

SCS 438 Zafira – a new plum cultivar resistant to leaf scald (*Xylella fastidiosa*)

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Crop Breeding and Applied Biotechnology
18: 229-233, 2018
Brazilian Society of Plant Breeding.
Printed in Brazil
<http://dx.doi.org/10.1590/1984-70332018v18n2c33>

Abstract: ‘SCS438 Zafira’ is a novel plum cultivar, adapted to southern Brazil. It produces high-quality fruits, very similar to ‘Fortune’, the standard mid-season cultivar. Its main advantage is the resistance to leaf scald. Apparently, the mechanism of resistance blocks the transmission of the bacteria by natural insect vectors (sharpshooters).

Key words: *Prunus salicina*, insect vectors, disease resistance, sharpshooters.

INTRODUCTION

Plum production, in Brazil, is based on “Japanese” cultivars (*Prunus salicina*) for their lower chilling requirement when compared with “European plums” (*Prunus domestica*) (Ducroquet and Mondin 1997). Although the term Japanese plum was originally applied to the species *Prunus salicina*, most commercial cultivars involve crosses with several plum species of the same genus. Consequently, the term ‘Japanese plum’ is currently applied to cultivars of *Prunus salicina* and its interspecific hybrids.

The most important limiting factor for plum production in Brazil is the leaf scald disease, which is caused by the bacterium *Xylella fastidiosa* Wells et al. (Xanthomonadales: Xanthomonadaceae) (Ducroquet et al. 2001). This bacterium infects the xylem vessels of plants and causes significant economic losses in several crops (Hopkins 1989). For instance, it causes leaf scald in plums (Raju et al. 1982), phony peach disease (Wells et al. 1987), pierce’s disease of grapevine (Davis et al. 1978), leaf scorch in coffee (Hartung et al. 1994), and citrus variegated chlorosis (CVC) (Chang et al. 1993, Hartung et al. 1994), among others.

Leaf scald seriously attacked plum orchards in the state of Santa Catarina from 1975 to 1982, causing damage to 90% of crops (Ducroquet and Mondin 1997). Despite the occurrence in all over the state, the disease is less intense in cold areas (Ducroquet and Mondin 1997).

X. fastidiosa, a gram-negative and xylem-limited bacterium, proliferates only in xylem vessels in roots, stems, and leaves. The vessels are ultimately blocked by bacterial aggregates and by tyloses and gums formed by the plant. Other forms of occlusion occur as a reaction of the host, such as the release of pectin and gums. Thus, the water and nutrients translocation is affected, which provokes water stress, membrane destruction, and obstruction xylem vessels (Mollenhauer and Hopkins 1976, Fry and Milholland 1990).

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Received: 03 May 2017
Accepted: 23 July 2017

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The bacterium is efficiently acquired by insect vectors, with no latent period, and persists in infective adult insects indefinitely. Therefore, this bacterium is primarily transmitted by insects, generally hemipterans (Yonce and Shang 1987), such as sharpshooters. In coffee, where the average level of natural infectivity potential was 30.4%, *X. fastidiosa* is transmitted by xylem-feeding insects, and four sharpshooters species have been reported as vectors (Vieira et al. 2007).

In plums, disease symptoms take three or more years to manifest in contaminated plants, which can be identified by apex drought, marginal necrosis, and leaf fall, delaying the growth and fruit ripening, reducing plant development, and finally, causing the plant to die (Mohan et al. 1980). Affected trees produce fewer and smaller fruits, and after 3-5 years, they become economically worthless.

Most of the plum cultivars are susceptible to this disease. Since the disease is transmitted by sharpshooters and due to the many *X. fastidiosa* alternative hosts, the inoculum dissemination is practically unavoidable (Ducroquet et al. 2001). Thus, the primary challenge of plum breeding programs in Brazil is to obtain plum cultivars resistant or tolerant to leaf scald. Although some cultivars have been reported as resistant, they usually produce low-quality fruits. In addition, the inheritance of resistance is polygenic and predominantly recessive (Dalbó et al. 2010).

The plum breeding program of Epagri, in the state of Santa Catarina, started in 1990, and involves two Experiment Stations, one in Videira and another in Urussanga. The sources of resistance used in crosses were materials collected in the delta of Parana River (Argentina) and in Florida (USA), where the disease has been occurring since long time ago. A major finding was the identification of a plum selection (SC7) that seems to be immune to *X. fastidiosa*, and other selections with the mechanism that blocks the transmission of the bacteria by insect vectors (Dalbó et al. 2016). This study presents the first commercial plum cultivar that is not naturally infected with *X. fastidiosa*.

PEDIGREE AND BREEDING METHODS

'SCS438 Zafira' was selected from the cross SC7 ('Laetitia' x 'Piamontesa') x 'Fortune', carried out in 2007, at Epagri – Videira Experiment Station (lat 27° 02' 12" S, long 51° 08' 04" W, alt 820 m asl), in the municipality of Videira, state of Santa Catarina, Brazil. 'Piamontesa' is an old plum landrace, collected in the delta of Paraná River (Argentina), where it was selected for resistance to leaf scald (Bakarcic and De Santis 1969). Laetitia (or Letícia, as it is known in Brazil) and Fortune cultivars are moderately resistant to leaf scald and the most planted plum cultivars in southern Brazil.

Two hundred and seventy-five seedlings were obtained from this cross in 2007. The first harvest was performed in 2010, when the plant was selected as SC 13 due to its superior fruit quality (size, appearance, and taste). In 2011, SC 13 was grafted over peach seedlings, and three plants were introduced to the plum cultivar collection of Videira Experiment Station to be compared with standard cultivars. In 2012, SC13 was multiplied, and 60 plants were planted in two private plum orchards to be evaluated under standard commercial conditions. From 2013 to 2016, the following traits were evaluated: yield, fruit quality (size, appearance, flavor), and cold storage capacity (compared with Fortune, a standard cultivar for the region). PCR tests were regularly performed to detect the presence of *Xylella fastidiosa* in field-maintained plants. The results were always negative, indicating that this cultivar is not infected under natural conditions. However, when the cultivar was grafted over infected plants of cultivar Fortune, besides becoming positive for *Xylella* by the PCR test, it also presented some symptoms of leaf scald.

PERFORMANCE

The fruits of 'SCS438 Zafira' are very similar to those of the cv. Fortune, which is a standard mid-season cultivar in southern Brazil, used as the male parent of the former. Both produce large, bright-red, and very attractive fruits. Consumers do not visually distinguish these two cultivars when the fruits are fully ripened. Nevertheless, differences are observed in the evolution of ripening. In 'Fortune', fruit color comes up approximately one week earlier; however, the maturation process is slower, with a relatively long period when the fruits are well colored but not proper for consumption yet. Conversely, in 'SCS438 Zafira', the maturation process is faster, and the fruit color provides a better indication of the point of maturity for consumers. The disadvantage is a shorter shelf life and a shorter harvest period for growers. However, the first experiences on the market indicated that consumers preferred the taste of SCS 438 Zafira cultivar when compared with that of 'Fortune', which was probably because the former was consumed at the right point of maturation.

'SCS438 Zafira' is an alternative to 'Fortune' in the south of Brazil, since both are harvested at the same time, when there is a peak of fruit consumption in the market. The great advantage is the possibility of being produced in the absence of leaf scald. Table 1 shows the comparison between the two major plum cultivars (Fortune and Laetitia) of the south of Brazil. The fruits of 'SCS438 Zafira' are bigger, probably because the evaluations were performed in a region where *Xylella fastidiosa* is endemic, and the absence of infection was advantageous for this cultivar.

The blooming time of 'SCS438 Zafira' occurs between that of Fortune and Laetitia, but it can be anticipated with treatments for dormancy breakage. Data presented in Table 1 were obtained with the application of Dormex (1%) in the last two years, when the blooming time was very close to that of cultivar Fortune. In the first year (2013), without dormancy breakage treatments, flowering started 12 days later when compared with Fortune.

'SCS438 Zafira' is adapted to regions with 350-550 chilling hours (<7.2 °C), which corresponds to altitudes between 600 to 1000 meters above the sea level in the south of Brazil. The adaptation range is probably higher; however, further experiments in different areas are required for an accurate evaluation.

The fruit yield capacity of 'SCS438 Zafira' has not been well estimated due to difficulties in finding good pollenizers. This cultivar is not self-compatible and requires an adequate distribution of pollenizer plants in the orchard. Although standard cultivars can be used as pollenizers, breeding selections that have not been infected by *Xylella fastidiosa* are adequate to guarantee the same shelf life expectation. Some resistant materials available in the breeding program of Epagri were initially used as pollenizers. However, the blooming time was not coincident in all the years of evaluation. The deficiencies in pollination resulted in crop losses and high variability among plants in terms of productivity. However, the occurrence of well-pollinated plants indicates that the productivity is similar to that of cultivars Fortune and Laetitia in the region, which means 30-35 t ha⁻¹ for low-density, and 40-50 t ha⁻¹ for high-density orchards. In one private orchard, for instance, productivity in 2015 (the first crop) was close to 30 t ha⁻¹ and it was less than 20 t ha⁻¹ in the following year (2016), due to an inadequate pollination.

The difficulty in defining good pollenizer genotypes was due to a large variation in climate in the past years. From 2014 to 2015, the region underwent the effect of "el niño", a climatic phenomenon that causes high rainfall and mild winters in the south of Brazil. In 2016, the winter was much colder, and the pollenizers that had been selected in previous years flowered earlier than 'SCS438 Zafira'. Nevertheless, some selections had similar flowering time during all these years, such as SC17 and SC27 (Table 1), and can be used to pollinate 'SCS438 Zafira'. Up to now, only SC7, the mother plant, showed to be incompatible with 'SCS438 Zafira'.

OTHER TRAITS

According to the results of PCR tests, plants of 'SCS 438 Zafira' have been maintained free of *Xylella fastidiosa* for ten years, despite being close to contaminated plants of susceptible varieties. Apparently, these plants have a mechanism that

Table 1. Bloom, beginning of harvest, and mean fruit weight of SCS438 Zafira, SC27, and the most important plum cultivars in South Brazil (Fortune and Laetitia), in three consecutive years

Harvest	Genotype	Bloom	Beginning of harvest	Fruit weight (g)
2014/15	SCS438 Zafira	08.30 – 09.15	18/12	85
	Fortune	08.18 – 09.06	23/12	73
	Leticia	10.01 – 10.18	-	-
	SC27*	08.25 – 09.08	-	-
2015/16	SCS 438 Zafira	08.14 – 08.27	11/12	98
	Fortune	08.16 – 08.29	10/12	94
	Leticia	08.30 – 09.14	13/01	83
	SC27	08.13 – 08.24	-	-
2016/17	SCS 438 Zafira	08.10 – 08.24	09/12	108
	Fortune	08.09 – 08.23	09/12	96
	Leticia	08.30 – 09.16	17/01	92
	SC27	08.12 – 08.23	-	-

* Possible pollenizer for SCS438 Zafira; Site: Epagri – Estação Experimental de Videira (lat 27° 02'12" S, long 51° 08' 04" W, alt 820 m asl)

Table 2. Total soluble solids, titratable acidity, fruit firmness, and fruit weight of cultivars SCS438 Zafira and Fortune stored for 30 days in cold storage (0 – 0.8 °C), followed by three days of shelf life (23 °C)

Genotype	Storage	Soluble Solids (°Brix)	Titratable acidity (meq L ⁻¹)	Fruit firmness (lbs)	Fruit weight (g)
2016/2017					
SCS438 Zafira	harvest	10.7 bB	220 bA	5.6 bA	82.0 aA
SCS438 Zafira	30 days after	11.6 aA	211 aA	4.5 bB	75.0 aB
Fortune	harvest	11.1 aB	286 aA	6.4 aA	75.4 bA
Fortune	30 days after	11.6 aA	226 aB	5.0 aB	70.0 aB
2015/2016					
SCS438 Zafira	harvest	11.1 bA	217.0 bA	5.4 bA	110.0 aA
SCS438 Zafira	30 days after	10.9 bA	156.7 bB	4.5 bB	86.8 aB
Fortune	harvest	12.2 aA	263.3 aA	8.2 aA	95.7 Ba
Fortune	30 days after	11.7 aB	190.4 aB	6.2 Ab	92.3 Aa
2014/2015					
SCS438 Zafira	harvest	9.6 bB	194.9 aA	6.3 bA	105.3 aA
SCS438 Zafira	30 days after	10.7 bA	130.4 aB	3.8 aB	87.0 aB
Fortune	harvest	11.8 aB	211.4 aA	7.7 aA	88.0 bA
Fortune	30 days after	12.9 aA	133.7 aB	3.4 bB	82.0 aB
Mean					
SCS438 Zafira	harvest	9.6 bB	194.9 bA	6.3 bA	105.3 aA
SCS438 Zafira	30 days after	10.7 bA	130.4 aB	3.8 aB	87.0 aB
Fortune	harvest	11.8 aB	211.4 aA	7.8 aA	88.0 bA
Fortune	30 days after	12.9 aA	133.7 aB	3.4 bB	82.0 aA

* Lowercase letters: comparison between cultivars; uppercase letters: comparison between storage time, by the Tukey's test, at 5% of probability.

blocks the transmission by insect vectors (sharpshooters). However, transmission of the bacteria occurs by grafting on infected plants, as xylem vessels are connected. The reasons why the bacteria do not contaminate 'SCS438 Zafira' plants are not well understood, but some pieces of evidence indicate that this cultivar presents repellence effect. In a study carried out at USP-ESALQ (Insect Vectors Lab), the sharpshooter *Sibovia sagata* presented a clear preference to feed on 'Laetitia' than on 'SCS438 Zafira'. Although the mechanism that blocks *Xylella* transmission, present in this cultivar, seems to be effective in different environments, the stability of this form of resistance will only be known in long-term evaluations. Nevertheless, this resistance form is the easiest way to enable plum cultivation without leaf scald in areas where this disease is endemic.

This new variety is characterized by having good fruit appearance (Figure 1) and lower acidity at harvest time when compared with 'Fortune' (Table 2). Conversely, the lower sugar content and lower pulp firmness result in smaller storage potential when compared with 'Fortune', with a greater loss of weight and firmness of the pulp during cold storage (0 ± 0.8 °C) (Table 2). This fact does not compromise the variety, since at the harvest time (near Christmas), the fruit price is usually high, and the growers do not store them for a long time.

GERMPLASM MAINTENANCE AND DISTRIBUTION

'SCS438 Zafira' is registered by the National Cultivar Registry (Registro Nacional de Cultivares - RNC) of the Ministry of Agriculture, Livestock, and Food Supply (Ministério da Agricultura Pecuária e Abastecimento – MAPA), under the number 36024, in Brazil. Epagri is in charge of the genetic and basic material.



Figure 1. General aspects of SCS438 Zafira fruits.

ACKNOWLEDGEMENTS

The authors thank FINEP and FAPESC for the financial support of this work.

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