Cell size in trays for the production of strawberry plug transplants

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Abstract – The objective of this work was to evaluate the influence of cell sizes used for strawberry plug production in trays compared to bare root transplants, regarding initial plant size, harvest timing, and total strawberry fruit yield. Plug transplants were produced from runner tips rooted in trays with cell sizes of 26.5, 50, 100 and 150 cm^3 filled with Plantmax HA organic substrate. Bare root transplants (control) were produced in a closed soilless system using sand as substrate. A randomized block design was used, with four replicates with 16 plants per plot. Bare root transplants and plug transplants from 100-cm^3 cells had larger crown and higher leaf and root dry mass. Early fruit yield was higher in plants propagated from plugs than in those propagated from bare root transplants. Spring and total fruit yield did not differ among treatments, with an average yield of 435 and 874 g per plant, respectively. Earlier strawberry fruit yield was obtained by using plug transplants, even from trays with small cells of 26.5 or 50 cm^3.

Index terms: *Fragaria ananassa*, bare root planting, plant nursery, plant propagation.

Tamanho das células em bandejas para produção de mudas de morangueiro

Resumo – O objetivo deste trabalho foi avaliar a influência do tamanho das células utilizadas na produção de mudas de morangueiro em bandejas, comparadas a mudas de raízes nuas, quanto ao tamanho inicial da planta, período de colheita e produção total de frutos. As mudas em bandejas foram produzidas a partir de pontas de estolões enraizadas em células de 26,5, 50, 100 e 150 cm^3, com o substrato orgânico Plantmax HA. As mudas de raízes nuas (controle) foram produzidas em um sistema sem solo com areia como substrato. O delineamento experimental foi o de blocos ao acaso, com quatro repetições de 16 plantas. As mudas de bandejas com células de 100 cm^3 e de raízes nuas atingiram diâmetro da coroa e massa de matéria seca de folhas e raízes mais elevadas. A produção precoce foi maior nas plantas propagadas por estolões que naquelas propagadas por raízes nuas. A produção de primavera e a total não diferiram entre os tratamentos, com média de 435 e 874 g por planta, respectivamente. A produção mais precoce de frutas foi obtida com mudas em bandejas, mesmo naquelas com células pequenas de 26,5 ou 50 cm^3 de volume.

Termos para indexação: *Fragaria ananassa*, plantio de raiz nua, viveiro de planta, propagação vegetal.

Introduction

Low quality of transplants is the main limiting factor of strawberry crops in Brazil. Stock plants from in vitro propagation are planted in soil to produce bare root transplants, and their physiological and sanitary quality is low due to contamination by pathogens like *Colletotrichum*, *Phytophthora* and *Verticillium*. High quality bare root transplants used in Brazil are currently imported from Argentina and Chile (Santos & Medeiros, 2003).

Soil disinfection with methyl bromide is a practice that has been used around the world to control pathogens and weeds in nurseries (Durner et al., 2002). Methyl bromide has been banned from use in Brazil, so there is scientific and commercial interest in soilless strawberry propagation methods.

Planting of strawberry in southern Brazil is done in early fall, under high levels of solar radiation and elevated air temperature. Intensive overhead irrigation is required for 1–2 weeks after transplanting (Santos & Medeiros, 2003). Many bare root transplants do not survive, leading to heterogeneous crop stands and low fruit yield. The use of containerized plug transplants is a way to avoid the need for fumigants in the propagation phase and to improve plant survival at planting (Durner

et al., 2002). Plug transplants are being adopted in Europe and North America. Plants from transplants are easier to plant, require less irrigation during crop establishment, and produce higher fruit yield (Durner et al., 2002; Takeda & Hokanson, 2003; Hochmuth et al., 2006a, 2006b; Takeda & Newell, 2006).

The planting timing is an important factor for achieving full potential strawberry fruit production. The production of plug transplants can be programmed in such a way that they are available for planting at the right time (Lieten, 1998; Bish et al., 2002; Fernandez & Ballington, 2003; Hochmuth et al., 2006a). A period of about 4–5 weeks should be necessary for production of plug transplants (Durner et al., 2002), and during this time the container size can influence water and nutrient availability. Container size can affect growth of plants in soilless culture (Nesmith & Duval, 1998). The use of trays with large cell size can stimulate transplants' growth. Large cell size increases the amount of substrate, reduces the number of transplants per tray, and increases the costs of package and shipping (Durner, 1999; Bish et al., 2002; Hochmuth et al., 2006a, 2006b). The use of trays with small cells is a way of reducing the cost of transplants, but the physiological quality of the plants must not be affected (Durner et al., 2002). Data about the influence of container size in the production of strawberry plug transplants are scarce in the literature.

The objective of this work was to evaluate the influence of cell size used for strawberry plug production in trays compared to bare root transplants regarding initial plant size, harvest timing, and total strawberry fruit yield.

Materials and Methods

The experiment was carried out from April 21st to December 19th, 2006, at Departamento de Fitotecnia, Universidade Federal de Santa Maria, Brazil. Stock plants of the LBD 15.1 clone from the Strawberry Breeding Program were propagated in vitro at Laboratório de Biotecnologia, Departamento de Fitotecnia. Stock plants were acclimatized during 15 days in a screenhouse and planted in a closed soilless system using sand as growing bed. Hennion & Veschambre (1997) nutrient solution was used in mmol L^{-1}: 12 NO_3^-, 2 NH_4^+, 6.2 K^+, 2.2 $H_2PO_4^-$, 1 SO_4^{2-}, 1 Mg^{2+} and 3 Ca^{2+}, and, in mg L^{-1}: 0.03 Mo, 0.26 B, 0.06 Cu, 0.50 Mn, 0.22 Zn and 4.00 chelated Fe. The pH and electrical conductivity were maintained between 5.5 and 6.5 and between 1.4 and 1.5 dS m^{-1}, respectively. The soilless system and nutrient solution management were done according to Andriolo (2007).

Treatments consisted of plug transplants produced in trays with cell volumes of 26.5, 50, 100, and 150 cm^3 (V-26.5, V-50, V-100 and V-150, respectivelly). Plug transplants were produced from runner tips bearing 2–3 leaves and with crown diameters between 3.0 and 3.9 mm. They were collected on March 19th 2006, and rooted in cell trays filled with the organic substrate Plantmax HA (Eucatex, Paulínia, SP, Brazil). The plants in the trays were misted for five days (one minute of mist every hour) followed by overhead sprinkling irrigation (one minute every hour) for 27 days.

Bare root transplants produced in a closed soilless system using sand as substrate were used as control. Bare root transplants were harvested by digging in the soilless system.

A randomized block design was used, with four replicates and 16 plants per plot. The physiological quality of plug and bare root transplants at planting were determined by crown diameter and leaf and root dry mass, after drying at 60°C in a forced-air oven until constant mass. Planting was done in soil on April 21st 2006, in an annual hill system with raised beds under low 100-µm polyethylene tunnels at a density of 6.6 plants m^{-2}. The row surface was mulched with 30 µm black polyethylene. Water and nutrients were delivered to plants by drip irrigation, according to cropping practices reported by Santos & Medeiros (2003). Ripe fruit were harvested and weighed weekly from June 15th to December 19th. The early and spring fruit production were defined as the ranges from June 15th to September 30th and from October 1st to December 19th, respectively. The data were submitted to analysis of variance, and significance among means was tested by Tukey's test, at 5% probability.

Results and Discussion

Significant differences among treatments were found in crown diameter and in leaf and root dry mass of transplants at planting (Table 1). The largest crown

and greater dry mass of leaves were obtained in plug transplants grown in 100-cm^3 cells and in bare root transplants. The highest root dry mass was recorded in bare root transplants, and did not differ from plug transplants grown in 100 and 150-cm^3 cells. After planting, survival of plug transplants from all cell sizes was 100%, while it was necessary to replant 18% of bare root transplants. Hochmuth et al. (2006b) suggested that a crown diameter of 8.0 mm could be one of the parameters taken into account for screening the physiological quality of strawberry transplants. Transplants from all treatments reached crown diameters higher than 8.0 mm and, in this sense, can be considered of high physiological quality (Table 1).

Early fruit yield did not differ among plug transplant treatments, with an average of 460.7 g per plant, and was higher than in bare root transplants (Table 2). Spring and total fruit yield did not differ among treatments treatments, with average yields of 435.2 and 873.8 g per plant, respectively. Similar results were reported in the United States of America from plug transplants grown in 75–150-cm^3 cell trays and in Europe from containerized transplants in cells of about 300 cm^3 (Baruzzi & Faedi, 1998; Lieten, 1998; Bish et al., 2002; Durner et al., 2002; Lieten et al., 2004; Hochmuth et al., 2006a).

Monthly distribution of early fruit yield was affected by treatments (Table 3). In June, lower yields were found in plants from bare root and V-50 plug transplants. In September, bare root and V-26.5 plug transplants did not differ. In July, August and September, similar yields were observed for all plug transplants. Higher early fruit yield of plants from plug transplants in comparison to plants from bare root transplants is in agreement with data from other authors (Durner, 1999; Bish et al., 2002; Hochmuth et al., 2006a, 2006b). The main explanation for such difference is related to planting stress. Absorbent roots of bare root transplants are mechanically damaged at digging and older leaves are pruned off before planting. New roots and leaves must be grown during plant establishment and carbon is allocated from the pool of assimilates to sustain their growth. As a consequence, plant growth is delayed and early fruit yield is reduced. The plugs are transplanted with the rooting system intact and protected from mechanical damage by the substrate remaining attached to the roots. As a consequence, their initial growth after planting is enhanced, leading to early flowering and fruit harvest (Duval et al., 2006; Hochmuth et al., 2006a).

Increasing the volume of the substrate in the production of strawberry plug transplants can lead to higher early and total fruit yield (Bish et al., 2002; Hochmuth et al., 2006b). No significant differences in fruit yield were observed among plug transplants from different cell sizes in the present experiment (Table 2). Higher early fruit yield was confirmed in plug transplants. For commercial production of plug transplants, smaller cell size of trays is advantageous because the amount of substrate is reduced and the surface use efficiency of the screenhouse is increased.

Table 1. Crown diameter, leaf and root dry mass at planting of strawberry bare roots and plug transplants produced in trays with different cell sizes[(1)].

Treatment	Crown diameter	Dry mass (g per plant)	
	(mm)	Leaf	Root
V-26.5	8.4b	1.15b	0.19b
V-50	8.0b	0.91b	0.17b
V-100	10.8a	1.85a	0.35a
V-150	8.8b	1.28b	0.29a
Bare root	9.9a	1.68a	0.40a
CV (%)	8.24	15.9	13.9

[(1)]Means followed by the same letter in the column do not differ by Tukey's test, at 5% probability.

Table 2. Early, spring and total fruit yield of strawberry using bare roots and plug transplants produced in trays with different cell sizes[(1)].

Treatment	Fruit yield (g per plant)		
	Early	Spring	Total
V-26.5	420a	416	836
V-50	475a	467	942
V-100	479a	441	921
V-150	469a	437	906
Bare root	348b	415	764
CV (%)	12.3	9.4	20.7

[(1)]Means followed by the same letter in the column do not differ by Tukey's test, at 5% probability.

Table 3. Monthly early yield distribution of strawberry from bare root transplants and plug transplants produced in trays with different cell sizes[(1)].

Treatment	Fruit yield (g per plant)			
	June	July	August	September
V-26.5	11.0bc	12.6a	141a	141ab
V-50	7.8cd	12.5a	182a	159a
V-100	20.9a	12.6a	173a	160a
V-150	15.8ab	11.8a	169a	167a
Bare root	0.2d	9.2b	142a	111b
CV (%)	22.5	9.5	20.3	13.3

[(1)]Means followed by the same letter in the column do not differ by Tukey's test, at 5% probability.

Conclusion

Earlier strawberry fruit yield is obtained with plug transplants, and the earliness can be achieved even in trays with cells as small as 26.5 or 50 cm^3.

Acknowledgements

To Conselho Nacional de Desenvolvimento Científico e Tecnológico, and to Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul.

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Received on March 3, 2009 and accepted on June 23, 2009