Pruning system effect on greenhouse grafted tomato yield and quality

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Abstract

This study aimed to evaluate the effects on tomato yield and quality of three pruning systems (2, 3 and 4 stems) of grafted plants (cv. Vinicio and Multifort) used to prevent the incidence of soil diseases. It was also investigated if the two stems from nodes of the cotyledon leaves improved crop performance compared to the two stems from the first true leaves nodes. The experiment was conducted in the spring/summer season, under greenhouse conditions at NW Portugal, with a randomized block design with three blocks. Total yield was significantly increased for the double-stem tomato crop, without significant differences between both stem nodes position (26.5 kg m^{-2}), compared to plants with 3 and 4 stems (19.5 kg m^{-2}). The fruit grade between 57-102 mm represented 96.3% of total yield and this was similar for all plant treatments. Fruit quality was not influenced by the pruning systems. Higher yield and fruit quality from double-stem tomato plants offset the increased planting costs.

Introduction

Intensification of vegetable crop production has contributed to increased incidence of soil pests and diseases. However, this incidence can be mitigated by vegetable grafting, which is particularly important for organic production where synthetic pesticides are not allowed. The grafting induce the resistance/tolerance to various soil diseases such as *Pyrenochaeta lycopersici*, *Fusarium oxysporum* f. sp. *lycopersici*, *Ralstonia solanacearum*, *Verticillium albo-atrum* (Louws et al., 2010) and may also provide resistance to nematodes (Rumbos et al. 2011) and tobacco mosaic virus (TMV) (McAvoy et al. 2012). The use of a vigorous rootstock induces robust plants, which allows decreased planting density without changing the harvest period in crops such as tomato, pepper, eggplant and cucumber (Lee et al. 2010). Grafting with specific rootstocks may induce plant tolerance to salinity and/or increase plant nutrient uptake, decreasing the need for fertilizers to match nutrient availability with crop demand (Colla et al. 2010; Savvas et al. 2011). Grafted tomato may also contribute to increase fruit quality under multiple and combined stress conditions (Rouphael et al. 2010). This study aimed to evaluate the effects on grafted tomato yield and quality of three pruning systems (2, 3 and 4 stems) as well as if the 2 stems from nodes of the cotyledon leaves improved crop performance compared to the 2 stems from the first true leaves nodes.

Materials and methods

The experiment was conducted with tomato (*Lycopersicon esculentum* Mill.) during spring/summer under greenhouse conditions, at Santo Tirso, Portugal (41º 20' 41.6'' N, 8º 28' 18.4'' W). The soil was a cambisol with a sandy loam texture with high organic matter (OM) and nutrient contents and high electrical conductivity (EC) (Table 1). A randomized block design experiment with three repetitions and four treatments was carried out to evaluate crop yield and quality. The four treatments were three pruning systems of grafted plants with 2, 3 and 4 stems from the first true leaves (P2, P3, P4) and one pruning system of grafted tomato plants with 2 stems from the nodes of the cotyledon leaves (P2c). The organic fertilizer applied was produced from vinasse, molasses, bone meal and feather meal and was applied at a rate of 3 t ha^{-1}.

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Table 1. Soil characteristics of the greenhouse

pH	EC	OM	$P_2O_{5\ ER*}$	$K_2O_{\ ER*}$	Ca	Mg
H_2O	(dS m^{-1})	(g kg^{-1})	(mg kg^{-1})			
6.2	3.6	54	579	368	2810	117

* ER - Egner-Rhiem method.

The beef type tomato cv. Vinicio (E27.33490) was grafted on the inter-specific rootstocks Multifort. The spacing between stems was 0.5 m and between lines was 0.8 m, resulting in a plant density of 1.25, 0.83 and 0.63 plants m^{-2}, respectively for plants with 2, 3 and 4 stems. The soil was covered with a fabric film and the nylon strip tutors were 2.5 m height. The plant protection included the application of the predator *Nesidiocoris tenui* (Heteroptera: Miridae) to control 45 days after planting; sulphur to control the mite *Aculops lycopersici*, compatible with the auxiliary *N. tenui*. The irrigation was performed by a drip system. Bumblebees (*Bombus terrestre*, Beeline bb Bioline Syngenta) were used for pollination. The first harvest took place on the 25th June 2013 (104 days after planting) and the last harvest on 24th September (195 days after planting). Over this 91 day period two plants for each treatment repetition were harvested weekly (14 harvests). The number of fruits as well as fresh weight for each of the following grades: ≤ 57, 57-66, 67-81, 82-102 and > 102 mm were recorded. The firmness, pH, total soluble solids content, titratable acidity and dry weight were evaluated for five harvests during the harvesting period. The fruit firmness was determined with a penetrometer (TR Snc), the soluble solids with an ABBE refractometer (Vitrilab), the pH with a potentiometer and the acidity by titration at pH 8.1 with a solution of 0.1N NaOH and expressed as a percentage of citric acid. Fruit dry matter content was determined after drying the fruit in a ventilated oven at 70°C for 48 hours. The analysis of variance and least significant difference tests were used to test for significant differences between mean data. Statistical analysis was carried out using SPSS 17.0 for Windows (SPSS Inc.). A probability level of α=0.05 was applied to determine statistical significance.

Results

The number of fruits and total yield were significantly higher for the double-stem tomato plants from both nodes position (first true leaves and cotyledon leaves) (26.5 kg m^{-2}), compared to plants with 3 and 4 stems (19.5 kg m^{-2}) (Table 2). Tomato grade between 57-102 mm represented 96.3% of total yield and this was similar for all plant treatments (Fig.1). The percentage of unblemished fruits was similar for all plant treatments, with a mean of 90.9%. However, the fruits with healed cracks were higher in P2 and P4 (8.0%) compared to the other crops treatments (5.6%). Fruit quality was not influenced by the pruning system and mean characteristics were as follows: fruit firmness (1.0 kg), content of soluble solids (5.1°Brix), acidity (1.0 g 100 g^{-1}), pH (4.4) and dry mater content (4.9%) (Fig.2). Taking into account the unit price of grafted plants (0.71 € $plant^{-1}$), the differences between plant density of 2, 3 and 4 stems (respectively 1.25, 0.83 and 0.63 plants m^{-2}), the yield increase (7.0 kg m^{-2}) and the mean price of tomato (0.50 € kg^{-1}), it can be concluded that the gross income with the double stem tomato could be about 3.0 € m^{-2} higher compared to 3 and 4 stems grafted plants.

Table 2. Total number of fruits (m^{-2}) and total crop yield (kg m^{-2}) for grafted tomato with 2, 3 and 4 stems from upper nodes (P2, P3, P4) and with 2 stems from nodes of the cotyledon leaves (P2c).

Treatments	No of fruits (m^{-2})	Yield (kg m^{-2})
P2c	121.5	25.79
P2	125.0	27.22
P3	82.9	18.79
P4	89.0	20.15
LSD	*9.8*	*2.01*

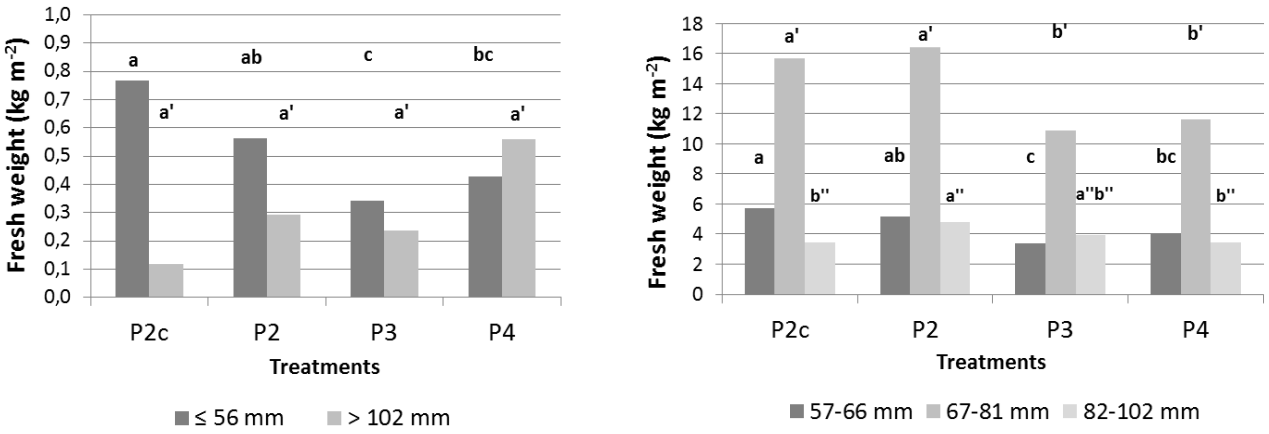

Figure 1. Tomato fresh weight (kg m-^{2}) for fruit grade ≤ 56, 57-66, 67-81, 82-102 and > 102 mm, for grafted tomato with 2, 3 and 4 stems from the first true leaves (P2, P3, P4) and with 2 stems from nodes of the cotyledon leaves (P2c). Different letters for the same series means significant differences between crop treatments (p <0.05).

Discussion

Higher yield and fruit quality of double-stem tomato plants offset the increased planting labour and higher plant cost, compared to the 3 and 4 stems grafted plants. Similar results were obtained for double-stem plants grown from cotyledon leaves nodes compared to those grown from the first true leaves, suggesting that the former plants should not be recommended as they need higher nursery pruning care. Perspectives include further evaluation of vegetable grafting (tomato, cucumber, pepper, melon, water melon and green beans) to improve yield and fruit quality under biotic and abiotic stress conditions in organic production and with vegetable cultivars that are suitable for organic production due to their higher fruit quality but often with soil diseases susceptibilities.

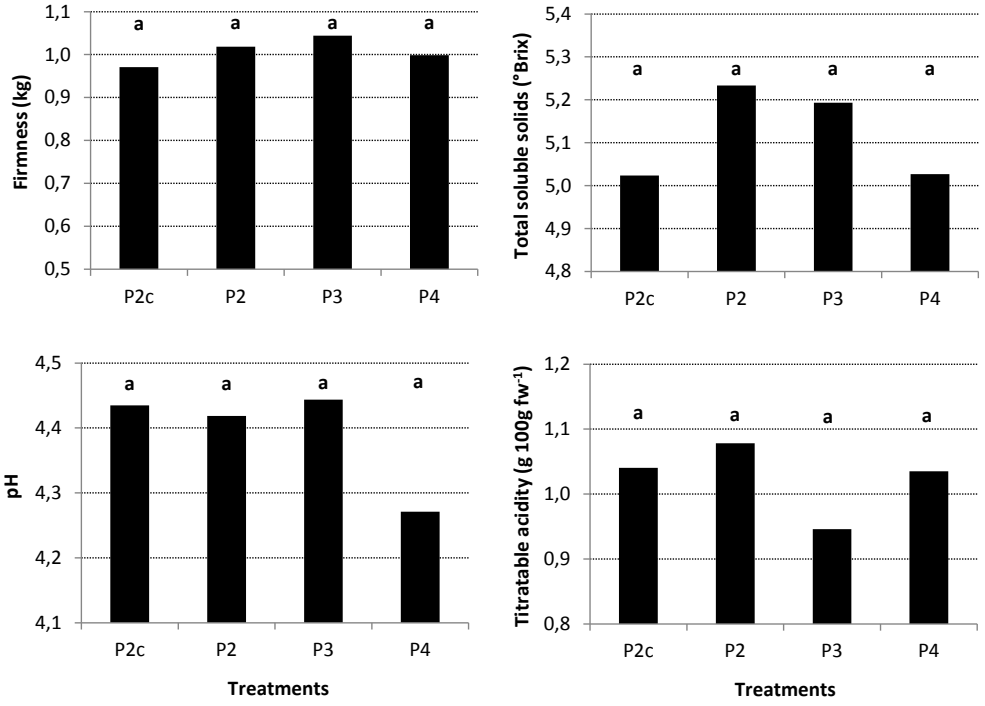

Figure 2. Fruit firmness (kg), total soluble solids (g 100 g fw^{-1}), pH and titratable acidity (°Brix), for grafted tomato with 2, 3 and 4 stems from the first true leaves (P2, P3, P4) and with 2 stems from nodes of the cotyledon leaves (P2c). Different letters for the same series means significant differences between crop treatments (p <0.05).

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