Scientia Horticulturae 228 (2018) 81–90

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Research paper

Hybrids and allied species as potential rootstocks for eggplant: Effect of grafting on vigour, yield and overall fruit quality traits

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ARTICLE INFO

Keywords:
Eggplant
Solanum spp.
Grafting
Scion/rootstock combination
Nutraceutical

ABSTRACT

Grafting of fruiting vegetables is an effective technique to overcome pests and diseases in modern cropping systems and it is often used to improve yield and fruit quality. Eggplant is an important vegetable crop that benefits significantly from grafting. In this regards, the exploitation, valorization and breeding of new rootstock genotypes as possible substitute to those commonly used (*Solanum torvum* and tomato hybrids) would permit an intensive eggplant crop system in those situations where a rootstock rotation is required. In the present article, we study the effects of several potential rootstocks including both wild/allied species of eggplant [*S. torvum* (STO), *S. macrocarpon* (SMA), *S. aethiopicum* (accession SASI), *S. aethiopicum* (accession SASa2), *S. paniculatum* (jurubeba) (SPA) and *S. indicum* (SIN)] and Msa 2/2 E7 and 460 CAL. eggplant hybrids on plant vigor, yield and fruit characteristics of eggplant F_1 hybrid ('Birgah'), in two spring-summer growing seasons (2014 and 2015). SPA and the hybrids Msa 2/2 E7 and 460 CAL. displayed a high percentage of grafting success. 'Birgah' scion grafted onto the two above-mentioned rootstocks showed a notable vigour and yield. Both rootstocks did not promote any unfavorable effects on apparent fruit quality traits and overall fruit composition. Furthermore, the concentration of glycoalkaloids in the fruit remained below the recommended safety value (200 mg/100 g of dw). These results suggest that SPA and Msa 2/2 E7 and 460 CAL. eggplant hybrids might represent a potential rootstock alternative to *S. torvum*.

1. Introduction

Eggplant (*Solanum melongena* L.) is one of the most cultivated fruiting vegetable crops world-wide, and it is ranked among the top six for the amount of its production (FAOSTAT, 2014). Italy is one of the top producers of eggplant among European countries. Eggplant is mostly cultivated in southern Italy in open field during spring-summer or under unheated greenhouses for early production. In many cases, the Solanaceous cultivation has become an intensive cropping system, with the consequent disease problems and soil fatigue that affect plant growth and yield (Bletsos et al., 2003). Lack of genotypes tolerant to biotic and abiotic stresses, together with the ban of the use of methyl bromide, has led to an increasing interest in eggplant grafting (Bletsos, 2005; Davis et al., 2008a,b; King et al., 2008; Miguel et al., 2004). Eggplant benefits significantly from grafting because soilborne diseases and abiotic stresses can cause important production losses (Bletsos et al., 2003). Among the eggplant wild and allied relatives which can be exploited as potential rootstocks, *Solanum torvum* Sw., native to India (Deb, 1979), and distributed in most pantropical areas, particularly South East Asia, the Mascarene and Pacific islands and the West Indies, has been reported to overcome a wide range of soilborne pathogens (*Verticillium dahliae* Klebahn, *Ralstonia solanacearum* (Smith) Yabuuchi et al., *Fusarium oxysporum* (Schlechtend:Fr.) f. sp. *melongenae* Matuo and Ishigami, and *Meloidogyne* spp. root-knot nematodes) (Bletsos et al., 2003; Daunay, 2008; Singh and Gopalakrishnan, 1997; King et al., 2010). However, *S. torvum* use has been limited due to lack of rapid and homogeneous seed germination (Ginoux and Laterrot, 1991). In order to overcome *S. torvum* limitations, Miceli et al. (2014) have proposed the production of grafted eggplant plantlets via unrooted grafted cutting propagation technique. Other wild relatives of eggplant, which

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http://dx.doi.org/10.1016/j.scienta.2017.10.020
Received 23 May 2017; Received in revised form 20 September 2017; Accepted 11 October 2017
Available online 17 October 2017

have been tested as potential rootstocks for grafting include: *Solanum sisymbriifolium* Lam. and *Solanum integrifolium* Poir. (=*Solanum aethiopicum* L. Aculeatum group), although poor performance in growth, development and production has been reported (Rahman et al., 2002; Yoshida et al., 2004); the scarlet eggplant (*S. aethiopicum* Gilo, Shum, or Kumba groups) and the gboma eggplant (*Solanum macrocarpon* L.), phylogenetically close to *S. melongena* (Furini and Wunder, 2004), have been also described as tolerant to *F. oxysporum* f. sp. *melongenae* and resistant to *R. solanacearum* (Cappelli et al., 1995; Daunay et al., 1991; Hébert, 1985); *S. aethiopicum* Gilo group (Hébert, 1985) has also been reported to induce resistance to root-knot nematodes; *Solanum incanum* L. has been described as resistant to *F. oxysporium* f. sp. *melongenae* (Yamakawa and Mochizuki, 1979) and tolerant to abiotic stresses such as water and thermal stress, which are important eggplant breeding goals (Daunay, 2008). Interspecific hybrids are used as rootstock to induce pathogen tolerance, plant vigor, and greater degree of rootstock-scion compatibility specially when one of the parents is from the same species of the scion (Daunay, 2008; Lee and Oda, 2003; Miguel et al., 2007; Gisbert et al., 2011). Hybrids of tomato (*Solanum lycopersicum* L.) and interspecific hybrids of *S. lycopersicum* × *S. habrochaites* S. Knapp and D.M. Spooner are also used as eggplant rootstocks (Bletsos et al., 2003; Miguel et al., 2007; King et al., 2010). However, some tomato rootstocks are moderately compatible when grafted onto eggplant (Kawaguchi et al., 2008). Consequently, without a painstaking selection, negative effects might appear (Kawaguchi et al., 2008; Leonardi and Giuffrida, 2006; Oda et al., 1996). As the demand for eggplant grafted plantlets is growing rapidly, increasing researches have focused on the effects of the rootstock/scion combinations on plant performance in terms of yield and fruit quality. In this respect, yield, apparent quality characteristics and chemical composition of the fruits from grafted plants should remain equal or improved with respect to the non-grafted plants. According to Gisbert et al. (2011), Moncada et al. (2013), Maršič et al. (2014) and Sabatino et al. (2016) grafting can influence yield and fruit quality in eggplant. Gisbert et al. (2011) found that the use of interspecific hybrid rootstocks derived from fully compatible crosses of eggplant with related species can be a valuable approach to improve eggplant production. Although *S. torvum* remains the most used eggplant rootstock, testing a panel of potential eggplant rootstocks (wild and allied species of eggplant and/or hybrids of *S. melongena*) might be very useful in sustainable intensive eggplant cropping systems. In this article, we study the influence of a group of potential rootstocks including both wild/allied species and hybrids of eggplant on plant vigor, yield and fruit quality traits of 'Birgah' F_1 eggplant hybrid.

2. Materials and methods

2.1. Plant material and nursery production

The study was carried out in 2014 and in 2015 at the experimental farm of the Department of Agricultural, Food and Forest Sciences of Palermo (SAAF) (longitude 13°19′E, latitude 38°09′N) in the northern coast of Sicily (Italy). Eggplant F_1 hybrid 'Birgah' (violet globose shape) was used as scion. Eight potential rootstocks were tested: *S. torvum* (STO), *S. macrocarpon* (SMA), *S. aethiopicum* (SASI), *S. aethiopicum* (SASa2), *S. paniculatum* (jurubeba) (SPA), *S. indicum* (SIN), 460 CAL., which is a tetraploid hybrid between *S. melongena* and *S. integrifolium* and, finally, Msa 2/2 E7 which is a double haploid line obtained from anther culture of the tetraploid backcrosses from the somatic hybrid eggplant cv Dourga(+) *S. aethiopicum* with a tetraploid plant of the eggplant line DR2 (Rizza et al., 2002; Toppino et al., 2008). Self-grafted and ungrafted controls were included.

For the production of the grafted plant material, rootstock seeds were planted in 44-cell seedling trays, under a temperature regime of 25 °C/18 °C (day/night) in a propagation greenhouse. After 20 days, seeds of the F_1 eggplant scion were planted in 104-cell trays under the same temperature regime and planting method as the rootstocks. Due to the faster germination and growth, the hybrid rootstock Msa 2/2 E7 was sown simultaneously to the F_1 hybrid scion. Trays were watered manually every day to maintain the substrate at water holding capacity. Seventy-five days after planting all seedlings had reached an adequate diameter for grafting. Grafting was carried out using the tube grafting method as described by Lee et al. (2010), but using grafting plastic clips rather than silicon tubes. The grafting involved cutting off the rootstock at a 45° angle and making a similar cut on the scion. Attention was paid to be sure that the diameters of the rootstock/scion were nearly identical so that the two exchange sites fitted perfectly. The grafting technique used was completed by attaching a plastic clip in the grafting point to ensure the correct fit and the correct amount of pressure was applied. The grafted plants were misted and maintained at a temperature of 20 °C and a humidity rate of 95% for 7 days. After 7 days, the grafted plantlets were acclimatized to the natural conditions of the greenhouse by slowly dropping the humidity (RH 70–80%) during 3 days, until they were ready for transplant.

2.2. Growing conditions

'Birgah' plants ungrafted, self-grafted, and grafted onto STO, SMA, SASI, SASa2, SPA, SIN, Msa 2/2 E7 and 460 CAL. rootstocks were transplanted on 5th May 2014 and 4th 2015 on a Typic Rhodoxeralf soil. The field trial was conducted in a sandy clay loam soil (46.5% sand, 22.3% silt, 31.2 clay) at pH 7.2. In both years, the preceding crop was cauliflower. The soil was prepared by making a medium-deep plowing (35 cm) and a reduction of the earth aggregates achieved by mechanical rotating means. The soil was mulched with a 20 μm black polyethylene (PE) film and plug plants were transplanted in single rows 100 cm apart. In row spacing was 0.50 cm (2 plants m^{-2}) and drip irrigated. During the growing period the crop received, by drip irrigation system 250 kg nitrogen ha^{-1}, 150 kg phosphorous pentoxide ha^{-1} and 250 kg potassium oxide ha^{-1}. The fertilization was calculated on the basis of theoretical uptake, expected yields and mineral elements in soil. All cultural practices recommended for eggplant cultivation in Mediterranean environment were adopted uniformly according to crop needs (Baixauli, 2001).

2.3. Weather conditions

Meteorological data (monthly air temperature, temperature deviation from the 1986–2015 average, maximum air temperature for the month and minimum temperature for the month) from May to August of 2014 and 2015 from the meteorological station of the experimental farm of the Department SAAF, University of Palermo, Italy (°C) were obtained (Table 1). In terms of temperatures, the weather during the experimental period in 2014 and 2015 was comparable to the long term average. However, the average monthly temperatures showed the

Table 1
Average monthly air temperatures, 1986–2015 temperature deviations, monthly maximum and minimum air temperatures for 2014 and 2015.

Month	Monthly air temperature (°C)	Temperature deviation from the 1986–2015	Maximun air temperature for the month (°C)	Minimum air temperature for the month (°C)
2014				
May	19.0	−0.2	23.1	16.9
June	21.6	−1.8	24.2	19.0
July	21.5	−0.5	28.5	22.8
August	27.0	0.1	31.2	24.0
2015				
May	18.7	−0.5	21.8	16.4
June	21.2	−2.2	23.5	18.6
July	21.4	−0.6	28.2	22.0
August	26.6	−0.3	30.2	23.6