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The Effects of Substrate and Cultivar in Quality of Strawberry

Atefe Ameri*, Ali Tehranifar, Gholam Hossein Davarynejad and Mahmoud Shoor
Ferdowsi University of Mashhad, Agriculture Faculty, Horticultural Sciences Department, Mashhad, IRAN

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ABSTRACT

The investigation was carried out to evaluate the effects of substrate and cultivar on biochemical characteristics of strawberry in soilless culture system. The experiment was conducted in a factorial experiment based on randomized complete design with four replications. Experimental treatments consisted of three strawberry cultivars (Camarosa, Mrak, and Selva) and six substrates (Rice hull, Sycamore pruning waste, Cocopeat + Perlite (50:50), Vermicomposts + Perlite + Cocopeat (5:45:50), (15:40:45), (25:35:40). Results of this experiment showed that the highest percentage of malformed fruits was observed in Selva cultivar in Rice hull (48.46%) and Camarosa cultivar in vermicompost + perlite + cocopeat (25:35:40) (48.46%), the highest of total anthocyanin content in Camarosa in vermicompost + perlite + cocopeat (15:40:45) (222.65 mg/100g), the highest of antioxidant in Camarosa and Mrak cultivars in substrates of Sycamore pruning waste and cocopeat + perlite (50:50) respectively (58.76% and 62% respectively), the highest of TSS in Selva in vermicompost + perlite + cocopeat (5:45:50) (8.66), the highest of Vitamin C in Selva in vermicompost + perlite + cocopeat (15:40:45) (108.05 mg/ 100cc), the highest of TA in Camarosa in vermicompost + perlite + cocopeat (5:45:50) (2.87 mg/100g). Response of each cultivar was different in each substrate. Therefore, the substrate affects on quality of fruit in strawberry and suitable choice of substrate is caused to production of desirable fruit.

Key Words: Mrak, rice hull, sycamore pruning waste, vermicompost

INTRODUCTION

Because of increased demand for more products with high quality and off-season, greenhouse productions are increasing. Soilless media are popularly used in greenhouse crop production because they are relatively lightweight, free from diseases, readily available and more uniform and more suitable for containerization than minerals soil (Yuan et al. 1996). The choice of the substrate should be based on physical characteristics as well as availability, cost (Lieten et al. 2004). There is great variation in pH of the coir growing media with values ranging from 4.8 to 6.9. Generally coir has low P content. Coir also contains significant amounts of micronutrients and these can also vary a great deal. CEC deals are high and are similar to peat (Maher et al. 2008). Tomatoes was grown in coir were better than in Rock wool, particularly under temperature stress, namely 30℃ and 35℃ compared with 25℃ (Islam et al. 2002). Because of quicker root development of tomatoes in coir was caused consequently better yield (Garcia and Deverde 1994, Maher et al. 2008). Strawberry (*Fragaria ×ananassa* Duchense) had grown in coir better than in perlite (Lopez- Medina et al. 2004, Maher et al. 2008). The composting process is the biological decomposition of organic materials under controlled conditions into a stable humus-like product (Golueke 1972, Maher et al. 2008). This process is aerobic and part of it is carried out under thermophilic conditions which it reduces phytotoxicity, pathogens and weed seeds and can be used as soilless growing medium (Maher et al. 2008). Rice hulls, both fresh and decomposed, are often used as an amendment to peat (Papafotiou et al. 2001, Maher et al. 2008). Vermicompost, in contrast to conventional compost is the product of an accelerated biooxydation of organic matter by the use of high densities of earthworm populations without passing a thermophilic stage (Domı´nguez et al. 1997, Subler et al. 1998, Zaller 2007). Ercisli et al. (2005) reported different substrate was effective on growth of strawberry cultivars in order that peat, finpeat or finpeat + perlite gave the best results in terms of above and underground parts of plants in Camarosa and Fern cultivars.

Ors and Anapali (2010) reported soil addition to perlite substrate improved vegetative parameter of strawberry such as length of developed roots and increase fresh root weight. The used substrate consisting (100% Perlite, 10% Soil + 90% Perlite, 20% Soil + 80% Perlite, 30%Soil + 70% Perlite, 40% Soil + 60% Perlite, 50% Soil + 50% Perlite. Caso et al. (2009) reported among of used growing media rice husks (100%) had the highest of yield (496.73 g plant^{-1}) in column system of strawberry which it refers to desirable physicochemical properties for the growth and development of roots. Latigui et al. (2011) used four substrate consisting (100% oil cake, 90% oil cake+ 10% vermiculite, 80% oil cake+ 20% vermiculite, 70% oil cake+ 30% vermiculite) and study them on strawberry plant, was considered 100% oil cake and 90% oil cake gave better condition for the growth of strawberry plant. Jafarnia et al. (2010) reported total soluble solid are influenced substrate and cultivar so that, the highest of values were obtained in Selva in 60% perlite+ 40% peat moss and 80% perlite+20% peat moss

* Corresponding author: atefeameri@yahoo.com

(8.34 and 8.32 respectively) also in this experiment interaction of substrate and cultivar was effective on Total soluble solid.

The objective of this study was to evaluate the use of different substrates for soilless cultivation of strawberries and assess their effects on quality properties.

MATERIALS AND METHODS

The investigation was conducted in 6 Jul. 2010 to 2 Feb. 2011 at the experimental greenhouse of the Agricultural Faculty, Ferdowsi University of Mashhad (latitude 36◦ 16´ N, longitude 59◦36′ E and 985 m elevation), Iran. The experiment was arranged in factorial experiment based on randomized complete design with four replications. Experimental treatments consisted of three strawberry cultivar (Camarosa, Mrak, and Selva) and six growth media

M1= Rice hull
M2= Sycamore pruning waste
M3= 50% cocopeat +50% perlite
M4= 5% vermicomposts + 45% perlite + 50% cocopeat
M5= 15 % vermicomposts + 40% perlite + 45% cocopeat
M6= 25% vermicomposts + 35% perlite +40% cocopeat
Day/ night temperature was 22/17. Growth media were prepared based on volume. (Volume of growth media were 2500-2800 cm^3) Roots were put in fungicides (mancozeb and captan) for 5 seconds before planting.
The hydroponic system was soilless and the nutrition system was open. Nutrient solution containing NH_4, Ca, Mg, NO_3, SO_4, H_2PO_4 and K with 9, 110, 24, 62, 198, 121.25 and 204.75 ppm nutrient solution containing Fe, Mn, Zn, B, Cu and Mo with 1.12, 0.55, 0.26, 0.22, 0.048 and 0.048 ppm (Kerej et al., 1999) were used based on 100-250 ml $plant^{-1}$ day^{-1} depending on growth stage. The pH and EC of nutrient solution were adjusted to 5.7 and 0.9-1.4 dS m^{-1}, respectively. Several factors as the most important indicators of vegetative and reproductive traits were recorded. Physical characteristics of different substrates were calculated (Verdonck and Gabriels, 1992). pH and EC was measured from watery extraction (1:10) at the beginning and end of cultivation of strawberry (Table 1). Measured factors consisted of titratable acidity, anthocyanin, antioxidant, Vitamin C, total soluble solids and percentage of malformed fruits.

Table 1. Substrate analyses at the beginning and at the end of strawberry cultivation.

Substrate	pH		EC	
	Initial	Final	Initial	Final
Rice hull	7.10	7.22	0.83	0.11
Sycamore pruning waste	7.46	7.55	0.65	0.55
50% cocopeat: 50% perlite	7.22	7.46	1.32	0.84
5% vermicomposts: 45% perlite: 50% cocopeat	7.15	7.22	1.95	1.5
15 % vermicomposts: 40% perlite: 45% cocopeat	7.12	7.29	2.43	1.98
25% vermicomposts: 35% perlite: 40% cocopeat	7.52	7.66	2.73	2.22

Determination of anthocyanin

Total anthocyanin content was determined by the pH differential method (Bacchella et al. 2009). An aliquot of strawberry extract (1 ml) was diluted up to 10 ml with pH 1.0 solution (125 ml of 0.2 M KCl and 375 ml of 0.2 M HCl). A second aliquot (1 ml) was diluted up to 10 ml with a pH 4.5 buffered solutions (400 ml of 1 M CH_3CO_2Na, 240 ml of 1 M HCl, and 360 ml of H_2O). Absorbance of the solution was measured by spectrophotometer at 510 nm and the concentration of anthocyanins was calculated by the following equation:
$C mg/100\ g = [(AbspH1.0 – AbspH4.5) \times 484.82 \times 1000/24825] \times DF$
Where the term in parentheses is the difference of absorbance at 510 nm between pH 1.0 and pH 4.5 solution, 484.82 is the molecular mass of cyanidin-3-glucoside chloride, 24825 is it molar adsorptivity (ε) nm in the pH 1.0 solution, and DF is the dilution factor.

Determination of antioxidant activity

Determination of antioxidant activity was done by 1, 1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging activity (Brand-Williams et al., 1995). To 3.9 mL methanolic DPPH solution (0.004%, w/v), 0.1 mL of methanolic extract at various concentrations was added, mixed thoroughly and left in a dark place. After 30 min the absorbance was read at 517 nm against control without the extract. DPPH radical scavenging activity was obtained with the following equation:

Radical scavenging activity (%) = $(A_0 - A)/A_0 \times 100$
A_0 is control absorbance and A is sample absorbance.

Total soluble-solids were determined by refractometer model Erma, Tokyo, Japan (AOAC, 1998). Acidity was determined by titration of fruit juices with 0.3 N NaOH and was expressed as mg citric acid in 100 g fruit fresh weight (AOAC, 1984). Vitamin C was determined based upon the quantitative discolouration of 2, 6-dichlorophenol indophenols (Merck KgaA, Darmstadt, Germany). Titrimetric method as described in AOAC methodology No. 967.21 (AOAC, 2000). Data were analyzed using SAS 9.1 and means were compared by LSD test at 5% level of confidence.

RESULTS AND DISCUSSION

Analysis of variance showed that the effect of substrate, cultivar and interaction between substrate and cultivar in all measured factors were significant (Table 2). The substrate had different effects on quality properties. The highest of total anthocyanin content was observed in M5. The highest of free radical scavenging activity was obtained in M3. M6 had highest of percentage of malformed fruits while the highest of TA was observed in M1. The highest of vitamin C was observed in M1, M5, and M6. M4 had the highest of total soluble solid content (Table 3). The highest of anthocyanin was related to Camarosa, its lowest was related to Mrak and Selva. Mrak cultivar had the highest of Free radical scavenging activity and percentage of malformed fruits. The highest of Vitamin C were observed in Selva. Camarosa and Mrak cultivars had the highest of TA. The highest of TSS was observed in Selva and Camarosa cultivars (Table 4). The highest of free radical scavenging activity was observed in Camarosa cultivar in M2 and Mrak cultivar in M3. The highest of total anthocyanin content was observed in M5 (Table 5). The highest of percentage of malformed fruits was observed in Selva cultivar in Rice hull substrate (48.46%) and Camarosa cultivar in vermicompost + perlite + cocopeat (25:35:40) substrate (48.46%). The highest of TA was related Camarosa cultivar in M4. The highest of Vitamin C content was related to Selva in M5. The highest of TSS was obtained in Selva cultivar in M4 (Table 6). The highest of anthocyanin content was related to Camarosa cultivar in M5. (Table 5) M5 had the lowest pH (Table 7). Results of physical and chemical properties of substrate showed the highest of pH, EC and bulk density was related to M6 and the lowest EC and Bulk density was related to M2 and M1 respectively while M6 had the lowest of porosity and the highest of porosity was related to M1, M3 had the highest of particle density and inorganic material and the lowest were observed in M2. The highest of organic material was observed in M2 and the lowest of organic material was related to M3 (Table 7).

Table 2. Analysis of variance of the traits under study

Source of variation	df	M.S					
		Total anthocyanin content (%)	**Free radical scavenging activity (%)**	**Malformed fruits (%)**	**TA**	**Vitamin C**	**TSS**
Substrate	5	7551.57 **	434.95 **	743.23**	0.68 **	468.06 **	1.66 **
Cultivar	2	1690.82 **	115.48 *	234.70.234 **	0.25 **	317.19 **	1.90 **
Substrate × cultivar	10	6806.84 **	312.88 **	756.43**	0.91 **	1359.2 **	2.90 **
Error	36	277.13	32.65	6.89	0.03	9.52	0.29

NS, *,** Nonsignificant or significant at $P = 0.05$ or 0.01, respectively

Table 3. Effect of substrate on biochemical properties of strawberry.

Treatment	Total anthocyanin content (mg/100g)	Free radical scavenging activity (%)	Malformed fruits (%)	TA	Vitamin C	TSS
Rice hull	64.70 bc	42.87 b	24.88 d	2.68 a	66.23 a	6.77 bc
Sycamore pruning waste	54.15 cd	44.84 b	25.45 d	2.19 b	52.57 bc	6.22 d
50% cocopeat: 50% perlite	75.53 b	52.96 a	29.66 c	2.02 bc	49.70 c	6.33 cd
5% vermicomposts: 45% perlite: 50% cocopeat	46.27 d	44.84 b	25.65 d	2 c	54.65 b	7.33a
15 % vermicomposts: 40% perlite: 45% Cocopeat	119.62 a	31.33 c	34.19 b	1.95 c	63.66 a	7.11 ab
25% vermicomposts: 35% perlite: 40% cocopeat	39.54 d	43.66 b	36.97 a	1.99 c	65.32 a	6.77 bc

Different letters indicate significant difference between treatments at 5% levels in each column

Table 4. Effect of cultivar on biochemical properties of strawberry

Treatment	Total anthocyanin content (%)	Free radical scavenging activity (%)	Malformed fruits (%)	TA	Vitamin C	TSS
Camarosa	77.54 a	40.95 b	26.28 b	2.16 a	55.91 b	6.88 a
Mrak	58.98 b	46.01 a	34.63 a	2.24 a	56.63 b	6.38 b
Selva	63.39 b	43.29 ab	27.65 b	2.01 b	63.52 a	7.0 a

Different letters indicate significant difference between treatments at 5% levels

Table 5. Effect of substrate and cultivar on Free radical scavenging activity and Total anthocyanin content.

Treatment		**Free radical scavenging Activity (%)**	**Total anthocyanin content (mg/100 g)**
Substrate	**Cultivar**		
Rice hull	Camarosa	49.00 bcde	21.66f g
	Mrak	46.43 cdef	69.43 de
	Selva	33.20 hi	103.03 b
Sycamore pruning waste	Camarosa	58.76 a	43.35 ef
	Mrak	37.00 fghi	58.95 de
	Selva	38.76 fghi	60.16 de
50% cocopeat: 50% perlite	Camarosa	40.90 efgh	62.66 de
	Mrak	62.00 a	98.57 bc
	Selva	56.00 ab	65.37 de
5% vermicomposts: 45% perlite: 50% cocopeat	Camarosa	35.53 ghi	31.28 fg
	Mrak	54.76 abc	42.08 ef
	Selva	44.23 defg	65.46 de
15 % vermicomposts: 40% perlite: 45% Cocopeat	Camarosa	30.10 i	222.65 a
	Mrak	29.56 i	64.16 de
	Selva	34.33 hi	72.07 cd
25% vermicomposts: 35% perlite: 40% cocopeat	Camarosa	31.43 i	83.62 bcd
	Mrak	46.33 cdef	20.73 fg
	Selva	53.23 abcd	14.28 g

Different letters indicate significant difference between treatments at 5% levels

Table 6. Effect of substrate and cultivar on biochemical properties of strawberry.

Treatment		**Malformed fruits (%)**	**TA**	**Vitamin C**	**TSS**
Substrate	**cultivar**				
Rice hull	Camarosa	13.61gh	2.80 ab	53.14 f	6.00 cde
	Mrak	12.58 gh	2.65 abc	59.55 e	6.66 c
	Selva	48.46 a	2.57 abcd	86.00 b	7.66 b
Sycamore pruning waste	Camarosa	30.79 d	2.09 fgh	53.74 f	5.66 de
	Mrak	12.07 h	2.19 fgh	66.83 d	6.33 cd
	Selva	33.5 cd	2.29 defg	37.15 i	6.66 c
50% cocopeat: 50% perlite	Camarosa	36.13 c	1.17 k	42.60 h	6.66 c
	Mrak	29.99 d	2.35 def	53.55 f	6.66 c
	Selva	22.87 d	2.55 bcde	52.95 f	5.66 de
5% vermicomposts: 45% perlite: 50% cocopeat	Camarosa	47.44 a	2.87 a	64.29 de	6.66 c
	Mrak	16.73 fg	1.95 hi	50.16 fg	6.66 c
	Selva	12.68 gh	1.17 k	49.50 fg	8. 66 a
15 % vermicomposts: 40% perlite: 45% Cocopeat	Camarosa	44.69 ab	2.35 cdef	45.70 gh	8.00 ab
	Mrak	44.68 ab	2.06 fgh	37.23 i	6.66 c
	Selva	13.21 gh	1.43 jk	108.05 a	6.66 c
25% vermicomposts: 35% perlite: 40% cocopeat	Camarosa	48.46 a	1.68 ij	76.00 c	8.3 ab
	Mrak	42.25 b	2.26 efg	72.51c	5.33 e
	Selva	20.2 ef	2.04 gh	47.45gh	6.66 c

Different letters indicate significant difference between treatments at 5% levels

Table 7. Physical and chemical characteristics of different substrate

Substrate	**PH**	**EC Ds/m**	**Porosity (%)**	**Bulk density (g/cm^3)**	**Particle density (g/cm^3)**	**Organic material (%)**	**Inorganic material (%)**
Rice hull	7.10	0.83	95.7	0.079	1.82	59.94	40.05
Sycamore pruning waste	7.46	0.65	95.10	0.086	1.74	68.69	31.30
50% cocopeat: 50% perlite	7.22	1.32	93.40	0.141	2.11	36.24	63.75
5% vermicomposts: 45% perlite: 50% cocopeat	7.15	1.95	90.61	0.194	2.04	38.75	61.25
15 % vermicomposts: 40% perlite: 45% Cocopeat	7.12	2.43	87.44	0.253	1.98	42.66	57.34
25% vermicomposts: 35% perlite: 40% cocopeat	7.52	2.73	84.11	0.304	1.94	47.88	52.12

Jafarnia et al. (2010) reported Total soluble solid are influenced substrate and cultivar which is in agreement to result of this experiment. The highest of titrable acidity was observed in M1, it refers to this substrate had the lowest pH. Some of the quality properties such as vitamin C and titrable acidity were highest in rice husks substrate. Caso et al. (2009) used rice husks and pumice with different ratio in column system for production of strawberry. They recommended rice husks (100%) substrate in the majority of the measured traits was best.

The quantity of total soluble solids in the investigated cultivars ranged from 5.3 to 8.6%. Voca et al. (2008) reported that, range their TSS from 5.2 to 10.4 %. In the research of Testoni et al. (2006) the quantity of total soluble solids for Marmolada cultivar ranged from 5.8 to 7.5 % and for Miss Cultivar from 8.6 to 9.6 %. Hansawasdi et al. (2006) reported Vitamin C content was from 52.25 to 53.21 mg. Laugale and Bite, (2006) reported 38.4 to 72.1 mg per 100 g of fresh mass, depending on the cultivar. Titratable acidity content was 6.02 to 9.73(g/kg) in ripe fruits (Kafkas et al. 2007) while TA of the fruits was range (0.31 to 0.36) (Spayed and Morris 1981). Titratable acidity gradually declined during ripening. So content of TA was in different reports and in recent experiment ranged in 1.17 to 2.87 which it can be because of no completely ripening of fruits. Strawberries contain high levels of antioxidant compounds such as anthocyanins, and Phenolic acids, which provide protection against harmful free radicals. Content of Phenolic compounds, especially anthocyanin depend on substrate pH (Schmitzer and Stampar, 2009). The highest of anthocyanin content was related to Camarosa cultivar in M5 (Table 5). M5 had the lowest pH (Table 7). Lopes da Silva et al. (2007) reported: Total anthocyanins would range between 200 and 600 mg kg^{-1} fresh weight.

The results of pH and EC concurred with those observed by Melgar-Ramirez and Pascual-Alex (2010). At the beginning of cultivation increased the EC values above optimal range. Leaching caused by fertigation or irrigation reduced EC of the substrate down which it is similar to Altieri et al. (2010). The substrate, a medium in which roots can grow, also serves as physical support for plants. It can be constituted of pure materials or mixtures. An adequate substrate for plant growing must present high water retention capacity, fast water drainage, and appropriate aeration. These characteristics are directly influenced by the substrate's particle size distribution and bulk density (Ansorena 1994, Fernandes and Corá 2004). Porosity affects the balance between water and air content for each moisture level (Raviv et al. 1986). In general, increasing the bulk density value decreased total porosity and increased remaining water. The result of this experiment is similar to Khalighi and Padasht-Dehkaee (2000), Fernandes and Corá (2004). The highest of EC of substrates was related to vermicompost + perlite + cocopeat (25:35:40) which was caused the highest of malformed fruits (36.97 %) also highest percentage of malformed fruits was observed in interaction effect Selva and rice hull due to its low bulk density and low water holding capacity on the other hand Selva is day neutral cultivar so it has high production fruit and high requirement to nutrient solution. Also Camarosa in vermicompost + perlite + cocopeat (25:35:40) have high percentage of malformed fruits which have no significant difference with selva in rice hull. The reason of it refers to high EC of that substrate.

CONCLUSIONS

In this experiment, we have been looked for introduction suitable substrate for strawberry. Today, investigations are increasing on substrate. We expect result of this investigation will be useful step for improvement of future researches. Used substrates in this experiment had different chemical and physical characteristics so, were caused different biochemical characteristics in fruits of each substrate such as, substrates with lower pH have high titrable acidity. Also response of each cultivar was different in each substrate. Therefore, the substrate affects on quality of fruit in strawberry and suitable choice of substrate is caused to production of desirable fruit.

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