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Effect of substrate on vegetative quality of strawberry plants (*Fragaria* × *ananassa* Duch.) produced by a soilless method

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SUMMARY

The effect of substrate on the quality of strawberry plants produced by soilless method was determined in a vegetation chamber. 'Elsanta' and 'Honeoye' cultivars were rooted in a substrate mixture of peat with pine bark (1:1 v/v), in coconut fibre, in a mixture of brown coal with disintegrated rockwool (2:1 v/v) and in rockwool blocks.

Rockwool was found to be the most useful substrate for the production of strawberry plants. Plants obtained in this substrate had the greatest crown diameters and the highest number of leaves. Statistical analysis showed that substrate also had a significant effect on fresh weight of the whole plant and on dry matter content of the root system. The average diameter of the crown ranged between 10.0 and 18.0 mm. Plants grown in rockwool showed the greatest average number of leaves (11.8 pcs). Plants grown in coconut fibre and in the mixture of brown coal

with disintegrated rockwool had the least number of leaves (10.5 pcs). Fresh weight of the whole plants and dry matter content of root systems were the highest when strawberry plants were rooted in rockwool.

INTRODUCTION

Poland belongs to world leaders in the production of strawberries. Recently, an increasing number of strawberry producers change their profile to dessert fruits. These changes contribute to the development of new cultivars and new growing technologies. Furthermore, there is an increasing interest in the plants produced by soilless method which decreases the risk of plant infection by soilborn diseases caused by *Verticillium sp.* and *Phytophtora sp.* (Durner and Poling 2000, Durner et al. 2002). The use of such plants for establishing a plantation allows avoiding danger of root system damage. It decreases the risk of diseases and permits to reduce water amount used for plant irrigation (Lieten 2000). It also permits to establish a plantation in an optimal time and insures almost 100% of rooting (Poling and Mass 2000).

The objective of this work was to determine the effect of substrate on crown diameter, number of leaves, plant fresh weight and root dry weight of strawberries (*Fragaria × ananassa* Duch.).

MATERIAL AND METHODS

The studies were carried out in 2004 in a vegetation chamber of the Experimental Station "Marcelin" of The August Cieszkowski Agricultural University in Poznań. A three-factor experiment was established in a completely randomized design in four replications. One replication included 48 plants. The first factor comprised the following substrates: 1) a mixture of peat and pine bark (1:1 v/v), 2) coconut fibre, 3) a mixture of brown coal with disintegrated rockwool (2:1 v/v) and 4) rockwool blocks (Grodan blocks). The second factor referred to the sequence of daughter-plants developed on the stolon. Daughter-plants developed in the closest distance from the mother-plant and the second and the third daughter-plants on the mother-plant stolon were used in the experiment. The third factor was the plant cultivar. 'Elsanta' and 'Honeoye' cultivars were compared. The rooting of plants was performed in multipots with twenty holes of 65 × 65 × 90 mm dimensions and in rockwool blocks of 100 × 100 × 65 mm.

The substrate consisting of a mixture of peat and pine bark, coconut fibre, a mixture of brown coal and disintegrated rockwool was enriched with nutritive components to the level recommended by Komosa (2003) and the rockwool blocks were soaked with the solution containing the same nutritive components.

Subsequently, the substrate was filled into the multipots. The multipots and rockwool blocks were placed on benches in the vegetation chamber. The rooting started on 23.08.2004. Strawberry daughter plants with a 2 cm fragment of stolon and primary roots of about 0.5 cm length were used for rooting. The oldest leaves were removed. In each multipot hole and in each rockwool block, a single plant was planted. During the whole experiment in the vegetation chamber, there was an automatic control of temperature, air humidity and illumination. The plants were rooted at 23°C, RH of 90% and carbon dioxide concentration in the range of 550-600 ppm. Fluoroescence lamps of FL-40, hanging 50 cm above the plants were used. Photosynthetic photon flux density was 100 μmol m^{-2} s^{-1} and 12-hour day length was applied.

After 100 days, the following data were recorded: crown diameter, number of leaves, fresh weight of the whole plant and dry weight of roots. Crown diameter of each plant was measured exact to 1 mm with a slide caliper. The measurements were done beneath the leaf base. Fully expanded leaves were counted to assess their number. All plants in each replication were analyzed. Measurement of the whole plant weight was done after a thorough plant rinsing and substrate separation from the root system. Fresh weight was estimated in 48 plants from each experimental object. The weighing procedure was done on a precision balance determining the weight exact to the decimal parts of a gram. Root dry weight was measured by a drier-weighter at 105ºC in 48 plants from each experimental object.

The results obtained from the measurements of each studied feature were statistically analysed. Analysis of variance was carried out using "STAT" statistical program. Significant differences between the compared objects were defined with Newman-Keuls test at the significance level of $\alpha = 0.5$.

RESULTS AND DISCUSSION

According to Kramer and Schultze (1985), Paszko (1998), Pérez De Camacaro and others (2004), crown diameter is a good indicator of plant growth intensity and of yield size. According to them, plants with a bigger crown have more flower buds than plants with a smaller crown.

In our experiment a significant effect of the substrate and sequence of plant development on the stolon of mother-plant on the plant crown was found. Daughter-plants rooted in rockwool blocks had a significantly bigger crown diameter than those rooted in the remaining substrates (Table 1). The greatest mean crown diameter (18 mm) was obtained in the daughter-plants of 'Elsanta' cultivar rooted in rockwool while the smallest crown diameter (10 mm) was found in the daughter-plants of 'Honeoye' cultivar produced in the mixture of brown coal with disintegrated rockwool. In the studies by Borkowska (1997) on the rooting of

strawberry plants obtained by *in vitro* method, substrate of rockwool also gave the most favourable effects.

Furthermore, the analysis of the results obtained in our studies indicated significantly bigger crown diameters ('Elsanta' and 'Honeoye' 14.2 mm and 13.4 mm, respectively) in the plants produced from daughter-plants which were the first ones on the mother-plant stolon in comparison with those obtained from the third daughter-plant on the stolon. No effect was found of a plant cultivar on the size of a plant crown (Table 1). According to Jansen (1997), the crown diameter of strawberry tray plants does not depend on the initial dimensions, but on the density of rooted plants. D'Anna and Iapichino (2002) argued that the sequence of development on the stolon may have an influence on the yield of plants.

The number of leaves in the plants depended on the type of the applied substrate and the sequence of plant development on the stolon. No effect of the cultivar on the number of leaves was found (Table 2). The greatest significant number of leaves was obtained in the plants rooted in rockwool, on the average 11.8 pcs. Plants rooted in the remaining substrates had 10.4-10.5 leaves. The greatest number of leaves was found in the plants developed as the first ones on the mother-plant stolon, while the smallest number of leaves was found on the third daughter-plant on the stolon. In 'Elsanta' cultivar, there were 16.2 and 6.9 leaves, and in 'Honeoye' cultivar l5.5 and 6.5 leaves respectively. According to Himelrick and Galletta (1990), a significant effect on the growth of strawberry plants is exerted by genetic and environmental changes. The authors reported that factors such as climate, irrigation, soil fertility and temperature significantly modify plant growth.

A significant effect of the substrate type, the sequence of plant development on mother-plant stolon and the effect of cultivar on fresh weight of rooted plants were determined (Table 3). Plants produced in rockwool obtained the highest weight (29.2 g), and in the mixture of brown coal with disintegrated rockwool and the lowest weight (11.7 g). It was found that the first plant from the stolon rooted in rockwool had a significantly bigger mean weight ('Elsanta' and 'Honeoye' 24.4 g and 18.8 g, respectively) than the third plant from the stolon ('Elsanta' and 'Honeoye' 12.9 g and 12.8 g, respectively). The differences between the sequence of development on the stolon and the weight of rooted plant were also found by Takeda and others (2004). According to them, plants developed in further distance from the mother-plant have a reduced ability of producing a satisfactory root weight.

Dry matter content of the plant root system depended on the type of substrate and the place of plant development on the stolon. No effect of the cultivar on the dry weight of the root system was found (Table 4). The root system of the plants rooted in a mixture of brown coal and rockwool was characterized by a significantly lower dry matter content (16.8%) than the root system of the plants rooted in the remaining substrates (Table 4).

Table 1. The effect of substrate and development sequence on the stolon on the crown diameter of plants of two strawberry cultivars [mm]

Substrate	'Elsanta'			'Honeoye'			Mean for substrates
	Development sequence on the stolon						
	1st	2nd	3rd	1st	2nd	3rd	
Peat + pine bark	13.1 b-e*	12.1 c-f	10.6 d-f	11.8 c-f	10.9 d-f	11.8 c-f	11.7 b
Brown coal + rockwool	11.7 c-f	10.4 ef	10.6 d-f	13.3 b-d	11.5 c-f	10.0 f	11.2 b
Coconut fibre	14.1 bc	12.6 c-f	10.9 d-f	11.7 c-f	10.8 d-f	10.3 ef	11.7 b
Rockwool	18.0 a	14.1 dc	11.8 c-f	17.7 a	15.0 b	11.9 c-f	14.7 a
Mean for development sequence on stolon	14.2 a	12.3 b	10.9 c	13.4 a	12.3 b	11.0 c	
Mean for cultivar	12.5 a			12.2 a			

*Means followed by the same letters are not significantly different at α = 0.05

Table 2. The effect of substrate and development sequence on the stolon on the number of leaves in the plants of two strawberry cultivars [pcs]

Substrate	'Elsanta'			'Honeoye'			Mean for substrates
	Development sequence on the stolon						
	1st	2nd	3rd	1st	2nd	3rd	
Peat + pine bark	15.5 a*	9.2 cd	5.8 f	15.4 a	10.0 bc	7.0 d-f	10.5 b
Brown coal + rockwool	16.9 a	8.5 c-e	7.0 d-f	14.7 a	9.7 bc	5.3 f	10.4 b
Coconut fibre	15.3 a	8.4 c-e	6.2 ef	16.7 a	9.3 cd	6.7 ef	10.4 b
Rockwool	17.2 a	11.0 bc	8.7 c-e	15.1 a	11.9 b	7.0 d-f	11.8 a
Mean for development sequence on stolon	16.2 a	9.3 c	6.9 d	15.5 a	10.2 b	6.5 d	
Mean for cultivar	10.8 a			10.7 a			

*Means followed by the same letters are not significantly different at α = 0.05

Table 3. The effect of substrate and development sequence on the stolon on the plant fresh weight of two strawberry cultivars [g]

Substrate	'Elsanta'			'Honeoye'			Mean for substrates
	Development sequence on the stolon						
	1st	2nd	3rd	1st	2nd	3rd	
Peat + pine bark	17.1 de*	14.2 d-f	10.9 ef	14.3 d-f	12.6 d-f	10.1 ef	13.2 b
Brown coal + rockwool	13.1 d-f	12.7 d-f	9.6 f	13.1 d-f	11.7 d-f	9.8 f	11.7 b
Coconut fibre	18.5 d	13.9 d-f	11.0 ef	12.3 d-f	12.2 d-f	11.7 d-f	13.3 b
Rockwool	49.2 a	25.9 c	16.6 d-f	37.0 b	29.3 c	17.2 de	29.2 a
Mean for development sequence on stolon	24.4 a	15.9 c	12.9 d	18.8 b	16.2 c	12.8 d	
Mean for cultivar	17.7 a			15.9 b			

*Means followed by the same letters are not significantly different at α = 0.05

Table 4. The effect of substrate and development sequence on the stolon on dry matter content in root system of two strawberry cultivars [%]

Substrate	'Elsanta'			'Honeoye'			Mean for substrates
	Development sequence on the stolon						
	1st	2nd	3rd	1st	2nd	3rd	
Peat + pine bark	19.2 ab*	17.6 c	17.0 cd	18.1 bc	17.4 c	17.5 c	17.8 a
Brown coal + rockwool	17.9 bc	16.8 c-e	16.4 d-f	17.2 c	16.3 d-f	16.6 c-e	16.8 b
Coconut fibre	18.8 ab	17.8 bc	16.7 c-e	19.0 ab	18.1 b	16.4 d-f	17.8 a
Rockwool	20.3 a	18.5 b	16.1 d-f	19.5 ab	17.3 c	17.0 cd	18.1 a
Mean for development sequence on stolon	19.0 a	17.7 c	16.5 d	18.4 b	17.2 c	16.9 d	
Mean for cultivar	17.7 a			17.5 a			

*Means followed by the same letters are not significantly different at α = 0.05

CONCLUSIONS

– Among the studied substrates, rockwool was the most useful for the production of strawberry plants.

– Crown diameter, number of leaves and fresh weight of produced strawberry plants significantly depended on the place of the plant on the stolon from which the plant was taken for rooting. It was also found that the sequence of development on the stolon had a significant effect on dry matter content of roots.
– Statistical analysis did not show any differences between the cultivars in crown diameter, leaf number and dry matter content in root system. There was a significant effect of cultivar on the fresh weight of plants.

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WPŁYW PODŁOŻA NA JAKOŚĆ SADZONEK TRUSKAWKI (*FRAGARIA* × *ANANASSA* DUCH.) PRODUKOWANYCH METODĄ BEZGLEBOWĄ

Streszczenie: W roku 2004 w kamerze wegetacyjnej określano wpływ podłoża na jakość sadzonek truskawki produkowanych metodą bezglebową. Sadzonki odmiany ‘Elsanta’ i ‘Honeoye’ ukorzeniano w 4 podłożach: w mieszaninie substratu torfowego z korą sosnową (1:1), we włóknie kokosowym, w mieszaninie węgla brunatnego z rozdrobnioną wełną mineralną (2:1) oraz w wełnie mineralnej.

Stwierdzono, że najbardziej przydatnym podłożem do produkcji sadzonek była wełna mineralna. Uzyskano w niej sadzonki o największej średnicy korony i największej liczbie liści. Analiza statystyczna wykazała również, że podłoże istotnie wpływało na świeżą masę całej rośliny i zawartość suchej masy w systemie korzeniowym sadzonki. Średnia średnica korony wahała się od 10,0 do 18,0 mm. Największą średnią liczbę liści (11,8 sztuk), wytworzyły sadzonki produkowane w wełnie mineralnej a najmniejszą (10,5 sztuk) w włóknie kokosowym i mieszaninie węgla brunatnego z rozdrobnioną wełną mineralną. Sadzonki produkowane w wełnie mineralnej miały największą świeżą masę całych roślin i najwyższą zawartość suchej masy w systemie korzeniowym.

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