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Effects of Different Growing Mediums on Nutrient Concentration of Eggplant in Soilless Culture

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Abstract

This study was aimed to determine the effect of some inert and non-inert growing substrates. Fort this, two inert (perlite and volcanic tuff) and three non-inert (used mushroom compost, Coconut fiber and saw dust) growing substrates were used as growing medium. Study was conducted under green house conditions at Suleyman Demirel University, Agriculture Faculty, Soil Science and Plant Nutrition department material in Isparta, Turkey. The experiment was planned according as completely randomized with four replications. Plants were fertigated during the experiment with the solutions containing 135 ppm N, 48 ppm P, 283 ppm K, 128 ppm Ca, 67 ppm Mg, 1.8

ppm Fe, 0.6 ppm Zn, 0.09 ppm Cu, 0.0.5 ppm Mo and 0.5 ppm B. In order to compare nutritional differences of plant grown on different growing medium, leaf N, P, K, Ca, Mg, Fe, Cu, Zn, Mn and B concentrations were determined. Our results indicated that nutrient concentration of plants showed differences depending on the growing medium.

Key words: eggplant, growing mediums, nutrient concentrations, soilless culture

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Introduction

Growing mediums are the materials, other than soils, in which plants are grown. These covers different substances such as organic (peat, compost, tree bark, coconut, sawdust etc.) and inorganic materials (clay, perlite, vermiculite, mineralwool, volcanic tuff, etc.). While these substrates can be used alone, mixtures of the substrates such as peat and perlite; coir and clay, peat and compost (Grunert et al., 2008; Vaughn et al., 2011., Nair et al., 2011) are also be used widely. Growing mediums can be divided two groups as inert and nun-inert substances. Inert substances don't supply any nutrition to the plants so all the nutrition comes from the nutrient solution. You can therefore, easily control everything the plants receive. The EC and pH of the nutrient solution is easy to adjust so that the plants receive the right amount of nutrients. The watering/feeding cycles can be controlled by an inexpensive timer so that the plants get watered on schedule, as needed. Organic substrates with a moderate, or low bio-stability, will release available nutrients, decrease porosity, increase salinity due to mineralization and vary in their chemical properties, such as pH, electrical conductivity (EC) and CEC as a consequence of the decomposition of the substrate's organic matter (Lemaire, 1995).Growing media have some functions such as providing aeration and water, allowing maximum root growth and supporting physically the plant. There are many different materials that have been used for vegetable production. Throughout the world, the raw materials used vary based on their local availability (Schmilewski, 2009). Such raw materials can be inorganic or organic, but growing media are often formulated from a blend of different raw materials in order 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). It is reported that a high percentage of inorganic growing media such as rock wool, sand, perlite, vermiculite, pumice, clays, and others, are used in soilless plant production while only about 12% uses organic growing media such as peat, bark, wood residues (leaf mould, sawdust, barks), coir, bagasse, rice hulls and others (Donnan, 1998., Sawan et al. 1999; Böhme et al., 2001; Böhme et al., 2008). However, there is no growing medium that can be labeled as the "best" since each particular medium has both advantages and disadvantages. Several factors determine the type of growing medium appropriate for specific growing conditions. The importance of growing medium choice, relative to other production factors, needs to be evaluated for hydroponic vegetable production. Several studies have investigated the effect of growing media on the yield of vegetables. However, only a few studies investigated the effects of the growing medium on the quality parameters of the crops and plant nutrient concentrations and uptake

In a study, it was aimed to determine the effect of bark- and peat-amended spent mushroom compost for containerized culture on shrubs growth. For this, four deciduous ornamental shrubs were grown in eight media consisting different composition of sphagnum peat or composted pine bark, sand and spent mushroom compost. According to results it was seen that growth of three species was 20% greater in peat-based than in bark-based, compost-amended media. Also it was indicated that there were variations in leaf macro and micro elemental composition attributable to differences in the media, but all nutrients were present in acceptable levels (Maher, 1991). In a study, Birben et al., (1999) indicated that begonia plant growing in spent mushroom compost had higher N and K comparing to plant growing in peat substrate. In another study, conducted with six different media containing different perlite/cocopeat ratios, it was seen that flower dry weight was higher in higher perlite containing pots, but higher leaf K and Ca concentrations where determined in the plants growing in higher coco peat levels (Lee et al., 1999). Foliar dry weight and N, K, Ca, Mn, Fe, and Mo concentrations differed significantly by medium. And it was indicated that some chemical and physical properties of medium such as cation exchange capacity, nutrient content, water holding capacity etc. can effect plant growth and nutrient concentrations (Rose **&** Haase., 2000). Nurzynski (2005) did not find significant differences in a yield of tomato cultivated in sand, peat and rock wool. Also, leaf N, P, K, Ca and Mg contents did not vary significantly. Dry matter, vitamin C, sugars, as well as N, P, K, Ca, and Mg contents in fruits did not depend significantly on growth medium type. Similarly, Alifar et al. (2010) showed that substrates including peat, coco peat and perlite had no significant difference on concentration of nitrogen, phosphors and potassium in cucumber fruit. According to different studies some phsico-chemical properties of different growing substrates vary with the origin of the materials. Some of them were given in Table 1. Also, Saberi et al. (2006) showed that substrates (mica, rice hull, coco peat, perlite and zeolite) had no significant difference on concentration of phosphorus in fruit. Comparison of means showed that the media had no significant effect on concentration of nutrient elements in fruit such as N, P, K and yield in all treatments.

In this study, it was aimed to research the effect of five organic and inorganic growing media (coco peat, spent mushroom compost, perlite, volcanic tuff and oak sawdust) on nutrient concentrations of eggplant.

Table 1. Some Characteristics of Growing Medium Indicated in Different Literature

Medium	EC	pH	OM	C/N	CEC	N	P	K	Mg	Ca	Fe	Zn	Mn	Cu	Source
Cocopeat	2.9 (ds/m)	6.7		48.5	139 (cmol/kg)	1.96	1.32	478							Ghehsareh, et al., (2011)
						(mg/L)									
Perlite	1.6 (ds/m)	7.8				0.27 (mg/L)	0.57 (mg/L)	0.1 (mg/L)							
Used mushroom compost	10106 (mmhos/cm)	7.3	42 (%)	13.4		1.8	0.57	1.0	1.0	5.4	8550	121	400		Demirtaş et al., (2005)
						(%)						(mg/kg)			
						Total concentrations									
Used mushroom compost	5970 (µmhos/cm)	7.0	63 (%)	16.9		2.11	0.5	2.1			2776	18.5	191	19	Uyanöz et al., (2006)
							(%)				(mg/kg)				
						Total concentrations									
Used mushroom compost	5.7 (ds/m)	7.0	46 (%)		52.5 (me/100g)	2.31	4.36	1.02	450	754	1.57	2.0	1.57	2.85	Çiçek et al., (2012)
						(%)			(mg/kg)						
						Total concentrations				Water soluble concentrations					
Used mushroom compost	12.5 (ds/m)	7.22	47 (%)	17.52	57.9 (me/100g)	2.55	0.40	2.3			3501	97	294	53	Baran et ., (1995)
						(%)					(mg/kg)				
						Total concentrations									
Sawdust						0.91(%)									Horisawa et al., (1999)
Sawdust		5.3		138		0.40 (%)									Dayegamiye & Isfan, (1991)
Sawdust					10-60 (me/100g)										Hershey et al., (1980)

Material and Method

Eggplant seedlings (Solanum melongena L.) cv. Faselis were grown in 1:1 (v/v) peat:vermiculite in polysteyrene trays at the Histhtil Nurseries (Antalya, Turkey). The variety is very popular and suitable for spring season under tunnel and greenhouse production in Turkey. In the study, coco peat, spent mushroom compost, perlite, volcanic tuff and oak sawdust were used as growing media. Oak sawdust was obtained from a forest product company in Isparta-Turkey. It has a pH of 5.0-6.8 which is neutral to slightly acidic. Coco-peat fiber (Gartengold, Sri Lanka) which is pH: 6-6.5 has the ability to store and release nutrient to plants for extended periods of time. Mushroom compost is made from horse manure, straw, chicken manure and gypsum. The spent mushroom compost was obtained Serpil village (Isparta, Turkey) which is very important mushroom produce area. Perlite is a versatile and sustainable mineral. Its unique characteristics of being lightweight, sterile, high water and oxygen capacity. The pH of it is 6.5 and some chemical characteristics are SiO_2: 72.0-74.0 %; Al_2O_3: 11.0-14.0%; Na_2O: 2.30-4.35%; K_2O: 4.0-5.0%; CaO: 0.4-0.8%; Fe_2O_3: 0.5-0.8%; MgO: 0.03-0.2%. Volcanic tuff which possesses a large amount of pores has very high capacity of air. The tuff which is size between 0.3-1.5 cm and pH: 7.5-8.0 was obtained from Suleyman Demirel University, Volcanic Tuff Research and Practice Canter (Isparta, Turkey). Some chemical compositions of tuff are; SiO_2: 52-75 %; Al_2O_3: 11.0-17.0 %: Fe_2O_3: 0.5-5.0; CaO: 1.0-8.0 % ; MgO: 0.5-3.0 %

This experiment was performed under glass greenhouse conditions. Average day and night temperatures in the greenhouse were 28°C and 20°C, respectively. The relative humidity varied between 60% and 70% and the light regimen ranged from 500 to 700 μmol m^{-2} for a 12 h photoperiod. Substrate were put in pillow type 0.050 mm thick inside black and outside white plastic which measured 35x20x10 (length-wide-high) cm (7 L). The packing was done by loosely filling and it set up on bench as horizontal position. The bags were spaced to achieve a density of 3.0 plants m^2. The experimental design was a randomized block design with twelve replicates. The drainage holes were made about 2 cm above the bottom of the bags. Each eggplant seedling was transplanted to a plastic bag which measured containing 7 L of growing medium on 25 May 2011, and was watered every day with top water during the first week. After first week, all the growing media was irrigated with a nutrient solution. Drip irrigation supplied a standard nutrient solution to the plants. The solution contained in ppm: 135 N, 48 P, 283 K, 128 Ca, 67 Mg, 1.8 Fe, 1.8 Mn, 0.6 Zn, 0.09 Cu, 0.05 Mo and 0.5 B. The electrical conductivity of solution was maintained from 1.8 to 2.1 mS $cm^{-}1$. The pH was maintained 5.5 - 6.0. The irrigation was set up according to 30 % drainage. The volume of nutrient solution applied per irrigation varied 310 to 1050 ml per plant.

The plants were irrigated 2 -7 times a day with the same nutrient solution until the end of experiment. Irrigation frequency was based on solar radiation and stage of plant growth in greenhouse. In the middle of the harvest season, leaf samples were collected to determine nutrient concentrations of plants grown in different growing substrates. Before analysis, samples were washed thoroughly with fountain water, dilute acid (0.2 N HCl) and distilled water to remove surface residues, then they were kept at 65±5 C^0 until they dried and were grounded for nutrient analysis. Nitrogen (N) concentration in samples was determined according to Modified Kjeldahl method in which 0.5 g sample was digested in concentrated H_2SO_4 and distilled with NaOH (40%). The ammonium N was fixed in H_3BO_3 (2%) and titrated with 0.1N H_2SO_4. In order to determine Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Iron (Fe), Zinc (Zn), Copper (Cu) and Manganese (Mn) concentrations, 0.5 g of samples were wet digested with microwave digestion unit and filled up to 50 ml with pure water. Phosphorus contents of samples were determined by vanadate-molybdate colorimetric method. Potassium, Ca, Mg, Fe, Zn, Cu and Mn concentrations were determined using atomic absorption spectrophotometer (Kacar & Inal, 2008). Statistical evaluations of the values were made using COSTAT program.

Results & Discussion

Macro Nutrient Concentrations

Effect of growing mediums on leaf N concentrations of tomato was significant ($P< 0.05$). As indicated in Table 2 leaf N concentrations varied between 4.58% and 5.28%. The highest leaf N concentration was found in the leaf tomato growing in perlite substrate, whereas the lowest was in spent mushroom compost.

Table 2. *Effects of Different Growing Mediums on N, P, K, Ca and Mg concentrations of Eggplant*

Mediums	Nutrient concentrations (%)				
	N	P	K	Ca	Mg
Sawdust	4.72 ab	0.52 a	2.68 b	0.74 b	0.20 b
Spent mushroom compost	4.58 b	0.50 a	3.24 a	0.86 ab	0.20 b
Volcanic tuff	4.64 b	0.32 c	2.74 b	0.94 a	0.20 b
Coco peat	4.84 ab	0.50 a	2.68 b	0.80 ab	0.21 b
Perlite	5.28 a	0.40 b	2.40 c	0.94 a	0.26 a
	*	***	***	*	*

***: $P<0.001$, *: $P<0.05$

Effects of sawdust and coco peat and the effects of spent mushroom compost and volcanic tuff on leaf N levels were similar. Leaf P, K, Ca and Mg concentrations were significantly affected by growing mediums (Table 2). As indicated there, leaf P concentrations ranged between 0.32% and 0.52%. While the highest P concentration was determined from the plant growing in organic substrates, the lowest P concentration was determined from the plants growing in inorganic volcanic tuff and followed by perlite. The spent mushroom compost had the highest effect on plant K concentration and the plant growing there had the highest K level (3.24%). The lowest K level vas measured from perlite (2.40%). Effects of the other tree media had similar on leaf K concentration of eggplant. Leaf Ca concentrations obtained from volcanic tuff and perlite where the plants grown in were higher than that the plants growing in other mediums. The highest leaf Ca concentrations obtained from both volcanic tuff and perlite were determined as 0.94%, but lowest leaf Ca concentrations were determined in sawdust as 0.74 %. Magnesium concentration of leaf was divided in two statistic groups. Leaf Mg concentration of eggplant in perlite was higher than that in other substrates.

Micro Nutrient Concentrations

Effect of growing mediums on leaf micronutrient concentrations of plant was found to be significant except for Fe (Table 3). Leaf Cu concentrations of plants obtained from spent mushroom compost and volcanic tuff were higher than that of obtained from other mediums. While the Cu concentrations obtained from Spent mushroom compost and volcanic tuff were in the same statistic group, the other tree mediums took place in another groups in terms of leaf Cu concentrations. Leaf Zn concentrations obtained from different growing mediums changed between 34.0 mg/kg (from perlite) and 56.2 mg/kg (Spend mushroom compost).

Table 3. *Effects of Different Growing Mediums on Fe, Cu, Zn and Mn of Eggplant*

Mediums	Nutrient concentrations (mg/kg)			
	Fe	Cu	Zn	Mn
Sawdust	66.4 a	7.6 b	38.9 b	64.2 b
Spent mushroom compost	69.5 a	11.3 a	56.2 a	115.7 a
Volcanic tuff	65.6 a	10.9 a	37.1 b	73.2 b
Coco peat	64.6 a	8.5 b	35.8 b	44.2 d
Perlite	67.2 a	8.2 b	34.0 b	54.2 c
	ns	***	**	***

***: $P<0.001$, **: $P<0.01$, ns: non- significant

Leaf Mn concentration showed significant differences depending on the each growing mediums. While the lowest Mn concentration was determined from coco peat medium (44.2 mg/kg), the highest concentration (115.7 mg/kg) was determined from spent mushroom compost medium. As seen from the results, growing mediums had different effect on leaf nutrient concentrations generally. While these effect can be seen clearly among some growing medias, there was not certain difference among the others (Nurzynski, 2005; Saberi et al. 2006; Alifar et al. 2010) This can be depended many different physical and chemical characteristic of growth media (Rose & Haase, 2000). If an evaluation was made on the effectiveness of growing mediums on plant nutrient concentrations it was seen that spent mushroom compost had the highest effect on leaf nutrient concentrations. As seen in Table 2 and Table 3 about all nutrients (except N, Ca and Mg) were the highest in the plants obtained from spend mushroom compost medium. And thus, it can be said that spend mushroom compost is more effective substrate for plant for having higher nutrient. This may be explained with the release of available nutrients due to mineralization during growth period (Lemaire, 1995). However the effect of spend mushroom compost on N concentrations, the effect of sawdust on leaf Ca and Cu concentration, the effect perlite on leaf K and Zn concentrations, the effect of volcanic tuff on P concentration and the effect of coco peat on Mn concentrations were lower than other mediums. As conclusion, different growth media had different effects on different nutrient concentrations in egg plant but it is found that all medias used this study can be used as soilless media for eggplant growth.

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