EFFECTS OF VARIOUS ORGANIC SUBSTRATES AND NUTRIENT SOLUTION ON PRODUCTIVITY AND FRUIT QUALITY OF STRAWBERRY 'SELVA' (*Fragaria* × *ananassa* DUCH.)

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A B S T R A C T

To investigate the interaction of organic substrates and fertilizers on productivity and quality of strawberry (*Fragaria* × *ananassa* Duch. 'Selva'), the experiment was conducted as a complete randomized design with four different organic media (S1; Persian turpentine trees leaf mold (50%) + mineral soil (50%), S2; oak leaf mold (50%) + mineral soil (50%), S3; cypress leaf mold (50%) + mineral soil (50%) and S4; liquorice processing wastes (50%) + mineral soil (50%)), three levels of complete fertilizer (0, 0.5 and 1 g L^{-1}) and five replications. The results showed that plants grown in S4 had highest numbers of floral buds, fruit yield and shoot and root fresh and dry weights. Vitamin C content was the greatest in S3 substrate. The interaction of substrates with nutrient solution did not show considerable increase in productivity and quality of strawberry. In the most cases, plant grown in organic media without fertilizer, had highest measured traits.

Key words: organic substrate, fertilization, strawberry, fruit productivity, fruit quality

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) is a fruit plant that grows in a wide range of environments (Galletta and Bringhurst, 1990). It can be grown successfully in different parts of Iran, where more than 20,000 tones of strawberries is produced each year (Eshghi et al., 2007).

Fruit yields of strawberry cultivars depend on soil fertility and water availability during growing season. Therefore, to obtain uniform high yield of good quality fruits it is essential to provide adequate nutrients for proper plant nourishment (Sharma, 2002). In the last decades more attention has been paid to developing organic farming and to minimizing the use of inorganic fertilizers. At present large quantities of organic residues are available which can be used in agriculture.

A list of organic wastes has already been reported in Spain for potted plants (Abad et al., 2001). An inexpensive and nutrient-rich organic media can reduce fertilization need, irrigation and nursery costs (Wilson et al., 2001). So, these substrates can be used noticeably in organic culture of agricultural crops. For that reason it has been decided to start using several types of leaf molds and liquorice processing wastes in the preparation of substrates for strawberry cultivation.

Thousands tons of leaf mold are produced per year at Zagros mountainous forests in South-Western Iran that can used by local farmers. Similarly, large quantities of liquorice processing wastes are available which farmers normally use to improve soil texture. These wastes can be purchased at low price. These agricultural wastes must be properly disposed so as not to create environmental problems.

So far, wide range of organic material including pine bark, leaf mold, sewage sludge, cocopeat, rice hull and others are reported being used for agriculture crops (Chen et al., 1988; Cull, 1981; Verdonck and Gabriels, 1992). Coir has been tested as a horticultural medium for several ornamental and agronomic crops with acceptable results (Cresswell, 1992; Evans et al., 1996; Meerow, 1994; Pill and Ridle, 1998). Increase in yield and fruit total soluble solids content has been reported in tomato when used either coconut coir or perlite plus carbonized rice hull as a growth substrate (Inden and Torres, 2004). Salvador and Minami (2004) reported that pine bark + earth worm humus substrate showed to be inadequate to Lisianthus cultivation. According to Parks et al. (2004), there was no significant effect of coir, sawdust, rock wool, perlite as substrate on plant dry weight, cucumber number, cucum-ber weight or on the fruit quality. Beneficial effects of mixtures of cotton gin trash compost and rice hulls as growing medium have been shown for some ornamentals (Papafotiou et al., 2001).

Recently, use of factory wastes has been expanded (Saviozzi et al., 1994; Tripepi et al., 1996; Baran et al., 1998). To recycle and reclaim solid wastes and various organic residues produced in agriculture, livestock farming, forestry and, industry are being successfully used as container media for ornamental plant production (Verdonck, 1988). Kütük et al. (2003), investigated the effect of brewery sludge on growth of sugar beet and found that it increased leaf and root yield, sugar content and refined sugar yield. Barbiris et al. (1988) made several experiments with encouraging result on container-grown olive trees, using several types of wastes. Tattini et al. (1990) used grape-urban sludge on container-grown olive trees.

The aim of this study was to compare four natural organic substrates on productivity and quality of strawberry of fruits in order to reduce inorganic fertilizers application.

MATERIAL AND METHODS

Experimental substrates

The experiment was arranged in a complete randomized block design with twelve treatments and five replicates. The treatments consist of mixture of four organic substrates and mineral soil and three levels of nutrient solution.
The compared substrates were:

S1: Persian turpentine trees leaf mold (50%) + mineral soil (50%).
S2: oak leaf mold (50%) + mineral soil (50%).
S3: cypress leaf mold (50%) + mineral soil (50%).
S4: liquorice processing wastes (50%) + mineral soil (50%).

The leaf molds used in this experiment were collected from Zagros mountainous forests located in Shoorab area in South of Shiraz, Iran. The liquorice processing waste was obtained from liquorice processing factory in Zarghan, North-Eastern of Shiraz.

The mineral soil used was sandy loam, pH 7.8, with available K content 250 mg kg^{-1} dry weight, available P content 27.5 mg kg^{-1} dry weight, total N content 0.14%, organic C content 1.4%, CEC (cation exchange capacity) 14.2 meq/100 g, EC (electrical conductivity) 1.5 dS m^{-1}, bulk density 1.3 g cm^{-3}, total pore space 50.94% and easily available water 28%.

Substrates physical and chemical properties

Substrate's bulk density (BD), particle density (PD), total pore space (TPS) and easily available water content (EAW) were measured by Verdonck and Gabriels (1992) methods.

pH and electrical conductivity (EC) was measured in soil/water suspension 1:5 (v/v). The organic carbon (OC) was measured by dichromate oxidation method according to Nelson and Sommers (1982). Cation exchange capacity (CEC) was determined using sodium acetate (NaOAc) at pH 8.2 (Chapman, 1965). Nitrogen was analyzed by Kjeldahal method, phosphorus spectrophotometrically and potassium by flame photometry.

Plant material and growth conditions

Cold stored rooted runners of strawberry (*Fragaria* × *ananassa* Duch. 'Selva') were planted on 10

March 2007 in plastic pots filled with 2 kg of mixture of substrates as above and mineral soil and then placed in a greenhouse under natural day length and average day and night temperatures 28 and 20°C, respectively. After the establishment of plants, they were fertilized fortnightly with a nutrient solution (Melspray) at concentrations 0, 0.5 and 1 g l^{-1}. The relative humidity varied between 55 and 60%. The plants were watered as needed. Yellow sticky glue traps were used to monitor insect population. During the experiment, the number of floral buds, primary fruit weight and fruit yield were measured. Total soluble solids content in the juice was determined using refractometer. Vitamin C content was determined by indophenol method. At termination of the experiment, roots were washed and plants were divided into shoot and root parts, weighted and then dried (at 70°C for 48 h) and finally shoot and root dry weights were measured.

Statistical analysis was performed using MSTATC and SPSS softwares. Means were compared using Duncan's multiple range tests at $p = 0.05$.

RESULTS

Chemical and physical properties of the substrates

The physical and chemical properties of the media are shown in Tables 1 and 2. Organic carbon (OC) content was the highest in S4 substrate and the lowest in S3. There were no significant differences in OC content between S1 and S2. Cation exchange capacity (CEC) of all potting media was very high. The highest value was 61.22 meq 100 g^{-1} for S4 and the lowest was 51.49 meq 100 g^{-1} for S1. There were no significant differences in pH between substrates, except for S1 for which it was the lowest. The electrical conductivity (EC) was the highest (2.4 dS m^{-1}) in S4 substrate and the lowest in S3 (1.5 dS m^{-1}). S4 had bulk density significantly lower than the rest of the substrates. On the contrary, particle density was the lowest in S3. Similarly, S3 had the lowest total porosity. The easily available water (EAW) content was significantly higher in S2 then in the other substrates. Substrates' mineral content were within acceptable range. There were no significant differences in nitrogen (N) content between treatments except for S3. S2 had higher phosphorus (P) and potassium (K) than other substrates.

Effect of nutrient solution and substrate on productivity and quality fruits

The number of floral buds was significantly on plants greater grown in S4 and S3 substrates (Tab. 3). But, the better result was obtained in interaction S4 with 0 and 0.5 g l^{-1} nutrient solution and also S3 with 0 g l^{-1} concentration, Strawberry plants grown in S2 had the highest primary fruit weight when compared with these grown in other substrates (Tab. 3). The interaction of S2 and 0.5 g l^{-1} nutrient solution increased mean fruit weight up to 13.61 g. In all substrates, except for S1, strawberry yield was high and there were no significant

Table 1. Physical properties of different media

Medium	Particle density (PD) [g cm^{-3}]	Balk density (BD) [g cm^{-3}]	Total porosity (TPS) [%]	Easily available water (EAW) [%]
S1	2.35 b*	0.55 a	76.59 b	15 b
S2	2.54 a	0.54 a	78.74 b	21 a
S3	2.01 c	0.56 a	72.14 c	16 b
S4	2.42 b	0.39 b	83.88 a	14 b

*Means within the column followed by the same letter are not significantly different at $p \leq 0.05$

Table 2. Chemical properties of different media

Medium	pH	EC [dS m^{-1}]	CEC [meq 100 cm^{-3}]	Organic carbon [%]	N [%]	P [mg Kg^{-1}]	K [mg Kg^{-1}]
S1	6.9 b*	1.66 c	51.49 d	10.41 b	3.1 a	61.3 b	120 c
S2	7.2 a	1.91 b	53.98 c	9.92 b	2.4 ab	75 a	200 a
S3	7.3 a	1.5 d	57.07 b	8.19 c	1.88 b	74 a	175 b
S4	7.1 ab	2.4 a	61.22 a	13.42 a	3.27 a	56 c	120 c

*Means within the column followed by the same letter are not significantly different at $p \leq 0.05$

differences among them (Tab. 3). Highest yield was obtained in S3 substrate without supplementary fertilization. Similarly, vitamin C content was the highest in fruits grown in S3 (Tab. 3). The shoot and root fresh weights were significantly greater in S4 than in other substrates (Tab. 4). Also, S4 substrate without supplementary fertilization had highest shoot and root fresh weights. Similar results were obtained on the shoot and root dry weights (Tab. 4).

Relationships between media properties and plant productivity and fruit quality indices

The correlation coefficients of substrate properties with fruit productivity and quality indices are shown in Table 5. Primary fruit weight had a positive and significant correlation with pH, phosphorus and potassium of the substrates. Fruit quality was controlled by organic carbon (%) and EC. Also, shoot and root fresh and dry weights had a positive and significant correlation with organic carbon (%), CEC, EC and nitrogen and a negative and significant correlation with phosphorus and potassium of substrates.

DISCUSSION

The number of floral buds, yield and shoot and root fresh and dry weights of plants were greater in S4 than in other substrates (Tab. 3, 4). The physical and chemical characteristics of S4 are in the range

Table 3. Interaction of different substrates and fertilizations on the numbers of floral buds, primary fruit weight (g), fruit yield (g), vitamin C (mg 100 g^{-1} f.w.) of strawberry

Treatment		Numbers of floral buds	Primary fruit weight [g]	Fruit yield [g]	Vitamin C [mg 100 g^{-1} f.w.]
Media	Nutrient solution [g l^{-1}]				
	0	1.25 c*	6.25 g	30.45 d	63.6 e
S1	0.5	3 b	10 cde	46.50 c	60 f
	1	1 c	8 f	30.50 d	62 ef
	0	3 b	11 c	48.93b c	82.8 b
S2	0.5	1.6 c	13.61 a	48.14 c	38.4 g
	1	2.8 b	12.6 ab	44.35 c	27.6 h
	0	4 a	12.57 ab	56.98 a	88.8 a
S3	0.5	3 b	9.33 def	43.50 c	70.2 d
	1	3 b	11.36 bc	50.66 abc	79 c
	0	4.2 a	8.63 ef	46.20 c	18 i
S4	0.5	4.2 a	10.08 cd	56.08 ab	40.8 g
	1	3 b	11.36 bc	51.04 abc	88 a
Means					
S1	▼	1.75 C	8.08 D	35.82 B	61.87 B
S2	▼	2.47 B	12.40 A	47.14 A	49.6 C
S3	▼	3.33 A	11.09 B	50.38 A	79.33 A
S4	▼	3.8 A	10.03 C	51.11 A	48.93 C
0 (g l^{-1})	▼	3.11 A	9.61 B	45.64 AB	63.3 A
0.5 (g l^{-1})	▼	2.95 A	10.76 A	48.56 A	52.35 B
1 (g l^{-1})	▼	2.45 B	10.83 A	44.14 B	64.15 A
Significance	▼				
Media [M]	▼	**	**	**	**
Nutrient Solution [NS]	▼	**	**	*	**
[M] x [NS]	▼	**	**	**	**

*, **significant at p = 0.05 and 0.01, respectively

acceptable for strawberry cultivation (Tab. 1, 2). In all substrates except for S4, bulk density values were high. High bulk density values have the disadvantage of increasing the transportation costs and reducing porosity and air capacity (Corti et al., 1998) (Tab. 1). Decreased bulk densities were associated with increased root growth (Abu-Hamdeh, 2003) (Tab. 5). Decreased cotton root growth in a soil with high bulk density was reported by Taylor and Gardner, in 1963. On the other hand, optimum plant yield and growth are dependent on optimum root growth (Abu-Hamdeh, 2003). Table 5 was shown a negative and significant correlation for shoot fresh and dry weights and substrates bulk density.

Table 4. Interaction of different substrates and nutrient solution on fresh shoot weight (g), fresh root weight (g), dry shoot weight (g), dry root weight (g) of strawberry

Treatment		Fresh shoot weight [g]	Fresh root weight [g]	Dry shoot weight [g]	Dry root weight [g]
Media	Nutrient solution [g l^{-1}]				
S1	0	50.77 de*	32.87 bc	7.93 c	8.55 b
	0.5	51.2 de	32.1 bc	8.58 c	7.18 bc
	1	56.50 cd	28.25 c	9.54 c	7.10 bc
S2	0	48.62 de	26.86 c	8.30 c	5.68 c
	0.5	54.50 cd	26.70 c	7.92 c	5.40 c
	1	65.88 b	27.78 c	9.38 c	6.33 c
S3	0	45.04 e	33.36 bc	7.19 c	6.86 bc
	0.5	56.57 cd	33.60 bc	8.88 c	7.49 bc
	1	63.36 bc	33.40 bc	9.35 c	7.39 bc
S4	0	90.36 a	47.72 a	14.99 a	11.73 a
	0.5	71.06 b	33.24 bc	12.24 b	6.71 bc
	1	85.40 a	37.94 b	14.12 ab	8.46 b
Means					
S1	▼	52.82 B	31.07 BC	8.68 B	7.61 B
S2	▼	56.33 B	27.11 C	8.53 B	5.80 C
S3	▼	54.99 B	33.45 B	8.44 B	7.25 B
S4	▼	82.27 A	39.63 A	13.78 A	8.97 A
0 (g l^{-1})	▼	58.70 B	35.20 A	9.57 A	8.20 A
0.5 (g l^{-1})	▼	58.33 B	31.41 A	9.41 A	6.70 B
1 (g l^{-1})	▼	67.78 A	31.84 A	10.60 A	7.32 AB
Significance	▼				
Media [M]	▼	**	**	**	**
Nutrient solution [NS]	▼	**	NS	NS	**
[M] x [NS]	▼	**	NS	NS	**

NS, *, **non-significant, significant at p = 0.05 and 0.01, respectively

Increased root growth may also have affected mineral element uptake (Preusch et al., 2003). The positive and significant correlation was obtained of media nitrogen content with fresh shoot weight (r = 0.404*) and dry shoot weight (r = 0.485*) (Tab. 5). Nitrogen is necessary for proper growth of the strawberry (Sharma, 2002). Breen and Martin (1981) reported that nitrogen deficiency in strawberry plants resulted in reduction of growth and yield. Moreover high levels of nitrogen enhance plant photosynthetic activities and hence more dry matter is produced. The numbers of floral bud, yield and fresh and dry shoot weights were also significantly controlled by CEC ($r \geq 0.501^{**}$, $p < 0.01$) (Tab. 5). The cation exchange capacity of all substrates was very high (Tab. 2), the

T a b l e 5. Coefficients of correlation between selected physical a chemical properties of substrates and productivity and quality indices of strawberry

Characteristics of media	Numbers of floral buds	Primary fruit weight	Fruit yield	Total soluble solids	Vitamin C	Shoot fresh weigh	Root fresh weight	Shoot dry weight	Root dry weight
Organic carbon [%]	0.240	-0.164	0.057	-0.026	-0.420*	0.644**	0.248	0.713**	0.269
CEC	0.614**	0.273	0.589**	-0.132	-0.110	0.609**	0.244	0.501**	0.164
Balk density	-0.314	-0.067	-0.365*	0.079	0.229	-0.466**	-0.329	-0.474**	-0.190
Particle density	-0.133	0.060	0.060	0.046	-0.428**	0.195	-0.090	0.207	-0.122
Total porosity	0.058	0.023	0.058	-0.119	-0.396*	0.535**	0.112	0.501**	0.094
pH	0.140	0.349*	0.330*	0.107	0.207	-0.070	0.151	-0.082	-0.054
EC	0.160	0.134	0.315	0.06	-0.386*	0.605**	0.160	0.606**	0.089
Easily available water	-0.165	-0.358*	0.050	0.300	-0.124	-0.233	-0.340*	-0.258	-0.237
Nitrogen	-0.027	-0.582**	-0.254	-0.036	-0.219	0.404*	0.205	0.485**	0.322
Phosphorus	-0.064	0.591**	0.084	0.155	0.165	-0.482**	-0.367*	-0.525**	-0.3
Potassium	-0.006	0.508**	0.214	0.119	0.075	-0.320	-0.339*	-0.401*	-0.354*

*,**correlation is significant at the 0.05 and 0.01 levels, respectively

highest value was 61.22 in S4. High CEC values have the advantage of increasing growth indices.

S2 had highest fruit weight in comparison with other media. This was probably due to the higher nutrient content in S2 than in other media. Increased phosphorus content may be effective in increasing yield, berry size and weight of strawberry (Sharma, 2002), and also increased in potassium levels the plants may improve the fruit quality (Sharma, 2002). Phosphorus and potassium were both significantly and positively ($r \geq 0.508^{**}$, $p < 0.01$) correlated with the primary fruit weight. Moreover, substrates chemical characteristics, such as EC, may have affected total vitamin-C content and fruit quality (Adams, 1991; Chrétien and Gosselin, 2000) (Tab. 2, 3). A negative and significant correlation was obtained for vitamin-C values and EC ($r = 0.386^{*}$, $p < 0.05$) (Tab. 5).

Plants in S3 did not grow as well as S2 and S4, probably due to high pH. Although strawberries are tolerant of a wide range of soil pH values, they grow better on soils with a pH of 6.0-6.5 (Hancock, 1999).

S1 showed the lowest productivity and quality indices compared with other substrates; despite its standard physical and chemical characteristics for growth. This might be due to allelopathic effects. Toxic allelochemicals especially have been found in leaves and roots and have been released mostly from degradation of dead plant parts (Kocacaliskan and Terzi, 2001).

In this study, the interaction of substrates with nutrient solution did not show considerable increase in productivity, quality and growth of strawberry (Tab. 3, 4). In fact in most cases, plants grown on substrates with no added nutrient had highest values. So, these substrates can reduce the amount of needed fertilizer for optimum strawberry plant growth.

CONCLUSION

The results obtained in this study point out the need for optimizing the tested organic growing media in order to increase the nutrient acquisition and utilization efficiency of the plants and also release the conclusion that improved organic growing media can supply most of the necessary plant nutrients needed for the plant, thus limiting the need for supplementary fertilization and being an alternative to conventional production with inorganic fertilizers.

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REFERENCES

Abad M., Noguera P., Bures S. 2001. National inventory of organic wastes for use as growing media for ornamental potted plant production. BIORES. TECHNOL 77: 197-200.

Abu-Hamdeh N.H. 2003. Compaction and subsoiling effects on corn growth and soil bulk density. SOIL SCI. SOC AMER. J. 67: 1213-1219.

Adams P. 1991. Effects of increasing the salinity of the nutrient solution with major nutrients or sodium chloride on the yield, quality and composition of tomatoes grown in rockwool. J. HORT. SCI. 66: 201-207.

Barbiris R., Bartolini G., Nappi P., Tattini M. 1988. Chemical characteristic of the substrate, fertigation and olive growth. ACTA HORT. 221: 161-166.

Baran A., Çayci G., Sozüdo S. 1998. The effect of beer factory sludge on some chemical and physical properties of a clay loam soil. International Symposium: ARIDE REGION SOIL 90: 179-183.

Breen P.J., Martin L.W. 1981.Vegetative growth response of three strawberry cultivars to nitrogen. J. AMER. SOC. HORT. SCI. 106: 226-272.

Chapman H.D. 1965. Cation exchange capacity. In: C. A. Black. (Ed.) Method of Soil Analysis, Part II, 2nd ed. Agron Monogar. 9. ASA and SSSA Madison, WI., USA, pp. 811-903.

Chen Y., Inbar Y., Hadar Y. 1988. Composted agricultural wastes as potting media for ornamental plants. SOIL SCI. 145: 289-303.

Corti C., Crippa L., Genevini P.L., Centemero M. 1998. Compost use in plant nurseries: hydrological and physicochemical characteristics. COMPOST SCI. UTIL. 6: 35-45.

Cresswell G.C. 1992. Coir dust-A viable alternative to peat? Biol. Chem. Inst., Rydalmere, Australia.

Chrétien S., Gosselin A. 2000. High electrical conductivity and radiation-based water management improve fruit quality of greenhouse tomatoes grown in rockwool. HORT. SCI. 35: 627-631.

Cull D.C. 1981. Alternative to peat as container media: Organic resources in UK. ACTA HORT. 126: 69-81.

Eshghi S., Abdi GH., Tafazoli E., Yavari S. 2007. Strawberry research and biotechnology in Iran. MEDITERA. EAST. RUSS. J. PLANT SCI. BIOTECHNOL. 1/1 and 2: 39-41.

Evans M.R., Konduru S., Stamps R.H. 1996. Source variation in physical and chemical properties of coconut coir dust. HORT. SCI. 31: 965-967.

Galletta G.J., Bringhurst P.J. 1990. Strawberry management. In: Small Fruit Crop Management. Galletta, G. J. and D. G. Himelrick (Eds.). Prentice Hall, New Jersey, USA, pp. 83-156.

Gregoriou C., Vakis N.J. 1992. Strawberry variety trials under cover. Miscellaneous Reports 49, Ag. Res. Inst. M. Ag. and Nat. Res. Niconsia, Cyprus, p. 5.

Hancock I.F. 1999. Strawberries. CABI Publishing, New York, USA. p. 237.

Inden H., Torres A. 2004. Comparison of four substrates on the growth and quality of tomatoes. ACTA HORT. 644: 205-215.

Kocacaliskan I., Terzi I. 2001. Allelopathic effects of walnut leaf extracts and juglone on seed germination and seedling growth. J. HORT. SCI and BIOTECH. 76/7: 436-440.

Kütük C., Çayci G., Baran A., Bakan O., Hartmann R. 2003. Effects of beer factory sludge on soil properties and growth of sugar beet (*Beta vulgaris saccharifera* L.). BIORES. TECHNOL. 90: 75-80.

Meerow A.W. 1994. Growth of two subtropical ornamentals using coir as a peat substitute. HORT. SCI. 29: 1484-1486.

Nelson D.W., Sommers L.E. 1982. Total carbon, organic carbon and organic matter. In: Page, A. L., Miller, R. H., Keeney, D. R. (eds), Methods of Soil Analysis, Part 2. Chemical and

Microbiological Properties, 2nd edn. (Agronomy series no.9) ASA, SSSA, Madison, Wis, pp. 539-579.

Papafotiou M., Cheonopoulos J., Kaegas G., Voreakou M., Leodarities N., Lagogiani O., Gazi S. 2001. Cotton gin trash compost and rice hulls as growing medium components for ornamentals. J. HORT. SCI and BIOTECHNOL. 76/4: 431-435.

Parks S., Newman S., Golding J. 2004. Substrate effects on greenhouse cucumber growth and fruit quality in Australia. ACTA. HORT. 648: 129-133.

Pill W.G., Ridle K.T. 1998. Growth of tomato and coreopsis in response to coir dust in soilless media. HORT. TECHNOL. 8: 401-406.

Preusch P.L., Takeda F., Tworkoski T.J. 2004. N and P uptake by strawberry plants grown with composted poultry litter. SCI. HORT. 102: 91-103.

Salvador E.D., Minami K. 2004. Evaluation of different substrates on lisianthus (Eustoma grandiflorum shinn) growth. ACTA HORT. 644: 217-223.

Saviozzi A., Levi-Minzi R., Riffaldi R., Cardelli R. 1994. Suitability of a winery-sludge as soil amendment. BIORES. TECHNOL. 49: 173-178.

Sharma R.R. 2002. Growing Strawberry. International Book Distributing Co. Indian, p. 164.

Tattini M., Bertoni P., Traversi M.L, Nappi P. 1990. Waste materials as potting media in olive pot production. ACTA HORT. 286: 121-124.

Tripepi R.R., Zhang X.G., Campell A.B. 1996. Use of raw and composted paper sludge as a soil additive or mulch for cotton wood plants. COMPOST SCI. UTIL. 4: 26-36.

Verdonck O. 1984. Reviewing and evaluation of new materials used as substrates. ACTA HORT. 150: 467-473.

Verdonck O. 1988. Composts from organic waste materials as substrates for the usual horticultural substrates. BIOLOGICAL WASTES 26: 325-330.

Verdonck O., Gabriels R. 1992. I. Reference method for the determination of physical properties of plant substrates. II. Reference method for the determination of chemical properties of plant substrates. ACTA HORT. 302: 169-179.

WPŁYW RÓŻNYCH SUBSTRATÓW ORGANICZNYCH I SKŁADNIKÓW MINERALNYCH NA PLON I JAKOŚĆ OWOCÓW TRUSKAWEK (F*ragaria x ananassa* DUCH.) 'SELVA'

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S T R E S Z C Z E N I E

Badano wpływ czterech organicznych substratów, kompostowanych liści perskiego terpentynowca, dębu, cyprysu i odpadów technologicznych z lukrecji, z dodatkiem gleby mineralnej (1:1) na plon i jakość truskawek. Rośliny uprawiane na substracie z odpadów technologicznych z przeróbki lukrecji w mieszaninie z glebą mineralną tworzyły największą liczbę pąków kwiatowych, wydawały najwyższy plon owoców i charakteryzowały się największą masą pędów i korzeni. Dodatkowe nawożenie mineralne nie miało większego wpływu na plon owoców i wzrost roślin uprawianych we wszystkich badanych substratach organicznych.

Słowa kluczowe: organiczne substraty, nawożenie, truskawka, plon owoców, jakość owoców