to reduce the use of peat in growing media and has encouraged research with composted organic wastes (Bragg et al. 2006).

2.1.2. Perlite

Perlite is heat-expanded volcanic rock that provides good drainage to the media while holding air in the rooting zone. Most of the water from perlite stays on the surface of the particles making it readily available to plants (Anonymous 2014). It has low cation exchange capacity and low water holding capacity. When used in a medium it increases aeration and reduces bulk density of the medium. It will not compact in a mix but has a tendency to float and separate from the other components when watered. Perlite should be considered for use only in propagation media for nursery crops. It is much too light and causes too much of a reduction in bulk density to be used as a container mix component.

About 75% of the perlite reserves in the world is located along the Aegean coast in Turkey. According to Alkan and Dogan (1998) and Dogan and Alkan (2004), that perlite is a glassy volcanic rock with a rhyolitic composition and different rate of combined water. The commercial product of perlite is produced by heating the ground sieved material to 760-1100 °C. The combined water in the perlite is converted to gas at high temperature in the heat treatment and cause the volume expands 4-20 times its original volume, consequently in a lightweight high porosity substances. In addition, perlite is used widely in potting soil mixtures and as a stand-alone growing medium (Grillas et al. 2001; Gül et al. 2005).

The various grades differ in their physical characteristics and the most common being 0–3.0 mm in diameter. Furthermore, it is very porous, has a strong capillary action and can hold many times its weight in water. This difference in water- holding capacity between the coarse and fine fractions state that most of the water is held by the coarse particles in internal pores. However, it is not explained by the volume of internal porosity alone (Burés et al. 1997a). Burés also indicated that the slope of the reduction in water content as the water tension rises is moderate relative to sand and stone wool. In addition, (Hanna 2005) indicated that before using perlite for second time after the separation of roots from the previous crops, used perlite was then treated with hot water. This treatment raised media temperatures above limits necessary to kill several fungi and nematodes and significantly reduced media salt (EC, NO3–N, and K) were reduced with no noticeable change in physical condition. Furthermore about cleaning and disinfecting used perlite for recycling saved 56% of the cost to replace the media and gave greater marketable production and heavier tomato fruit than new perlite. The observed yield benefit of perlite recycling was ascribed to the collective effect of salt decrease, media disinfection and the excise of an optimum level of nutrients that usually takes time to build nutrients to an optimum level in new perlite. Thus, it was summation that used perlite could be cleaned and disinfected as required and recycled for many years because it is not organic in nature and physically and chemically stable (Marfa et al. 1993; Hanna 2005) also found that perlite retains its physical properties for successive plant growth.

2.1.3. Vermiculite

The substrate, named expanded Vermiculite, is produced in a similar way to perlite by heating the grinded and sieved material to 1000 °C. Kipp et al. (2000) indicated that the raw material for vermiculite is a natural clay mineral (aluminum-iron magnesium silicates) that has a layered structure with water in between the layers. The water is converted to vapor by raising temperature in the oven and pushes the layers away from each other. This process is termed exfoliation or expansion. Vermiculite consists of granules with an accordion shape, light weight and more porosity.

Vermiculite is important and utilized as a sowing medium and as a component of potting soil mixtures. The best grades are used mainly as mulch in transplant production while coarse grades are frequently used in rooting media (Wright 1989). According to Asher et al. (2008), chemical characteristics of vermiculite are neutral clay, with a pH of 7.0–7.5 and low EC. This clay type contains two tetrahedral sheets for every one octahedral sheet such as the raw material it has a permanent negative charge. Also when the pH is reduced there is a risk of toxic (Al) aluminum release and distributed into the solution. Additionally, vermiculite is a sterile product as it is produced at very high temperatures. However, it cannot be steam-sterilized as it disintegrates during heating. In the past, asbestos was found in some vermiculite mines, all those mines were closed and now vermiculite is considered safe.

Horticultural vermiculite has the excellent property of improving soil aeration while retaining moisture and nutrients to feed roots, cuttings and seeds for faster, maximum growth. Horticultural vermiculite is permanent, clean, odorless, non-toxic and sterile. It will not deteriorate turn moldy or rot. The pH is essentially neutral (7.0) but owing to the presence of associated carbonate compounds, the reaction is normally alkaline. The pH, color and chemical composition of vermiculite will vary depending on the source from deposits around the world. Vermiculite possesses cation exchange properties, thus it can hold available to the growing plant ammonium, potassium, calcium and magnesium. Vermiculite, when combined with peat or composted pine bark compost, promotes faster root growth and gives quick anchorage to young roots. The mixture helps retain air, plant food and moisture, releasing them as the plant requires them. Vermiculite is very light in weight, easy to handle and easily mixes with soil, peat, composted pine bark, fertilizers, pesticides and herbicides. Its use as a carrier and bulking agent ensures more even distribution in mixing operations (Anonymous 2017a).

2.1.4. Coconut Coir

Coconut coir is a natural by-product of the coconut fiber industry (Gianquinto 2005). Also coconut coir made from the mesocarp tissue or husk of coconut fruit. The husk is first softened with water and then grinded, then after grinding, the long fibers are removed and the remaining material is screened. Screened coconut coir is then allowed to dry to suitable moisture depending on the specifications of the grower and then compressed and shipped Konduru et al. (1999). Coconut coir pith is available in large quantities as a by producing of the coconut industry. The major coconut coir producers are Sri Lanka, Philippines, India, Indonesia, Mexico, Costa Rica, and Guyana.

Its properties are similar to peat moss for water holding capacity, and cation exchange ability. Some of its benefit is neutral pH, less negative effect on environment, availability and cost effective (Gianquinto 2005). It is a suitable growth medium for growing many kinds of plant (Prasad 1997) and proven to have ion exchange and gas absorptive properties that can be used to absorb nitrogen in its NH+ and NO3– forms, protecting it from loss into the environment Evans et al. (1996). When used as a growth medium, it may be used solely or in mixing with other materials. (Awang and Ismail 1997) indicate that coconut coir is inexpensive soilless media; it has been characterized in terms of physical properties with good water retention capacity and aeration Noguera et al. (2003) and has performed better as compared to other media in ornamental crops (Abad et al. 2002; Aniel et al. 2007).

Savithri et al. (1993) state that coconut coir contains of cellulose and is rich in potassium equal portions of lignin and the micronutrients Fe, Mn, Zn, and Cu. Because of the high potassium content of the media a decreasing in potassium fertilization has been shown to produce positive results.

The particular structure of coconut fibers and their physical and chemical properties, make them appropriate for container media purposes (Batra 1985). Interest has also increased in the use of coconut coir (coconut pith) as an alternative vegetable transplant medium because of favorable physico-chemical properties such us high water holding capacity, low bulk density and high potassium content (Arenas and Vavrina 1998). Coconut coir is common-use growing medium in Mexico and Europe, and is gaining popularity among growers in the USA Cantliffe et al. (2007). In fact the utilizing of coconut fiber in European greenhouse production is well accepted as new technology.

Tsakaldimi and Ganatsas (2016), reported that coconut coir amendment to peat in a ratio 1:1 (v/v) can be positively examined, since it positively influenced seedlings below ground growth in the nursery that contributed to the significantly higher field survival of Mediterranean oaks (*Quercus ilex* and *Quercus macropleis*).

2.1.5. Rockwool

Rockwool also known as stone wool or mineral wool is the most widely used substrate for the commercial production of hydroponic vegetables. Rockwool is the most popular growing media for greenhouse production of vegetables (Islam 2008).

Rockwool is made from spinning molten basaltic rock with limestone and coke at high temperatures into fine fibers. Then the fibers are bound together by heating them with additives. As final product, fibers are then formed into a range of cubes, blocks, growing slabs and granular products (Smith 1998).

Rock wool originally started as a thermal insulation material in the construction industry, its lightweight but highly aerated nature helps keep heat inside buildings, while being easy to handle, cut and install. Towards the end of the 1960's trials were carried out in Denmark to test the possibility of using stone wool as a substrate for hydroponic plants and since then rock wool as a growing media has seen continuing development and improvement. The use of horticultural rock wool as the growing medium in open hydroponic systems is increasing rapidly. Such systems now receive more attention from research stations than any other type in Europe (Anonymous 2016). Rockwool is the preferred material because: 1) it is essentially almost chemically and biologically inert, making it free of any potential pests, diseases, and weed seeds; 2) rock wool slabs and blocks can be irrigated frequently as they drain freely and can thus be managed to provide an optimum ratio between air and water for crop production throughout the growing season (Bussell and Mckennie 2004).

Rockwool has a low volume weight of nearly 0.07–0.1 g cm-3 and a TPS of 92–97 percent (Smith 1987). One of the most important characteristics of rock wool is that plants are still able to extract water for growth at very low moisture tensions in the media. That means that plants can easily extract water when the rock wool is saturated from recent irrigation and when the rock wool slab has dried down considerably and lost as much as 70-80% of its moisture content, levels which in other growing media would cause severe wilting in the crop (Anonymous 2016).

Rockwool slabs or cubes must be soaked in water before used. After soaking for about 24 hours, the transplants are placed on the slabs with drainage slits cut at the bottom.

2.1.6. Lightweight Expanded Clay Aggregate-"LECA" or "Grow Rocks"

It is lightweight expanded clay formed by heating and firing natural marine clay in a rotary kiln at temperatures up to 1200 °C. The process transforms the clay into lightweight rounded ceramic granules, which have a hard ceramic shell and a porous core, making it perfect for holding oxygen as well as moisture around plant roots. It can be mixed with soil or used alone. It is supplied either as granules in a range of sizes (from 2mm up to 32 mm diameters or as a crushed version, with a unique set of characteristics (Anonymous 2017b).

Leca is heavy enough to provide secure support for the plants but still light weight. Grow rocks are a non-degradable, sterile growing medium that holds moisture, has a neutral pH, and also will pick up nutrient solution to the root systems the plants. Grow rocks are reusable; they can be cleaned, sterilized, then reused again.

Common applications for LECA rocks include tube systems bucket systems flood and drain tables, drip feed containers and troughs, and to improve the drainage and add cation exchange capacity to organic mediums and rock wool. Some of the advantages: Very light yet holds moisture; stays put can be sterilized and reused many times. Some of the disadvantages: Doesn't hold moisture as well as coco-coir; the solution: it can be combined with coco-coir.

2.1.7. Examples of Some Previous Studies Related The Growing Medium

Güvenç et al. (1998) investigated effects of different growing mediums on transplant growth and mineral matter content of cucumber. They mixed garden soil with peat and mushroom compost used, fresh and stored in different ratios. Adding peat to the soil affected positively the growth and mineral matter content in cucumber seedlings.

Combinations of some substrates are also common practice in transplant production. For example, vermiculite retains moisture well, while perlite provides the necessary circulation of oxygen; both of these combined in a 50/50 percent proportion provide a good balance of moisture and oxygen (Gibson 2001).

Ozbay and Isbeceren (2001) conducted a research to evaluate the effects of 20 growing media on tomato seedling production under lower plastic tunnel. Twenty growing media were prepared from topsoil, sand, farmyard manure, perlite, and sawdust by mixing them in different ratios by volume. A standard nutrient mixture was added to each combination. The results of the study have shown how the use of different growing media significantly influenced growth and quality of tomato seedlings. The best mixture consisted of (1 top soil : 1 perlite :1 manure (v/v/v) including a standard nutrient mixture.

Arenas et al. (2002) reported that sixteen different transplant media formulations (v/v) were tested in a mixture component, experiment with tomato, using vermiculite and perlite as inorganic components and coir and peat as organic components. It was also reported that coconut coir-medium compared well with the standard peat/vermiculite medium regarding the transplant quality parameters of stem diameter, root growth and height when used in the following growing mixtures: 50% peat/25% coir/25% vermiculite and 50% peat/25% coir /25% perlite.

In a study conducted to determine transplant response through an agronomic trail in field conditions a study was conducted to evaluate coir alone or combination with peat for lettuce production. For this purpose a greenhouse trial was conducted using six media prepared from peat and coconut coir (v/v) [coir: peat ratio 0:100; 20:80, 40:60; 60:40; 80:20; 100:0]. It was reported that medium composition did not affect seedling emergence, total chlorophyll, and nitrogen concentration. The highest transplant fresh, dry weight and leaf area were obtained with 40% peat and 60% coir Colla et al. (2007). They also suggested that coconut coir could be adopted in transplant production with an optimal combination of about 50% peat and 50% coir.

Herrera et al. (2008) investigated the possibility of use of municipal solid waste compost (MSWC) as a growing medium in the nursery production of tomato plants. Five media prepared from old peat (OP), white peat (WP) and municipal solid waste compost (MSWC) were used to determine optimum growing media for tomatoes (Lycopersicum esculentum Mill. cv "Atletico"). Researchers reported that the MSW compost was found to be an ideal component of mixed-peat substrates for tomato seedlings provided that it accounts for less than half the mixture (30% MSWC and 65% peat).

Medina et al. (2009) conducted in order to investigate the possibility of using spent mushroom substrate (SMS) in the production of horticultural seedlings replacing part of the peat in the growing media. Three vegetable species (tomato, pepper, and courgette) were grown in 12 media containing SMS of two types of mushroom (*Agaricus bisporus* (SMS-AB) and *Pleurotus ostreatus* (SMS-PO)) or a mixture of both 50% (v/v) (SMS-50), as well as peat in various ratios. The proportions of each residue in the mixtures elaborated with peat were 25%, 50%, 75% and 100% v/v residue. A substrate of 100% peat was used as control. Regarding the most suitable SMS-based substrates for plant growth, the researchers come to the conclusion that any substrate could be used for tomato seedling production. They also reported that SMS-AB-based substrates and the media containing low dose of SMS-PO and SMS-50 were adequate for growth of courgette and pepper.

Diaz-Perez M and Camacho-Ferre (2010) studied the effect of different substrate mixes composed of blond peat and compost produced from solid urban waste, vegetable waste, and vine pomace on the quality of tomato seedlings (*Solanum lycopersicum* cv. Dakapo). Results of the study showed that peat in nursery substrates can be partially substituted by these composts to grow tomato seedlings.

In an earlier study (Tsakaldimi and Ganatsas 2016), the experimental potting media tested were peat perlite (3:1), a common medium used for seedling production, peat spoils of peridotite (3:1), peat rice hulls (3:1), peat rice hulls (1:1), peat coconut fiber (1:1), kenaf (100%) and kenaf peat rice hulls (3:1:1). Researchers reported that the native plant seedlings produced in the control treatment (peat: perlite 3:1), were significantly taller and had a significantly greater diameter than all the other seedlings. However, seedlings, produced in peat rice hulls (3:1) even though they were smaller than the control seedlings were not significantly different.

3. MATERIAL AND METHODS

3.1. Location

The greenhouse experiments were conducted from April 2016 to July 2016 at the Horticultural Sciences Research Center of Bingöl University, in Bingöl, Turkey (38°53'N, 40°29'E, at 1139 m altitude) (Figure 1).

Figure 3.1. The research center where the experiments were conducted

3.2. Climate in Bingöl

Bingöl's climate is classified as warm and temperate. The rain in Bingöl falls mostly in the winter, with relatively little rain in the summer. The average temperature in Bingöl is 12.5 °C. Precipitation averages 823 mm. The least amount of rainfall occurs in August with an average of 5 mm. In March, the precipitation reaches its peak, with an average of

126 mm. The temperatures are highest on average in July, at around 26.8 °C. January is the coldest month of the year at -2.4 °C on average (Table 3.1, Table 3.2).

Table 3.1. Extreme maximum and minimum, average maximum and minimum, and average temperatures measured in long period (1950-2015) for Bingöl (MGM, 2016)

Months	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Extreme Maximum Temperature (°C)	13.3	16.2	22.3	30.3	33.4	39	42	41.3	37.8	32.1	25.5	22.8
Extreme Minimum Temperature (°C)	-23.2	-21.6	-20.3	-9.2	1	3.5	8.8	7.8	4.2	-2.4	-15	-25.1
Average Temperature (°C)	-2.4	-1.4	3.9	10.7	16.3	22.1	26.8	26.4	21.2	14	6.6	0.5
Average Maximum Temperature (°C)	2.1	3.6	9.2	16.4	22.8	29.3	34.5	34.5	29.7	21.5	12.5	5.0
Average Minimum Temperature (°C)	-6.1	-5.2	-0.4	5.7	10.1	14.6	19.0	18.6	13.5	8.2	2.2	-2.9
Average Sunshine Duration (h)	3.2	4.2	5.6	5.4	7.3	9.4	9.5	9.2	8.3	6.1	4.3	3.1
Precipitation (mm)	122	114	126	108	71	19	6	5	9	55	87	101

Table 3.2**.** Maximum, minimum, average temperature, and relative humidty outside and inside of the greenhouse during the experiments period in 2016

Months	**April**		**May**		**June**		**July**	
	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside
Average Temp. °C	13,91	21,0	16,33	24,7	22,2	27,5	26,9	29,4
Average Max. Temp. °C	21,28	29.5	23.35	37.3	29,4	38.5	34.6	38,2
Average Min. Temp. °C	7,28	12.5	10.2	13.7	15.35	16.5	19,6	22.6
Relative Humidity (%)	48,4	52.2	57,4	60.1	43,6	52.3	33,4	50.1

3.3. Vegetal material

Tomato seeds *(Lycopersicon esculentum* Mill., variety BT H2274, Bursa Seed Company, Turkey) and pepper seeds (*Capsicum annuum* L., variety BT Ince Sivri Kıl ACI-016, Bursa Seed Company, Turkey) were used for the experiments.

BT H2274 is a bush type tomato. It is mid-seasonal and it can preserve its hardness when it ripens. It can be grown in outdoor within all regions in Turkey. It is mid-early variety and harvested in 80 days. Fruits are roundish, red, and fleshy with thick skin. It is suitable for the transportation. The weight of fruit is about 160-180 g. Average yield is 60-80 tons/ha (Figure 3.2).

Figure 3.2. BT H2274 tomato variety

BT Ince Sivri Kıl ACI-016 is hot and suitable for open field production. Plant height is 60 cm and it has a strong plant habitus. Fruits are thin with 18-23 cm in length. Fruits mature in 60 days. It has long harvesting period. Suitable for consuming fresh (Figure 3.3).

Figure 3.3. BT Ince Sivri Kıl ACI-016 pepper variety

3.4. Growing Media

Twelve growing media were formulated using peat moss and coconut pith as the organic components, and perlite, vermiculite, rockwool, and expanded clay aggregate as the inorganic components (Table 3.3, Figure 3.4.). All growing media materials were purchased from E-Tartes Company (İzmir, Turkey). No pre-plant fertilization was included in the media.

At the beginning of the period of transplant growth pH and electrical conductivity (EC), organic matter (OM), Total porosity (TP), water holding capacity (WHC), and bulk density (BD) levels were determined according to the methods described by previous studies (De Boodt and Verdonck 1972; Tittarelli et al. 2009; Ceglie et al. 2011).

Table 3.3. Components of the 12 transplant media evaluated

Growing Medium	**Growing Media Composition (ratio by volume)**
1	Peat only
2	Coconut pith only
3	Rock wool only
4	Clay pellets only
5	Peat + Perlite (1:1)
6	Peat + Vermiculite (1:1)
7	Peat + Clay pellets (1:1)
8	Coconut coir + Perlite (1:1)
9	Coconut coir + Clay pellets (1:1)
10	Peat + Perlite + Vermiculite (1:1:1)
11	Peat + Perlite + Vermiculite (2:1:1)
12	Coconut coir + Perlite + Vermiculite (1:1:1)

Figure 3.4. Six growing media used fromulating 12 growing media

Electric conductivity (EC) and pH were determined using an extraction ratio 1:5 v/v. BD was determined as the ratio between the weight of the dried material (105°C) and volume at the time of sampling. The water holding capacity of the soil was determined by the amount of water held in the soil sample vs. the dry weight of the sample. Main chemical and physical characteristics of the growing media used in the experiments are given in Table 3.4.

Table 3.4 Main chemical and physical characteristics of the growing media used in the experiments

Growing Medium	**pH**	**EC (dSm^{-1})**	**Organic Matter (%)**	**Total Porosity (%)**	**Water Holding Capacity (%)**	**Bulk Density (g/cm3)**
1	5.17	1.37	92.1	86	84	0.12
2	6.56	1.21	88.6	85	79	0.11
3	6.52	0.52	2.51	93	80	0.22
4	7.91	0.44	4.84	80	20	0.56
5	6.17	0.84	4.85	75	54	0.18
6	6.51	0.83	4.94	80	81	0.15
7	6.62	0.74	3.2	69	30	0.37
8	5.85	0.58	3.49	77	52	0.09
9	6.75	0.84	3.2	58	31	0.39
10	6.58	0.65	4.36	73	56	0.12
11	6.43	0.81	4.91	80	60	0.14
12	6.24	0.62	3.78	72	58	0.13

3.5. The Greenhouse Experiment

The experiment was carried out at an automated and heated polycarbonate-covered greenhouse with natural daylight conditions at average day/night temperature of 29/18°C and relative humidity of 55%. The greenhouse experiment investigated the effects growing media on tomato and pepper seedling growth parameters.

Tomato and pepper seeds were sown (two-seed/cell) into 45-cell plastic trays (cell volume 75 cm^3) filled with growing media in different ratios of growing media ingredients mentioned above and grown on a greenhouse bench (Figure 3.5.).

Figure 3.5. Seedlings trays placed on greenhouse benches

Irrigation of seedlings was manually performed using a sprinkler nozzle connected to a hose and performed daily or twice a day according to the environmental conditions using enough water to avoid stress in the cultivated seedlings. Seedlings were fertilized with 18-18-18 N-P-K soluble fertilizer at a rate of 100 $mg.L^{-1}$ N once a week. The growth period of the seedlings in the nursery was 6 weeks, until reaching commercial transplanting size (Figure 3.6. and Figure 3.7).

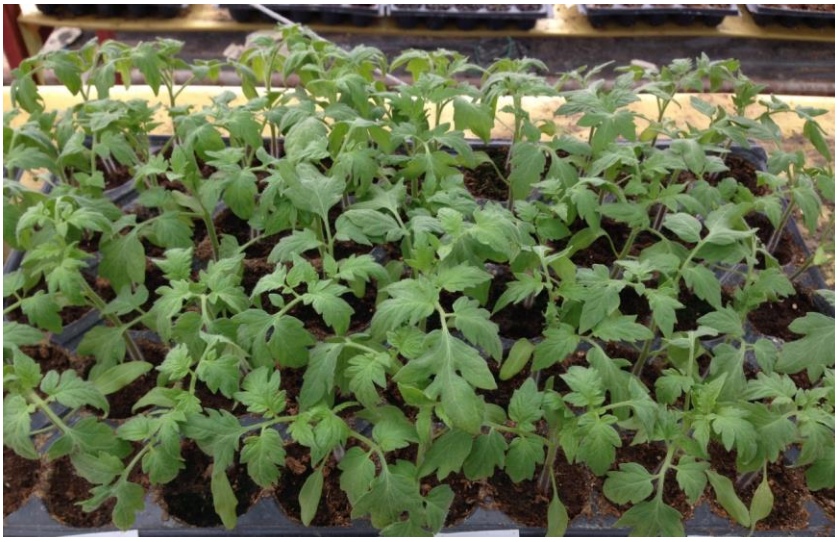

Figure 3.6. Six-week old tomato seedlings

Figure 3.7. Six week old pepper seedlings

3.6. Variables Determined in the Seedlings

Ten plants per treatment were randomly chosen from each replicate to determine seedling growth parameters. Plant growth measurements of the 6-week-old tomato and pepper transplants included seedling height, stem diameter (measured below cotyledons), number of true leaves, relative leaf chlorophyll content with a chlorophyll meter SPAD-502 (Konica Minolta Sensing, Inc., Sakai, Osaka, Japan), leaf area using LI-3100C portable area meter (LI-COR Biosciences, Lincoln, Nebraska, USA). The growing medium was then separated from the roots, and plant organs (shoots and roots) were separately weighted to determine fresh weights. The samples were then dried in a forced-air oven (105 °C) for 24 h and recorded as dry weights.

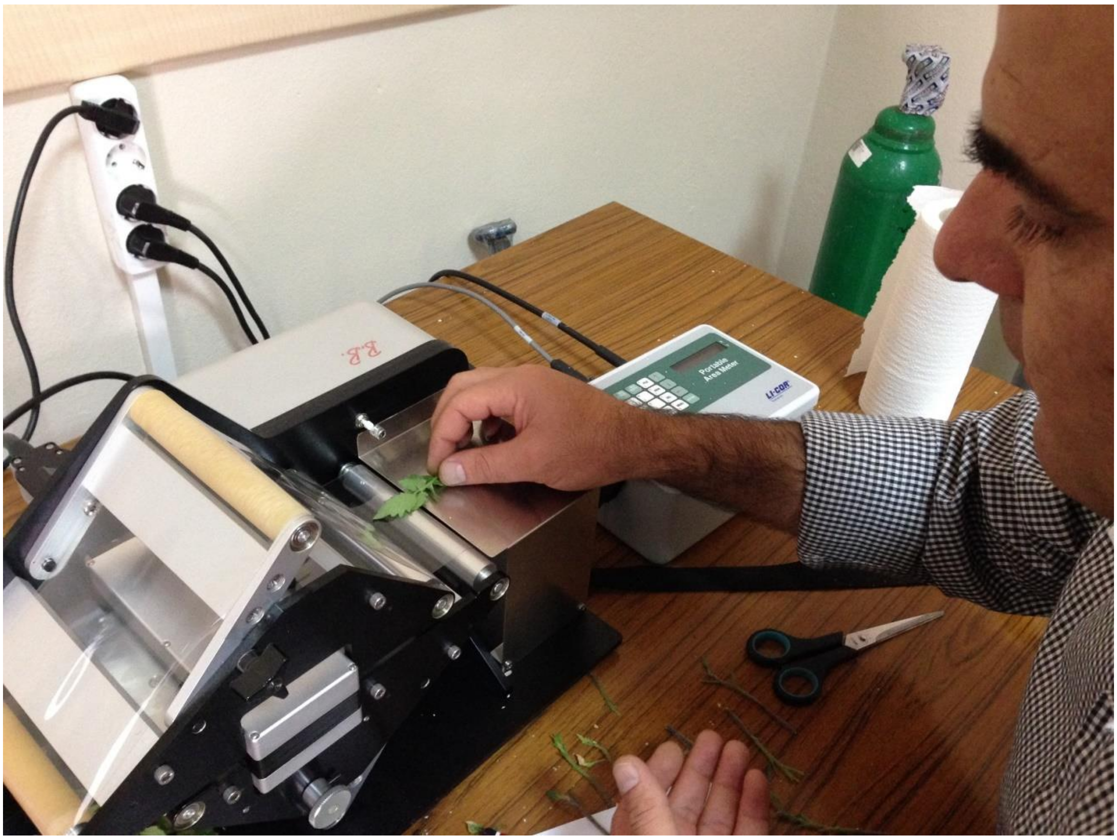

Figure 3.8 Leaf area measurement in LI-3100C portable area meter

3.7. Experimental Design and Statistics

Flats of the 12 growing media were arranged in randomized complete design with three replications on benches within the greenhouse. A rotation of the trays within parcels was performed daily to avoid positional bias. Mean values of the seedlings parameters were statistically analyzed by SAS ANOVA procedure to evaluate the significant effect of the growing media factor. Means were separated by using Duncan's Multiple Range Test (DMRT) at a significance level of *P* = 0.05.

4. RESULTS

4.1. Tomato Results

4.1.1. Seedling Height (cm)

Effect of different media on seedling height of six-week old tomato seedlings are given in Table 4.1. The results presented in Table 4.1 showed that there were significant differences among growing media treatments in seedling height of tomato seedlings (P<0.001).

The data related to seedling height shows that the growing media number 1, 6, 7 and 11 gave the tallest tomato seedlings. Grunert et al. (2008) reported that tomato plants grown in the pure peat rooted more easily than those grown in the peat or mineral wool but the total yield was similar for all media. The media number 8 and 9 were similar in significance, while these substrates maybe utilized alone or mixtures as coconut and pelleted clay. The growing media number 4 gave the shortest tomato seedlings. This might due to high bulk density of the media according to Grunt et al. (2008).

4.1.2. Root Length (cm)

Effect of different media on root length of six-week old tomato seedlings is given in table 4.1. The results presented in Table 4.1 showed that there were significant differences among growing media treatments in root length of tomato seedlings (P<0.001).

The results showed that the media number 10 significantly higher value that the mixture media (peat + perlite + vermiculite) which is 13.04 cm compared other media exception for media number 3, 4 and 12 (7.85, 8.50 and 8.68 cm, respectively). The lowest root length value was obtained from media number 3 and 4 which were 7.85 and 8.50 cm, respectively. The media number 3, 4, 9, and 12 were similar in significance in terms of root length.

Table 4.1. Effects of different growing media on seed ling height (cm) and root length (cm) of six week-old tomato seedlings under the greenhouse conditions

Growing Media		Seedling Height (cm)	Root Length (cm)
1	peat only (1)	9.38 a	12.23 ab
2	coconut coir only (1)	6.54 cd	10.37 bc
3	rock wool only (1)	7.68 bc	7.85 c
4	pelleted clay only (1)	5.75 d	8.50 c
5	peat + pearlite (1:1)	7.07 bcd	12.89 ab
6	peat + vermiculite (1:1)	8.33 ab	12.17 ab
7	peat + pelleted clay (1:1)	8.26 ab	12.94 ab
8	coconut coir + perlite (1:1)	6.56 cd	12.18 ab
9	coconut coir + pelleted clay (1:1)	6.23 cd	9.06 c
10	peat +perlite + vermiculite (1:1:1)	7.34 bc	13.04 a
11	peat +perlite + vermiculite (2:1:1)	8.22 ab	12.83 ab
12	coconut coir + perlite + vermiculite (1:1:1)	6.19 cd	8.68 c
Significance		***	***

*** Significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

4.1.3. Leaf Number

Effects of different media on leaf number of six-week old tomato seedlings are given in table 4.2. The results presented in Table 4.2 showed that there were significant differences among growing media treatments in leaf number of tomato seedlings ($P<0.001$).

The results of the study showed that media number 1 peat only and media mixture number 7 gave highest value of the leaf number (4.84 and 4.57, respectively). The lowest root leaf number value was obtained from media number 3 and 4 which is 3.93. The media number 3, 4, 9, and 12 were similar in significance in terms of root length. These results were supported by the findings of Raiz et al. (2008) who reported that maximum number of leaves was obtained in the media mixture. The possible reason was nutritional contribution of the treatment that produced maximum number of leaves.

4.1.4. Leaf Area (cm^2)

Effects of different media on leaf Area of six-week old tomato seedlings are given in table 4.2. The results presented in Table 4.2 showed that there were significant differences among growing media treatments in leaf area of tomato seedlings ($P<0.05$).

According to the Table 4.2, growing mediums (number 1, 2, 3, 7, 8, 10, 11, and 12) had significant similarity impact on leaf area of the tomato seedlings and produced higher leaf area compared to the other treatments. Leaf area value recorded in the medium number 4 was the lowest which is 26.02 cm^2. This might be the reason that it doesn’t hold moisture as well as other growing mediums (Anonymous 2017b).

Table 4.2. Effects of different growing media on leaf number and leaf area (cm$^{2)}$ of six week-old tomato seedlings under the greenhouse conditions

Growing Media		**Leaf Number**	**Leaf Area (cm^2)**
1	peat only (1)	4.84 a	38.65 ab
2	coconut coir only (1)	3.95 d	39.89 a
3	rock wool only (1)	3.93 d	37.38 ab
4	pelleted clay only (1)	3.93 d	26.02 c
5	peat + pearlite (1:1)	4.02 cd	30.24 bc
6	peat + vermiculite (1:1)	4.35 bc	33.87 abc
7	peat + pelleted clay (1:1)	4.57 ab	39.79 a
8	coconut coir + perlite (1:1)	4.15 cd	37.91 ab
9	coconut coir + pelleted clay (1:1)	4.20 cd	31.79 abc
10	peat +perlite + vermiculite (1:1:1)	4.15 cd	38.00 ab
11	peat +perlite + vermiculite (2:1:1)	4.22 cd	34.44 abc
12	coconut coir + perlite + vermiculite (1:1:1)	4.02 cd	33.95 abc
Significance		***	*

* Significant at $P<0.05$, *** Significant at $P<0.001$, Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

4.1.5. Stem Diameter (mm)

Effects of different media on stem diameter of six-week old tomato seedlings are given in table 4.3. The results presented in Table 4.3 showed that there were significant differences among growing media treatments in stem diameter of tomato seedlings (P<0.001).

The table 4.3 shows that the media number 1 and 6 gave highest stem diameter values (3.04 and 3.02 mm, respectively). Growing media number (2, 3, 9, 10, 11 and 12) fell into same statistical group in terms of stem diameter in terms of stem diameter.

On the other hand stem diameter value recorded in the medium number 4 was the lowest which is 1.69 mm. This might be the reason that it doesn't hold moisture as well as other growing mediums (Anonymous 2017b).

Table 4.3. Effects of different growing media on stem diameter (mm) and relative leaf chlorophyll content (spad) of six week-old tomato seedlings under the greenhouse conditions

Growing Media		Stem Diameter (mm)	Chlorophyll (SPAD)
1	peat only (1)	3.04 a	37.40 de
2	coconut coir only (1)	2.31 ef	30.69 gh
3	rock wool only (1)	2.24 f	33.53 efg
4	pelleted clay only (1)	1.69 g	37.82 de
5	peat + pearlite (1:1)	2.46 bcde	35.70 def
6	peat + vermiculite (1:1)	3.02 a	45.64 ab
7	peat + pelleted clay (1:1)	2.53 bc	48.26 a
8	coconut coir + perlite (1:1)	2.46 bcde	32.35 fgh
9	coconut coir + pelleted clay (1:1)	2.36 cdef	39.73 cd
10	peat +perlite + vermiculite (1:1:1)	2.50 bcd	30.75 gh
11	peat +perlite + vermiculite (2:1:1)	2.64 b	43.79 bc
12	coconut coir + perlite + vermiculite (1:1:1)	2.32 def	28.29 h
Significance		***	***

*** Significant at P<0.001. Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

4.1.6. Relative Leaf Chlorophyll Content (SPAD)

Effects of different media on relative leaf chlorophyll contents of six-week old tomato seedlings are given in table 4.3. The results presented in Table 4.3 showed that there were significant differences among growing media treatments in chlorophyll of tomato seedlings ($P<0.001$).

The media number 6 and 7 showed highest relative leaf chlorophyll content values (45.64 and 48.26 SPAD, respectively). On the other hand, the lowest relative leaf chlorophyll content (28.29 SPAD) was obtained from the growing media number 12 (coconut coir + perlite + vermiculite). Chlorophyll level gives an indirect estimate of the nutrient status, since most of the nitrogen is incorporated to the leaf chlorophyll (Filella et al. 1995; Moran et al. 2000).

4.1.7. Shoot Fresh Weight (g)

Effects of different media on shoot fresh weight of six-week old tomato seedlings are given in table 4.4. The results presented in Table 4.4 showed that there were significant differences among growing media treatments in shoot fresh weight of tomato seedlings ($P<0.05$).

The Table 4.4 shows that the medium numbers 1, 6 and 7 were recorded similar in high significant shoot fresh weight values (2.19, 1.95 and 2.00 g, respectively). The media number 3 had the lowest value which was 1.44 g. It may be because the media 3 has low nutrient and ion exchange capacity than the other growing media, therefore would cause weak growth or severe wilting in the crop (Anonymous 2016).

Table 4.4. Effects of different growing media on shoot fresh weight (g) and shoot dry weight (g) of six week-old tomato seedlings under the greenhouse conditions

Growing Media		Shoot Fresh Weight (g)	Shoot Dry Weight (g)
1	peat only (1)	2.19 a	0.15 a
2	coconut coir only (1)	1.66 bcd	0.13 ab
3	rock wool only (1)	1.44 d	0.09 c
4	pelleted clay only (1)	1.51 cd	0.12 abc
5	peat + pearlite (1:1)	1.60 bcd	0.13 ab
6	peat + vermiculite (1:1)	1.95 abc	0.13 ab
7	peat + pelleted clay (1:1)	2.00 ab	0.15 a
8	coconut coir + perlite (1:1)	1.57 bcd	0.12 abc
9	coconut coir + pelleted clay (1:1)	1.52 cd	0.11 bc
10	peat +perlite + vermiculite (1:1:1)	1.62 bcd	0.11 bc
11	peat +perlite + vermiculite (2:1:1)	1.72 bcd	0.12 ab
12	coconut coir + perlite + vermiculite (1:1:1)	1.54 cd	0.10 bc
Significance		*	**

* Significant at P<0.05, ** Significant at P<0.01. Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

4.1.8. Shoot Dry Weight (g)

Effects of different media on shoot dry weight of six-week old tomato seedlings are given in table 4.4. The results presented in Table 4.4 showed that there were significant differences among growing media treatments in shoot dry weight of tomato seedlings (P<0.01).

The shoot dry weight**s** in the medium number (1, 2, 4, 5, 6, 7, 8, and 11) had positive impact compared with some other media such as media number 9 and 10 high value. On the other hand, the lowest shoot dry weight (0.09 g) was obtained from the growing media number 3 (Rockwool only).

4.1.9. Root Fresh Weight (g)

Effects of different media on root fresh weight of six-week old are given in table 4.5. The results presented in Table 4.5 showed that there were significant differences among growing media treatments in root fresh weight of tomato seedlings (P<0.001).

Root fresh weights of tomato seedlings ranged from 0.70 to 1.60 g (Table 4.5). The table 4.5 shows in media number 1 had the highest value of root fresh weight which is 1.60 g. On the other hand, the lowest the root fresh weight value was recorded for medium number 3 which is 0.70 g.

4.1.10. Root Dry Weight (g)

Effects of different media on root dry weight of six-week old tomato seedlings are given in table 4.5. The results presented in Table 4.5 showed that there were significant differences among growing media treatments in root dry weight of tomato seedlings (P<0.001).

Root dry weights of tomato seedlings ranged from 0.05 to 0.12 g (Table 4.5). The table 4.5 shows in media number 1 had the highest value of root fresh weight which is 0.12 g. On the other hand, the lowest the root fresh weight value was recorded for medium number 3 which is 0.05 g. This might be due to physically impact of the media on the roots (Neelam et al. 2001).

Table 4.5. Effects of different growing media on root fresh weight (g) and root dry weight (g) of six week-old pepper seedlings under the greenhouse conditions

Growing Media		**Root Fresh Weight (g)**	**Root Dry Weight (g)**
1	peat only (1)	1.60 a	0.12 a
2	coconut coir only (1)	1.00 cde	0.08 cd
3	rock wool only (1)	0.70 g	0.05 f
4	pelleted clay only (1)	0.85 efg	0.06 def
5	peat + pearlite (1:1)	1.20 bc	0.09 bc
6	peat + vermiculite (1:1)	1.13 bcd	0.09 bc
7	peat + pelleted clay (1:1)	1.24 b	0.09 b
8	coconut coir + perlite (1:1)	0.95 def	0.07 d
9	coconut coir + pelleted clay (1:1)	0.76 fg	0.06 ef
10	peat +perlite + vermiculite (1:1:1)	0.95 def	0.07 de
11	peat +perlite + vermiculite (2:1:1)	1.04 bcde	0.08 cd
12	coconut coir + perlite + vermiculite (1:1:1)	0.83 efg	0.06 def
	Significance	***	***

*** Significant at P<0.001, Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

4.2. Pepper Results

4.2.1. Seedling Height (cm)

Effects of different media on seedling height of six-week old pepper seedlings are given in table 4.6. The results presented in Table 4.6 showed that there were significant differences among growing media treatments in seedling height of pepper seedlings ($P<0.001$).

The data related to seedling height shows that the growing media number 6 and 11 gave the tallest pepper seedlings (11.09 and 11.14 cm, respectively). Grunert et al. (2008) reported that tomato plants grown in the pure peat rooted more easily than those grown in the peat or mineral wool but the total yield was similar for all media. The growing media number 4 gave the shortest pepper seedlings (4.81 cm). This might due to high bulk density of the media according to Grunt et al. (2008).

Table 4.6.Effects of different growing media on seedling height (cm) and root length (cm) of six week-old pepper seedlings under the greenhouse conditions

Growing Media		**Seedling Height (cm)**	**Root Length (cm)**
1	peat only (1)	9.38 bc	9.28 a
2	coconut coir only (1)	7.86 de	9.32 a
3	rock wool only (1)	6.12 f	5.21 b
4	pelleted clay only (1)	4.81 g	6.02 b
5	peat + pearlite (1:1)	8.67 cd	8.63 a
6	peat + vermiculite (1:1)	11.09 a	9.22 a
7	peat + pelleted clay (1:1)	9.02 bc	8.89 a
8	coconut coir + perlite (1:1)	7.10 ef	8.67 a
9	coconut coir + pelleted clay (1:1)	6.92 ef	8.52 a
10	peat +perlite + vermiculite (1:1:1)	10.01 b	9.28 a
11	peat +perlite + vermiculite (2:1:1)	11.14 a	8.38 a
12	coconut coir + perlite + vermiculite (1:1:1)	7.90 de	9.48 a
Significance		***	***

*** Significant at $P<0.001$.Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

4.2.2. Root Length (cm)

The table 4.6 illustrates the effect of different growing media on root length (cm) during six weeks for cultivated pepper seedlings grown in greenhouse. The results presented in Table 4.6 showed that there were significant differences among growing media treatments in root length of pepper seedlings ($P<0.001$). Root lengths of pepper seedlings ranged from 5.21 cm to 9.48 cm (Table 4.6). The results of the experiment showed that there was no significant differences among the growing mediums except for growing media number 3 and 4. The lowest root length value was obtained from media number 3 and 4 which were 5.21 and 6.02 cm, respectively. The rest of the growing media were similar in significance in terms of root length.

4.2.3. Leaf Number

The table 4.7 is showing the effect of different media on leaf number of six weeks old pepper seedlings grown under greenhouse condition. The results presented in Table 4.7 showed that there were significant differences among growing media treatments in leaf number of pepper seedlings ($P<0.001$).

The results of the study showed that media number 1 peat only and media mixture number 6, 7, 10 and 11 gave highest value of the leaf number (7.43, 6.93, 6.95, 7.31, and 7.06, respectively). The lowest root leaf number value was obtained from media number 4 which is 5.35. These results were supported by the findings of Raiz et al. (2008) who reported that maximum number of leaves was obtained in the media mixture. The possible reason was nutritional contribution of the treatment that produced maximum number of leaves.

Table 4.7. Effects of different growing media on leaf number and leaf area ($cm^{2)}$ of six week-old pepper seedlings under the greenhouse conditions

Growing Media		Leaf Number	Leaf Area (cm^2)
1	peat only (1)	7.43 a	72.40 ab
2	coconut coir only (1)	6.62 cde	57.16 bcd
3	rock wool only (1)	6.18 ef	31.48 ef

Table 4.7. (Continue) Effects of different growing media on leaf number and leaf area (cm^2) of six week-old pepper seedlings under the greenhouse conditions

4	pelleted clay only (1)	5.35 g	22.12 f
5	peat + pearlite (1:1)	6.55 cde	60.81 abc
6	peat + vermiculite (1:1)	6.93 abcd	73.33 a
7	peat + pelleted clay (1:1)	6.95 abcd	55.00 cd
8	coconut coir + perlite (1:1)	5.93 f	44.13 de
9	coconut coir + pelleted clay (1:1)	6.45 def	52.13 cd
10	peat +perlite + vermiculite (1:1:1)	7.31 ab	71.37 ab
11	peat +perlite + vermiculite (2:1:1)	7.06 abc	72.39 ab
12	coconut coir + perlite + vermiculite (1:1:1)	6.87 bcd	44.98 de
Significance		***	***

*** Significant at P<0.001. Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

4.2.4 Leaf Area (cm^2)

Effects of different media on leaf area of six-week old are given in table 4.7. The results presented in Table 4.7 showed that there were significant differences among growing media treatments in leaf area of pepper seedlings (P<0.001).

According to the Table 4.7, growing mediums (number 1, 5, 6, 10, and 11) had significant similarity impact on leaf area of the pepper seedlings and produced higher leaf area (72.40, 60.81, 73.33, 71.37, and 71.39 cm^2, respectively) compared to the other treatments. Leaf area value recorded in the medium number 4 was the lowest which is 22.122 cm^2. This might be the reason that it doesn’t hold moisture as well as other growing mediums (Anonymous 2017b).

4.2.5. Stem Diameter (mm)

Effects of different media on stem diameter of six-week old pepper seedlings are given in table 4.8. The results presented in Table 4.8 showed that there were significant differences among growing media treatments in stem diameter of pepper seedlings (P<0.001).

Table 4.8. Effects of different growing media on stem diameter (mm) and relative leaf chlorophyll contents (SPAD) of six week-old pepper seedlings under the greenhouse conditions

Growing Media		**Stem Diameter (mm)**	**Chlorophyll (SPAD)**
1	peat only (1)	2.13 bcd	33.89 bc
2	coconut coir only (1)	2.02 cd	32.87 c
3	rock wool only (1)	1.76 e	33.51 bc
4	pelleted clay only (1)	1.84 e	33.99 bc
5	peat + pearlite (1:1)	2.08 bcd	34.95 bc
6	peat + vermiculite (1:1)	2.32 a	34.02 bc
7	peat + pelleted clay (1:1)	2.14 bc	37.48 a
8	coconut coir + perlite (1:1)	2.00 cd	35.82 ab
9	coconut coir + pelleted clay (1:1)	1.98 d	35.97 ab
10	peat +perlite + vermiculite (1:1:1)	2.19 ab	34.83 bc
11	peat +perlite + vermiculite (2:1:1)	2.32 a	34.01 bc
12	coconut coir + perlite + vermiculite (1:1:1)	2.00 cd	35.30 abc
Significance		***	**

** Significant at P<0.01, *** Significant at P<0.001. Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

The table 4.8 shows that the media number 6 and 11 gave highest stem diameter values (2.32 mm). Growing media number (2, 3, 9, 10, 11 and 12) fell into same statistical group in terms of stem diameter in terms of stem diameter. On the other hand stem diameter value recorded in the medium number 3 and 4 was the lowest (1.76 and 1.84 1.69 mm, respectively). This might be the reason that those growing media especially number 4 doesn’t hold moisture as well as other growing mediums (Anonymous 2017b).

4.2.6. Relative Leaf Chlorophyll Content (SPAD)

Effects of different media on relative leaf chlorophyll contents of six-week old pepper seedlings are given in table 4.8. The results presented in Table 4.8 showed that there were significant differences among growing media treatments in chlorophyll of pepper transplants ($P<0.01$).

The media number 7, 8, 9, and 12 showed highest relative leaf chlorophyll content values (37.48, 35.82, 35.97, and 35.30 SPAD, respectively). On the other hand, the lower relative leaf chlorophyll contents were obtained from the growing other growing media although there is a very small difference between some of the media (1, 3, 4, 5, 6, 10, 11).

4.2.7. Shoot Fresh Weight (g)

The table 4.9 illustrates the effect of different growing medium on shoot fresh weight (g) in six weeks old pepper seedlings under greenhouse condition. The results presented in Table 4.9 showed that there were significant differences among growing media treatments in shoot fresh weight of pepper seedlings (P<0.001).

The Table 4.9 shows that the medium numbers 6 and 10 were recorded similar in high significant shoot fresh weight values (1.70 and 1.67 g, respectively). The media number 4 had the lowest value which was 0.55 g. It may be because the media 3 has low nutrient and ion exchange capacity than the other growing media, therefore would cause weak growth or severe wilting in the crop (Anonymous 2016).

4.2.8. Shoot Dry Weight (g)

Effects of different media on shoot dry weight of six-week old pepper seedlings are given in table 4.9 the results presented in Table 4.9 shows that there are significant differences among growing media treatments in shoot dry weight of pepper seedlings (P<0.001).

The shoot dry weight**s** in the medium number (6 and 11) had positive impact and produced the highest shoot dry weights (0.27 and 0.29 g) compared with some other media. On the other hand, the lowest shoot dry weight (0.09 g) was obtained from the growing media number 4 (pelleted clay only).

Table 4.9. Effects of different growing media on shoot fresh weight (g) and shoot dry weight (g) of six week-old pepper seedlings under the greenhouse conditions

Growing Media		**Shoot Fresh Weight (g)**	**Shoot Dry Weight (g)**
1	peat only (1)	1.49 bc	0.23 c
2	coconut coir only (1)	1.22 cdef	0.19 ef
3	rock wool only (1)	0.85 g	0.13 h
4	pelleted clay only (1)	0.55 h	0.09 i
5	peat + pearlite (1:1)	1.40 cd	0.22 cd

Table 4.9. (Continue) Effects of different growing media on shoot fresh weight (g) and shoot dry weight (g) of six week-old pepper seedlings under the greenhouse conditions

6	peat + vermiculite (1:1)	1.70 ab	0.27 ab
7	peat + pelleted clay (1:1)	1.29 cde	0.20 de
8	coconut coir + perlite (1:1)	1.00 fg	0.16 g
9	coconut coir + pelleted clay (1:1)	1.14 def	0.18 fg
10	peat +perlite + vermiculite (1:1:1)	1.67 ab	0.26 b
11	peat +perlite + vermiculite (2:1:1)	1.83 a	0.29 a
12	coconut coir + perlite + vermiculite (1:1:1)	1.08 efg	0.17 fg
Significance		***	***

*** Significant at P<0.001. Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

4.2.9. Root Fresh Weight (g)

Effects of different media on root fresh weight of six-week old pepper seedlings are given in table 4.10. The results presented in Table 4.10 showed that there were significant differences among growing media treatments in root fresh weight of pepper seedlings (P<0.001).

Root fresh weights of pepper seedlings ranged from 0.08 to 0.54 g (Table 4.10). The table 4.10 shows in media number 6 had the highest value of root fresh weight which is 0.54 g. On the other hand, the lowest the root fresh weight value was recorded for medium number 3 and 4 (0.08 and 0.12 g, respectively). This might be due to physically impact of the media on the roots (Neelam et al. 2001).

4.2.10. Root Dry Weight (g)

Effects of different media on root dry weight of six-week old pepper seedlings are given in table 4.10. The results presented in Table 4.10 showed that there were significant differences among growing media treatments in root dry weight of pepper seedlings (P<0.001).

Root dry weights of pepper seedlings ranged from 0.06 to 0.42 g (Table 4.10). The table 4.10 shows in media number 6 had the highest value of root fresh weight which is 0.42 g.

On the other hand, the lowest the root fresh weight value was recorded for medium number 3 which is 0.06 g.

Table 4.10. Effects of different growing media on root fresh weight (g) and root dry weight (g) of six week-old pepper seedlings under the greenhouse conditions

Growing Media		**Root Fresh Weight (g)**	**Root Dry Weight (g)**
1	peat only (1)	0.20 cde	0.15 cde
2	coconut coir only (1)	0.17 def	0.13 def
3	rock wool only (1)	0.08 f	0.06 f
4	pelleted clay only (1)	0.12 ef	0.09 ef
5	peat + pearlite (1:1)	0.35 b	0.28 b
6	peat + vermiculite (1:1)	0.54 a	0.42 a
7	peat + pelleted clay (1:1)	0.31 bc	0.24 bc
8	coconut coir + perlite (1:1)	0.28 bcd	0.22 bcd
9	coconut coir + pelleted clay (1:1)	0.19 cde	0.15 cde
10	peat +perlite + vermiculite (1:1:1)	0.28 bcd	0.22 cb
11	peat +perlite + vermiculite (2:1:1)	0.36 b	0.28 b
12	coconut coir + perlite + vermiculite (1:1:1)	0.26 bcd	0.21 bcd
Significance		***	***

*** Significant at $P<0.001$. Means followed by the same letter are not significantly different at the 0.05 level, using Duncan's Multiple Range Test (DMRT).

5. DISCUSSION

Agriculture is the main source of providing food for human in terms of food security. Nowadays, the agriculture is faced with many problems such as affected by diseases lead to reduce yield and production. Also there are many problems related to soil such as soil born pest, lack of fertile soil and water shortage. The problems in agricultural land use such as soil exhaustion, pest infestation or chemical interference are increasing greatly, nematode, heavy to handle and shipping to labor, weeds, and pathogens due to intensive cropping, injudicious application of pesticides or continuous monoculture (Sevgican 1999; Asaduzzaman et al. 2013). It can provide several major advantages in the management of both plant nutrition and plant protection, with prevent and make the solution for those problems; there are many methods which can use organic and inorganic material, growing media influences seed germination and succeeding emergence and growth of seedlings in a nursery (Baiyeri and Mbah 2006). In this regard, soilless culture can avoid problems with monoculture of plants in the same land for years (Alan 1990). Usually peat moss characterized by low number of plant pathogens and weed seeds, which diminishes the risk of introduction of dissemination of soil-based pests (Reedy 2005). And it is a reservoir of moisture and plant nutrients (Grower 1987). In addition, it influences the performance of seedling before they are transplanted in the field such as perlite, peat moss, vermiculite, rock wool, coconut coir, pelleted clay (Sevgican 1999b). According to Bilderback et al. (2005), the purpose of using those medium is to provide enough nutrient for growing plant on it. In the present work, twelve growing medium have been used to compare between each media which one of these will have the more impact on tomato and pepper seedling under greenhouse condition.

The results reveal that growing tomato plants in peat moss caused a significant increase in root growth and vegetative growth also in chlorophyll peat mixed with pelleted clay which gives the high rate (Table 4.3 and 4.1, respectively). It can be seen clearly in Table (4.1) that the root length in peat medium number 1 was 12.23 cm, and mixture medium number 11 was 13.04 cm affected by peat moss. According to Barkham (1993) and Buckland (1993) one of the commonly used natural components is Sphagnum peat. Sphagnum peat is generally used in artificial substrates for its water- and nutrient-holding capacity. However, significant interest has been expressed in finding alternatives to peat due to environmental concerns. But when used peat with pelleted clay that gave the significant increase in seedling height (12.94 cm) due to calcined clays have a relatively high cation exchange as well as water holding capacity. This material is a very durable and useful amendment Verdonck et al. (2004). In addition the peat moss media had great influence on the quality of greenhouse grown tomato (Hanna 2009). Moreover, in Table 4.5, root fresh weight is obviously higher than other this may be confirms the impact of peat as well as for root dry weight. Also the media contain peat with pelleted clay it has greater value than some of the other medium as shown in table 4.5 which reached 1.24 g for root fresh weight as well as for root dry weight. It might be due to perlite media decreased the amount of macro pores which supply both drainage and aeration (Gemalmaz 1993; Caron et al. 2005) this lead to peat gives higher rate than peat and perlite.

Additionally, the table 4.7 shows that peat alone has high value of leaf number which is 7.43 and significant, if compared this value with other mediums it can be seen clearly the medium which not mixed with others and also gave a large number of leaves. However, all other medium mixed with peat gave high number of leaves. According to Schmileweski (2008) that the role of peat in assuring the quality of growing media. However, the leaf area is less in pelleted clay which is 22.12 cm^2 if compared with peat only which is 72.40 cm^2. Konduru et al. (1999) indicates that peat moss to specific moisture, and compressed and shipped, it is characteristics are similar to that coconut coir on water holding capacity, and cation exchange capacity (Mak and Yeh 2001; Gianquito 2005). In terms of seedling, cultivation from seedlings has many advantages such as, earlier harvest economization of land and seed healthy also homogenous production. Thus increasing their demands for the seedlings of various vegetables (Seniz 1992; Camlilar 2002; Kasim et al. 2006), in order to cultivate healthy seedling, growing media is important as ecological conditions. Various plant growing media were studied in the conducted by other researchers (Rippyet al. 2004; Moled et al. 2007; Osmosed et al. 2008). In this research Table 4.1 the seedling is recorded highest value in peat media which is 9.38 cm height if compare with other media, but peat also mixed with vermiculite gives the high value following peat only.

In the table 4.4 clearly seen that shoot fresh weight it has highest value which is 2.19 g, in peat media as well as for shoot dry weight it gives higher rate is 0.15 g, compare with other media. However, the media peat and pelleted clay (1:1) which is 2.00 g also for dry shoot weight is 0.15 g. This tells that there is not big difference between these two media for growing plants, but other medium gives low value. In terms of stem diameter in table 4.3 showed that stem diameter is highest value that is 3.04 mm, in media peat only, but if look at the media include both peat and vermiculite (1:1) which is 3.02 mm. That found the media also included peat. However, in media which include coconut coir with perlite found low value which is 2.46 mm in stem diameter due to coir was less acidic than peat and it had higher EC. Both coir and peat exhibited similar organic matter and mineral content as cited by Abad et al. (1992).

According to Vavrina et al. (1996), the water holding ability of the coir material may be disadvantages in fall tomato production as plant height control is a major concern of growers. A media with high water holding ability can support longer intervals without irrigation.

The effect of different growing media on root length and seedling height, the analysis Data shows that used treatments had a significant effect on evaluated root length and seedling height (Table 4.1). The grates and lowest root length observed in organic culture or organic media and inorganic media respectively. The Root length received the maximum value in media which is (peat + pelleted clay 1:1) is 12.94 cm and minimum value in media (Rock wool) is 7.85 cm with mixed composed (coconut coir + perlite + vermiculite 1:1:1) is 8.68 cm. The seedling height received the maximum value in media composed (peat + perlite+ vermiculite) 6.19 cm. And minimum value in (pelleted clay and Rock wool) 5.75 and 7.68 cm respectively due to the less nutrient in media and porosity with water holding capacity. Generally, the highest and the lowest root length were in organic media substrates (peat and coconut coir) due to more nutrients and high capacity of water retention and aeration (Noguera et al. 2003).

Table 4.7 showed the effect of different growing media on leaf number and leaf area of pepper. The significant difference between the treatments peat media only received the maximum leaf number (7.43). But pelleted clay and coconut coir achieved minimum number of leaf number this is rejected to fertile compared with (pelleted clay) and (coconut coir + perlite) 5.35 and 5.93 (respectively). So the leaf area was affected by media of growth it have a significant difference which is better treatments. Vavrina et al. (1996) state that coconut pith is available in big quantities as well as by the product of coir industry also coir was contain similar parts of lignin and cellulose and is contain potassium and the micro nutrient as Fe, Mn, Zn and Cu due to the higher potassium contained in the media coconut reduction in potassium fertilization has been shown to produce useful results Savithri et al. (1993).

Growing media number 6 (peat + vermiculite) received maximum value to leaf area 73.33 cm^2 and (Rockwool and pelleted clay) received minimum value from media number 4 and 3 is 22.12 cm^2 and 31.48 cm^2, respectively (Table 4.7). However, there was no better difference between (peat + perlite +vermiculite; 1:1:1, and 1:1:2) and the peat media only it is showed the treatments are containing peat substance obtained high value due to peat media has a rich nutrient and high water holding capacity (Kashmanian and Rynk 1995).

It can be seen clearly the data analysis in Table 4.8 showed the effect of growth media on stem diameter value in pepper. The growth media containing (peat + vermiculite) affected significantly stem diameter which is 2.32 mm that received high value, also may be contain high elements and high porosity with exchange gas and ions and exchange capacity but the media (Rockwool and pelleted clay) is 1.76 and 1.84 mm, received minimum value. It may be low fertility and less position of ion exchange capacity. So the chlorophyll content in plant affected by growth media and it has significant in media (peat + pelleted clay) which is 37.48 SPAD, received high and minimum value from media (coconut coir only) 32.87 SPAD also maybe different cation exchange capacity and neutral pH (Gianquinto 2005).

Table 4.9 shows the effect types of media growth on shoot fresh weight and shoot dry weight the (peat + perlite + vermiculite) received maximum value that is 1.83 g and received minimum value which is 0.55 g in media (pelleted clay) if compared with other media and it had a significant deferent between all treatment media . In addition, when the media had more fertility and water holding capacity this lead to had best vegetative growth. The media (Rockwool and pelleted clay) has less shoot fresh weight maybe due to less fertility. It is a well-known fact that organic fertilizers supply nutrients to the plants in adequate amount for optimum growth of plant and may increase the uptake of nutrients, assimilation capacity and the hormonal activity (Grappelli et al. 1985). The shoot dry weight decreases by the fertility of media growth. The result showed the significant different between treatment and obtained high and low value in treatment (peat + perlite + vermiculite) and media type (Rockwool and pelleted clay) respectively.

The effect of different media with regards to one of the vital parameter shoot fresh and dry weight. Data analysis given in the Table 4.10 showed the significant difference between growth media treatment on root fresh weight and root dry weight in the media (peat + vermiculite) that is 0.54 and 0.42 g respectively but received minimum value in root fresh weight and root dry weight in the media (rock wool only) is 0.08 and 0.06 g. The averages between growth media compared other media might has received high nutrient and water holding capacity and cat ion exchange capacity. The plant root which can easily be differed growing in media value of root fresh and root dry weight. It might be the rock wool media it has less fertility cat ion exchange and high bulk density it may be because less plant root growth and diffusion penetrate the media. According to Grunert et al. (2008) the plants grown in a pure peat rooted faster and easily that grown in the peat coconut or mineral wool but the total production was similar for the mediums.

This study indicates that peat moss and peat moss with other material in one media can be used as reliable media for growing cultivation tomato and pepper. However, there is some medium (coconut coir only, rook wool only pelleted clay only) which is less nutrient value for plant and the capacity of water holding is differing between these media it might be this cause not growing plants inside the medium well, but if mixes with peat moss will obtain better growing plant. The water holding capacity of the coconut coir substances may be a disadvantage in fall tomato yield as plant height control is a big concern of growers. The maturity of tomato will late in grow in the media contain coir only. This situation of delayed maturity was not seen in pepper Vavrina et al. (1996). In addition, rock wool and perlite are used most as a growing media rock wool is expensive if it is contain peat moss the media will be more expensive.

The perlite was used with peat moss in this study and the result from these two materials was great. The actual water availability in perlite rely on the grade of material used, but coarse perlite holds very little water moreover it is used for rooting the cutting because it has less water but more air capacity (Bunt 1976; Sevgican 1999). The perlite also contain cation exchange capacity and no buffer and essentially nutrient. Nowadays the perlite utilized widely in soil and peat mixes for plant raising (Butt and Varis 2000).

6. CONCLUSION

It can be clear that using different growing media for cultivation of vegetable transplants is important, in particular for the first of growing stage which in this stage the plant depends on the types of media to obtain nutrients. If soil based media used vegetable transplants usually face many problems such as diseases and pests affecting their growth. In addition, utilizing variety of growing media for different plant growing will give different result as in the research illustrated that peat moss media only has may be the greatest value than other media. However, mixed media with peat moss also has the positive impact as well. The reason is refer to many aspects one of them is water holding capacity, PH, EC and other factors such as easily be controlling with easy service. Indeed, my recommendation for anyone to conduct similar research to determine growing better plants and widely using from who working on all plants with scientific research as well using different plants. The best mixture consisted of peat and vermiculite (1:1; v/v) in terms of seedling growth and quality.

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