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Phenology, vegetative growth, and yield performance of fig in Southeastern Brazil

Abstract – The objective of this work was to evaluate the phenological patterns, vegetative growth, and yield characteristics of fig (*Ficus carica*) varieties in Southeastern Brazil. The 'Roxo de Valinhos', White Genova, PI-189, and Troyano varieties were distributed in a randomized complete block design and evaluated in the field. The following characteristics were assessed: number of days between pruning and the beginning of sprouting; leaf chlorophyll content; number of shoots on each branch; length, diameter, and number of internodes on each branch; number of leaves per plant; leaf area; number of fruit per plant; mass, length, and diameter of fruit; production and yield; and duration (days) of each phenological stage, such as thermal requirement models. 'Roxo de Valinhos' and White Genova sprouted the fastest and showed the largest number of shoots. Troyano obtained the greatest branch length and diameter, as well as the greatest number of fruit per plant, which had the shortest diameter and length and the lowest mass of fruit. Furthermore, Troyano showed the latest harvest, besides the thermal requirement of 4,577.31 degree-days. 'Roxo de Valinhos' and White Genova produced fruit with the greatest average mass and diameter and the longest length. Troyano shows better vegetative growth and produces more fruit per plant than 'Roxo de Valinhos', but both genotypes show similar yields.

Index terms: *Ficus carica*, degree-days, leaf area, production, pruning.

Fenologia, crescimento vegetativo e rendimento de figueira no Sudeste do Brasil

Resumo – O objetivo deste trabalho foi avaliar os padrões fenológicos, o crescimento vegetativo e as características de rendimento de variedades de figueira (*Ficus carica*) no Sudeste brasileiro. As variedades 'Roxo de Valinhos', White Genova, PI-189 e Troyano foram distribuídas em delineamento de blocos ao acaso e avaliadas em campo. As seguintes características foram avaliadas: número de dias entre a poda e o início da brotação; teor de clorofila das folhas; número de brotos por ramo; comprimento, diâmetro e número de entrenós de cada ramo; número de folhas por planta; área foliar; número de frutos por planta; massa, comprimento e diâmetro dos frutos; produção e produtividade; e duração (dias) de cada estágio fenológico, tais como modelos de requerimento térmico. 'Roxo de Valinhos' e White Genova brotaram mais rapidamente e apresentaram maior número de brotações. Troyano obteve os maiores diâmetro e comprimento dos ramos, assim como maior número de frutos por planta, os quais tiveram os menores diâmetro, comprimento e massa. Além disso, Troyano apresentou colheita mais tardia e necessidade térmica de 4.577,31 graus-dia. 'Roxo de Valinhos' e White Genova apresentaram frutos com maior massa, diâmetro e comprimento. Troyano apresenta melhor desenvolvimento vegetativo e produz mais frutos por planta do que 'Roxo de Valinhos', mas os rendimentos de ambos os genótipos são similares.

Termos para indexação: *Ficus carica*, graus-dia, área foliar, produção, poda.

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Introduction

The Mediterranean basin is the largest fig producer in the world. In this region, Turkey, Egypt, Algeria, Morocco, and Iran are known to grow figs. Besides, Turkey is known to be the world's largest producer. Some other countries, such as USA and Brazil, have also a significant fig production. In 2017, Brazil was the 9th largest producer, with 25,9 thousand tonnes (FAO, 2019).

The production of fig cultivars can occur twice a year; and the first crop is called Breba (one-year-old shoots), and the second is called mammoni (current-season shoots). In Brazil, there is only the production of mammoni figs, due to drastic pruning performed in winter. According to Gaaliche et al. (2011), climatic conditions during branch growth directly affect the production of mammoni figs.

'Roxo de Valinhos' (*Ficus carica* L.) is the most used by Brazilian producers due to its high economic value, rusticity, vigour, and yield, as well as to its severe pruning adaptation. Fruit from this cultivar are often destined to fresh consumption or industry (Dalastra et al., 2009). This cultivar originally produces breba and mammoni figs (Pio & Chagas, 2011). It has commonly been assumed that 'Roxo de Valinhos' came from a plant material that was introduced by Italian immigrants in Brazil. Furthermore, this cultivar would be known as Brown-Turkey, Corbo, Nero, Black-wide, Portugal-black, Nigra, among others.

Concerns about the sustainability of Brazilian fig production are growing, mainly because the cultivation is based on the use of a single cultivar. Although 'Roxo de Valinhos' is vigorous and rustic, some problems have been identified, such as its susceptibility to nematodes and high-fruit perishability.

Therefore, it is necessary to study other genotypes adapted to Brazilian production systems, which can allow of conducting plant diversity and productive orchards.

There are many fig varieties that are grown around the world. Although some fig varieties are not currently cultivated in massive scale in Brazil, some research institutes and universities maintain living collections of them, such as White Genova, Troyano and the fig selection of 'Roxo de Valinhos', obtained by irradiated buds. Nevertheless, Troyano and White Genova are Italian varieties of the common group that produce parthenocarpic fruit, and are freely accessible. White Genova has moderately vigorous plants with scattered branches and large leaves, and produces breba figs that are known for their average weight of 80 g; such figs are obliquely pear-shaped, with a short neck and, sometimes, show a prominent curved neck, a short stalk, also showing gelatinous pulp, with mild flavour, and is susceptible to deterioration. In USA, Troyano is widely grown, and is much appreciated for late summer and early autumn fruit production, that is, mammoni figs (Condit, 1955). Finally, PI-189 is a mutant selection of 'Roxo de Valinhos', originated from gamma-irradiated buds at the Centro de Energia Nuclear na Agricultura/Universidade de São Paulo (Cena/USP) in the municipality of Piracicaba, in the state of São Paulo, Brazil (Rodrigues et al., 2009). In comparison with 'Roxo de Valinhos', PI-189 stands out, since it shows good yields, as well as small and closed ostiole, according to the authors.

By evaluating the initial growth of 45 fig accessions in the municipality of Dracena, in the São Paulo state, Brazil, Rodrigues et al. (2019a) verified an intermediate growth for 'Roxo de Valinhos', White Genova, and Troyano. However, PI-189 plants showed a lower-vegetative development than these varieties. In another study, Rodrigues et al. (2019b) evaluated the biometric characteristics of several fig trees, highlighting Troyano for its divergence from others, as well as its potential for the genetic improvement of fig culture.

However, there is a paucity of literature examining the productive performance of these materials. Also, plant growth should be evaluated under different climatic conditions to represent safety to the crops. These types of study would allow of more options to producers by the identification of promising genotypes, as well as by strengthening the fig cultivation in Southeastern Brazil, which is a promising region due to the consumers proximity and good chances of export success.

The objective of this work was to evaluate the phenological patterns, vegetative growth, and yield characteristics of fig varieties in Southeastern Brazil.

Materials and Methods

The current study was conducted in the orchard of the Lageado experimental farm (22°51'55"S, 48°26'22"W, at 810 m altitude) which belongs to the

Universidade Estadual Paulista Júlio de Mesquita Filho, Faculdade de Ciências Agronômicas (Unesp, FCA), in the municipality of Botucatu, in the state of São Paulo, Brazil. According to the Köppen-Geiger's climate classification, the area is of the mesothermic type (Cwa), that is, humid subtropical, with dry winters; rains occur from November to April and the precipitation is 1,433 mm, with 71% relative, and mean temperature is 19.3°C (Cunha & Martins, 2009). In this area, the soil is classified as Nitossolo Vermelho, according to Santos et al. (2013). All meteorological data were provided by the de Soil and Environmental Resources Department, at the Unesp/FCA .

The experiment was carried out during the 2015/2016 crop season (July 2015 to July 2016) with two-year-old plants. Plant seedlings of White Genova, Troyano and PI-189 figs were obtained from the germplasm bank of Unesp, Faculdade de Engenharia (Unesp, FIES), in the municipality of Ilha Solteira, SP, Brazil. In addition, 'Roxo de Valinhos' seedlings were obtained from the nursery of Agência Paulista de Tecnologia dos Agronegócios (APTA) in the municipality of Itaberá, SP, Brazil. Seedlings were planted in plastic bags filled with the commercial substrate Tropstato HT Hortaliças (Vida Verde, Mogi Mirim, SP, Brazil) and sand at 2:1 ratio. Then, the seedlings were planted at 3.0 x 2.0 m spacing, in the previously fertilized field according to crop requirements (Raij et al., 2001) and soil analysis.

Soil samples were collected at 0–20 cm soil depths in June 2015. Subsequently, they were homogenized and sent for analysis to the Laboratory of Mineral Nutrition of Plants of the Unesp/FCA, and the following results were obtained: pH ($CaCl_2$), 5.1; OM, 31 g dm^{-3}; P_{resin}, 58 mg dm^{-3}; H + Al, 41 mmol dm^{-3}; K, 1.8 mmol dm^{-3}; Ca, 42 mmol dm^{-3}; Mg, 12 mmol dm^{-3}; sum of bases (SB), 56 mmol dm^{-3}; CEC, 97 mmol dm^{-3}; base saturation, 58%; and S, 51 mg dm^{-3}.

Winter pruning or dormant pruning was performed in all varieties on August 8, 2015. After pruning, six branches were conducted per plant. Throughout the whole experiment period, crop treatment recommendations were made (Maiorano et al., 2018).

The following varieties were used as treatments: 1, 'Roxo de Valinhos', a genotype that is more planted in Brazil and that was used as a control in this study; 2, White Genova, a genotype of Italian origin that was selected in the Instituto Agronômico (IAC), in the municipality of Campinas, in the state of São Paulo, and maintained in the germplasm bank of Unesp/FEIS; 3, Troyano, a genotype of Italian origin that was selected in the IAC and maintained in the germplasm bank of Unesp/FEIS; and 4, PI-189, a fig mutant selected from 'Roxo de Valinhos'.

The following phenological phases were evaluated: budding stage (BS), interval between pruning and the beginning of sprouting; growth stage (GS), that is the interval between sprouting and the beginning of harvest; harvest stage (HS), between the beginning and the end of the harvest; and total cycle (between the pruning and the of harvest end). These stages were evaluated for duration (number of days), thermal accumulation (degree-days, ΣDD, and time of occurrence (dates). The thermal accumulation was calculated by considering the minimum basal temperature of 8ºC, and the maximum basal temperature of 36ºC (Souza et al., 2009). For the characterization of the thermal requirements, we used the methodology proposed by Ometto (1981).

For the vegetative traits, three branches were marked in each plant, and evaluations were performed at a 30-day-interval, until 240 days after pruning (DAP), except for chlorophyll levels which were evaluated at the end of the period, and the number of shoots per branch which were evaluated at 7, 14, 21, 28, and 35 DAP. The following vegetative characteristics were evaluated: branch length (cm), measured using a graduated tape from the base to the apical branch meristem; branch diameter (mm), determined using a digital calliper in the basal region of the branch; number of shoots and number of internodes per branch; number of leaves per plant; and leaf area (cm^2), using the LI-3100C Area Meter (LI-COR Biosciences, Lincoln, USA); and leaf chlorophyll levels (a, b, and total), extracted in 10 mL of 80% acetone (for 4 cm of fresh sample), placed in 25 mL Becker, coated with aluminium foil, and stored under refrigeration for 48 hours. An aliquot of the chlorophyll extract was transferred to a 3 mL glass cuvette, and the absorbance reading was performed at 645 nm and 663 nm wavelengths. Arnon's equation (Arnon, 1949) was used to determine their absorbance (mg m^{-2}).

As to the production, a sum of the total number of ripe fruit harvested per plant was determined, to obtain the total number of fruit produced and the quantity produced per plant (g). Yield was determined considering a stand of 1,666 plants ha^{-1} (kg ha^{-1}).

A randomized complete block design was conducted, using four treatments, each one replicated four times, with eight plants per plot. The six central plants of each block were evaluated. For the vegetative characteristics of diameter and length of branches, number of internodes per branch, number of leaves per plant and leaf area, split-plot was considered in the design, and the plots corresponded to the fig varieties, and the subplots to the evaluation days (30 , 60, 90, 120, 150, 180, 210 and 240 DAP). Similarly, the same split kind was considered for the number of shoots per plant, for which the subplots were 7, 14, 21, 28 and 35 DAP. The analysis of variance was performed and, when means were significant, they means compared by Tukey's test, at 5% probability, and the regression analysis was performed for quantitative variables (DAP).

Results and Discussion

The results for the phenological cycles and occurrence periods indicated that Troyano showed the longest total cycle duration, as it took from the beginning of August (pruning) until the end of June (Figure 1). Fig trees require a warm climate and high luminosity to obtain high yields during the growth stage. In this sense, Troyano showed a late cycle, since its vegetative development and fruit emission took more time and warmer days, consequently enabling the photosynthetic activity and fruiting.

The harvest of Troyano began in the second half of February and was the longest one, that is, until the end of June, in comparison to 'Roxo de Valinhos' that is quite dominant in the state of São Paulo, and whose harvest lasted until the second half of March (Figure 1). These data allow of the indication of Troyano to enter the food market, when 'Roxo de Valinhos' ends its production in the state of São Paulo.

It is noteworthy to mention that the Troyano harvest occurred under a reduced precipitation and low-temperature period, whereas the harvest of the other varieties occurred under increased rainfall and high temperature conditions (Figure 1). Excess rainfall impairs fruit quality, but fruit development accelerates in a combination of adequate rainfall volume and high temperatures, which explains the longer cycle of Troyano (from 19/02 to 23/06).

As to the duration of the phenological cycles in days, Troyano showed the longest total cycle of 325 days (Table 1), which allowed of its characterization as a late variety. Such a characteristic can give plants a greater susceptibility to pests and diseases, since they spend more time in the field, which leads to more expenses to the producer. However, it also could allow of the production staggering by fig producers, who can use cultivars in different maturity periods, such as PI-189 and White Genova that showed the shortest cycle of 216 days in the current work. Furthermore, the other varieties also showed shorter cycles, although this finding was not statistically significant (Table 1).

Major differences among varieties in each stage duration were observed (Table 1). The budding stage of 'Roxo de Valinhos' (13.75 days) was the shortest one, did not differ from White Genova (14.25 days), while Troyano showed the highest averages in all stages, which resulted in a longer-cycle duration. The harvest stage contributed most to the longer-cycle length in Troyano (125.25 days).

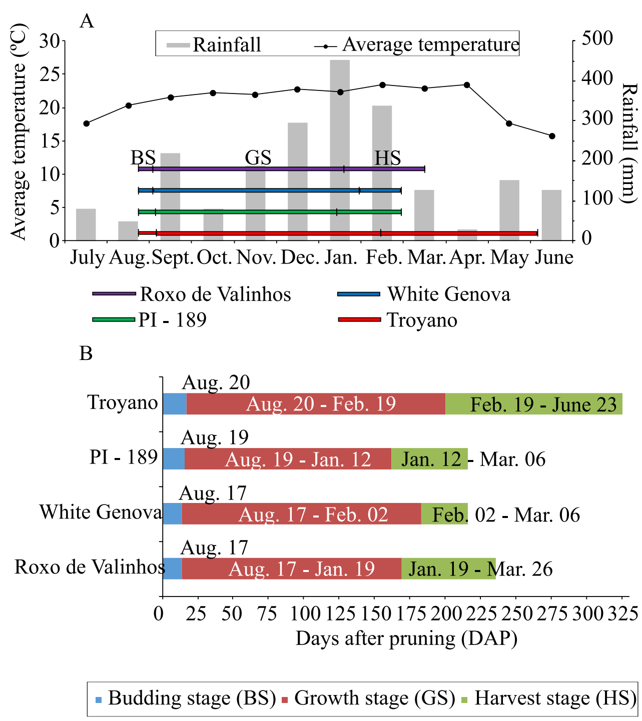

Figure 1. Mean monthly temperature, rainfall, and harvest period (A), and duration, in days, of each phenological cycle of fig tree (*Ficus carica*) varieties (B), of the 2015/2016 crop season, in the municipality of Botucatu, in the state of São Paulo, Brazil.

In a study with 'Roxo de Valinhos', in the municipality of Botucatu, SP, Brazil, Leonel & Tecchio (2010a) obtained a harvest stage of 91 days in the 2004/2005 cycle, and 132 days in the 2005/2006 cycle, indicating that the cycle length is intrinsically related to climatic factors. In the current study, 'Roxo de Valinhos' obtained a harvest stage of 67 days.

For the number of days of each stage, there was a similar effect on thermal accumulation (Table 1). 'Roxo de Valinhos' and White Genova were the ones with the shortest budding stage, with 204.66 and 207.98 degree-days (DD), respectively. For growth stage, PI-189 and 'Roxo de Valinhos' showed 2,115.87 and 2,254.13 DD, respectively. For harvest stage, White Genova and PI-189 showed the shortest period – 513.61 and 843.96 DD –, respectively. Considering the total cycle, Troyano showed 4,577.31 DD, which is the longest length.

Souza et al. (2009) reported that the thermal requirement was 1,955 degree-days for 'Roxo de Valinhos' to develop from August pruning until the beginning of the harvest in Botucatu, SP, Brazil. Dalastra et al. (2009) obtained 3,870.89 DD in 'Roxo de Valinhos' from pruning to the end of harvest, in the western of Paraná state, Brazil.

The cycle length varies according to the genotype and the environmental conditions, such as solar radiation, accumulated degree-days, and air temperature. Studies involving the relationship between cycle length and air temperature show that higher-air temperatures adversely affect the plant growth, as plants can rapidly develop, but the production cycle decreases (Neis et al., 2010).

Each evaluated cultivar responded differently to prevailing weather conditions, mainly in relation to the availability of solar radiation and air temperature which interfered in the calculation of degree-days. These results show the need of more local researches, since multienvironment trials are commonly assessed in cultivar adaptation patterns under different environmental conditions.

For vegetative characteristics, growth differences were observed in the evaluated cultivars, in relation to DAP. The number of shoots per branch of Troyano increased linearly until 35 DAP, reaching 2.48 (the lowest mean registered in this assessment) (Figure 2 A). However, there was a quadratic increase of the number of shoots for the other varieties. 'Roxo de Valinhos' had the highest number of shoots in all evaluations after pruning. Troyano obtained an average of two shoots per branch only at 28 DAP. However, the other varieties obtained similar values at 21 DAP.

Table 1. Number of days and degree-day accumulation (ΣDD) for budding, growth, and harvest stages, and total cycle of fig (*Ficus carica*) varieties, of the 2015/2016 crop season, in the municipality of Botucatu, in the state of São Paulo, Brazil[(1)].

Variety	Budding stage	Growth stage	Harvest stage	Total cycle
		Number of days		
Roxo de Valinhos	13.75c	154.75bc	67.00b	235.50b
White Genova	14.25bc	168.50ab	32.50c	215.25b
PI-189	15.75ab	145.75c	54.00bc	215.50b
Troyano	17.25a	182.50a	125.25a	325.00a
Coefficient of variation (%)	5.13	4.54	20.29	6.33
Least significant difference (LSD)	1.73	16.34	31.23	34.62
		Degree-day accumulation (ΣDD)		
Roxo de Valinhos	204.66b	2,254.13bc	1,053.64b	3,512.42b
White Genova	207.98b	2,467.25ab	513.61c	3,188.83b
PI - 189	228.69a	2,115.87c	843.96bc	3,188.51b
Troyano	244.14a	2,702.54a	1,630.62a	4,577.31a
Coefficient of variation (%)	4.05	4.95	20.98	6.74
Least significant difference (LSD)	19.78	260.66	468.12	538.59

[(1)]Means followed by equal letters, in the columns, do not differ by Tukey's test, at 5% probability.

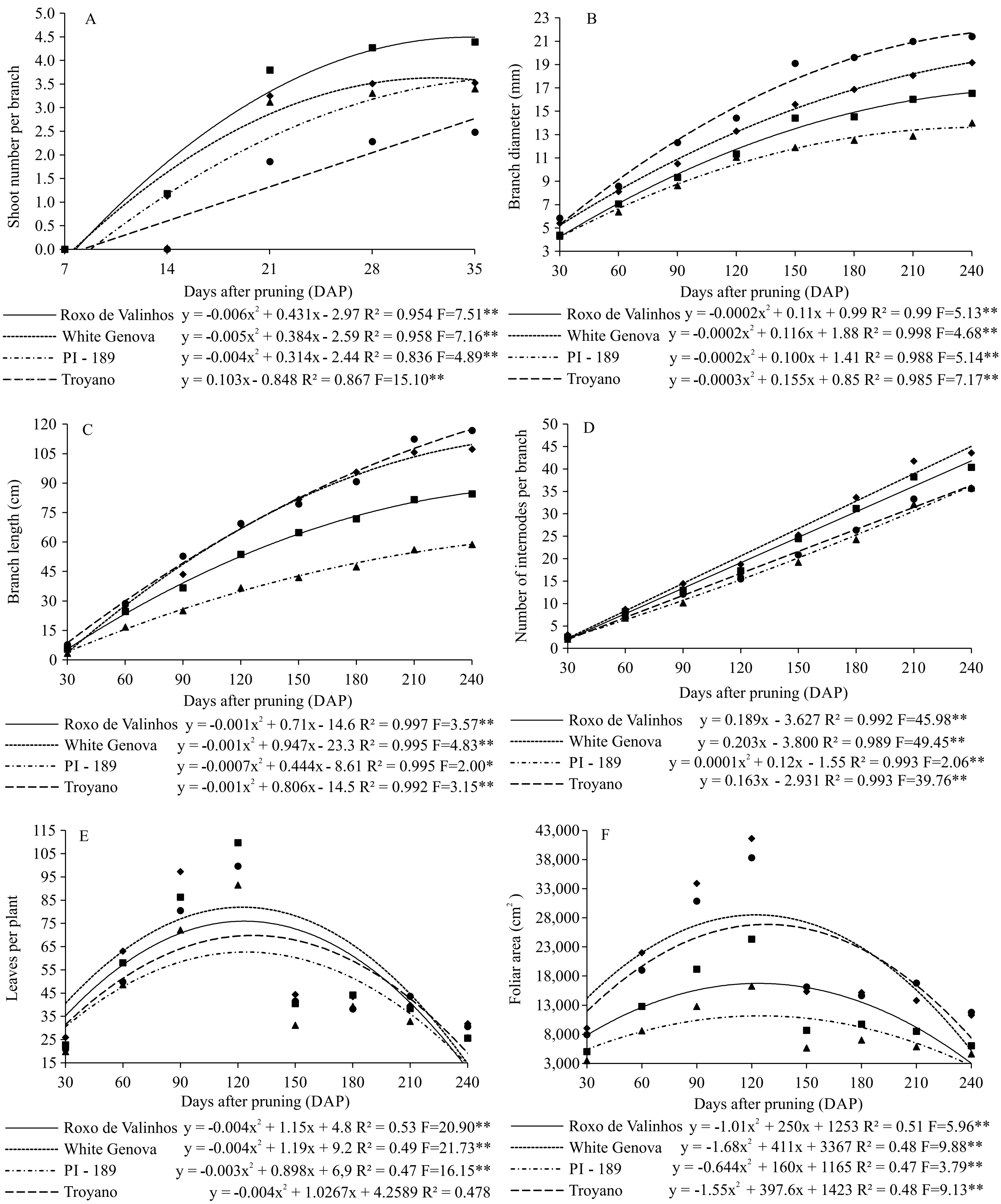

Figure 2. Number of shoots per branch (A), diameter (B), and length (C) of branches, number of internodes per branch (D), number of leaves per plant (E), and leaf area (F) in function of days after pruning for sprouting start in fig (*Ficus carica*) varieties, of the 2015/2016 crop season, in the municipality of Botucatu, in the state of São Paulo, Brazil.

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As to the interaction between varieties and DAPs, there was a significant effect for branch diameter, branch length, and number of internodes number. In most varieties, quadratic polynomial regression model appears to fit the data best for growth estimates, that is, a higher initial growth followed by a period of progressive reduction. Troyano showed the highest values (21.4 mm) for branch diameter from the first evaluation (30 DAP) to the last one (240 DAP) (Figure 1 B). PI-189 mutant selection had the lowest values from the first to the last evaluation.

'Roxo de Valinhos', the genotype used as control, performed higher values than PI-189; however, both showed lower values than the other varieties for branch diameter and length, in all evaluation periods (Figures 2 B and C).

'Roxo de Valinhos' mean values varied from 51.56 to 63.40 mm for primary branches diameter that had been pruned in August (Leonel & Tecchio, 2010b). Moreover, Souza et al. (2018) evaluated 'Roxo de Valinhos' in the presence or absence of irrigation for the first production cycle, and recorded values higher than 30 mm for branch diameter at 240 DAP.

Troyano showed the highest mean (116.83 cm) for branch length at 240 DAP, followed 'Roxo de Valinhos' (84.49 cm) (Figure 2 C). Leonel & Tecchio (2010a) reported mean values of 114 and 155 cm for 'Roxo de Valinhos'. Dalastra et al. (2009) reported that four-year-old plants pruned in August showed a mean branch length of 128.43 cm at the end of the cycle. In turn, Rodrigues et al. (2019a) evaluated one-year-old plants, and found higher lengths for 'Roxo de Valinhos' (101 cm), Troyano (100 cm), and White Genova (93 cm) than PI-189 (71 cm). These differences can be attributed to climatic and cultivation conditions during plant growth, as well as to genetic factors and plant age.

Results indicate a linear increase in all varieties for the number of internodes per branch, except for PI-189 that presented a quadratic increase (Figure 1 D). Troyano obtained a higher mean value than PI-189 only. However, Troyano has shown the highest values for branch length in almost all evaluation periods; such fact shows that this variety internodes are more spaced than the others; therefore, Troyano can better withstand water deficiency.

The maximum number of leaves per plant occurred at 120 DAP, from which a decrease in the number of leaves and, consequently, in the leaf area began (Figure 2 E). This decrease occurred because it coincided with the beginning of harvest for most varieties, which were considered preferential drains. These results corroborate those found by Silva et al. (2011), who evaluated the relation between source and sink through carbon isotopic labelling techniques, by using ^{13}C to study the allocation of photoassimilates in 'Roxo de Valinhos'; these authors found that in plants bearing fruit and shoots, the isotopic signal was higher in fruit, indicating that there is a greater translocation of photoassimilates to these organs.

Troyano and White Genova were the genotypes that obtained the largest leaf area in all evaluation periods (Figure 2 F). A higher-leaf area was expected for White Genova due to its larger number of leaves. However, Troyano obtained a reduction of the number of leaves per plant that was higher only than PI-189, showing the largest size of its leaves. Nevertheless, it is worth highlighting the vegetative performance of Troyano under the studied conditions, since there is an intrinsic relationship between leaf area and stomatal conductance, as high- and low-water regimes affect stomata opening, so that ideal conditions result in greater CO_2 assimilation and biomass accumulation (Nicotra & Davidson, 2010).

Leaf chlorophyll contents (a, b and total) did not differ among varieties (Table 2). According to Souza et al. (2019), the chlorophyll content represents the leaf quality, and it is directly related to plant photosynthetic

Table 2. Chlorophyll content (a, b, and total) in leaves of fig trees (*Ficus carica*), of the 2015/2016 crop season, in the municipality of Botucatu, in the state of São Paulo, Brazil[(1)].

Variety	Chlorophyll a (mg m^{-2})	Chlorophyll b (mg m^{-2})	Total chlorophyll (mg m^{-2})	Chlorophyll a/b
Roxo de Valinhos	404.60a	122.84a	527.45a	3.29ab
White Genova	403.42a	115.48a	518.90a	3.51a
PI-189	355.37a	108.81a	464.18a	3.26ab
Troyano	369.34a	115.30a	484.64a	3.20b
CV (%)	9.90	9.96	9.82	3.79
LSD	83.77	25.41	108.15	0.28

[(1)]Means followed by equal letters, in the columns, do not differ by Tukey's test at 5% probability. CV, coefficient of variation; LSD, least significant difference.

efficiency and, consequently, to their growth. However, differences were observed between varieties for the ratio of chlorophyll a/b (Table 2). The variations in chlorophyll a/b ratio rise due to the differences between photosystems I and II (PSI / PSII), as well as to size and composition of the antenna complex of each photosystem that is responsible for light collection. These differences also can be attributed to growing and environmental conditions, as well as to the phenological stage (Cancellier et al., 2011; Borek et al., 2016).

For Troyano, there was a reduction of the ratio of chlorophyll a/b, but that was not statistically different from 'Roxo de Valinhos' and PI-189. However, White Genova showed a higher chlorophyll a/b ratio (Table 2). According to Cancellier et al. (2011), cultivars that have a lower-chlorophyll a/b ratio are more efficient in capturing light, so that the plant can more efficiently capture the solar radiation at a time of low irradiance; therefore, there is a higher photosynthetic rate during its cycle. This fact explains the greater vegetative vigour of Troyano, as this genotype showed a larger branch diameter and a higher productive performance; the latter will be discussed below.

There were differences between fig varieties for all yield characteristics (Table 3). Troyano showed the highest number of fruit per plant (26.4). There was no difference among the other varieties for this trait. Leonel et al. (2015) obtained an average from 88 to 104 fruit per plant in five-year-old 'Roxo de Valinhos' plants, which is higher than the results observed in the current study that used two-year-old plants, whose canopy was not yet formed. According to the same authors, pruning was performed in August, when the greatest vegetative growth occurs and fruit emission phases; besides, this time of the year is known for its longer and warmer days in the municipality of Botucatu, in the state of São Paulo, which enables the photosynthetic activity and fruiting.

While evaluating fig genotypes in the municipality of Selvíria, in the state of Mato Grosso do Sul, Brazil, Rodrigues et al. (2009) verified that Troyano and PI-189 mutant selection showed higher fruit number per plant than the other genotypes, that is, 36 and 30 fruit per plant, respectively. According to Theron et al. (2011), the number of fruit per , or per fig plant, fluctuates according to the genotype and crop management practices.

'Roxo de Valinhos' and White Genova stood out with the highest values for fruit mass, length, and diameter, while Troyano and PI-189 showed the lowest means (Table 3). Similarly, Rodrigues et al. (2009) reported higher-fruit mass and length in White Genova, followed by 'Roxo de Valinhos'; moreover, these authors also reported a lower-fruit mass and size in Troyano.

Measurements of fruit physical dimensions, such as longitudinal, transverse diameter, or length, are of great use for fresh consumption, but not for industry use. Fruit destined for the fresh market should display from medium to large size, as 'Roxo de Valinhos' and White Genova, which allows of their possibility to be exported, as the Brazilian production takes place in an offspring period of the Northern Hemisphere countries, where the largest fig producers are found. However, small fruit are better suit for the industry,

Table 3. Number of fruit per plant, and mass, length, and diameter of fruit, production and yield of fig (*Ficus carica*) varieties, of the 2015/2016 crop season, in the municipality of Botucatu, in the state of São Paulo, Brazil(1).

Variety	Fruit per plant	Fruit mass (g)	Fruit length (mm)	Fruit diameter (mm)	Production (g per plant)	Yield (kg ha^{-1})
Roxo de Valinhos	14.51b	40.84a	58.68a	45.01a	592.73ab	987.88ab
White Genova	4.86b	44.58a	56.27a	47.51a	216.67b	361.11b
PI - 189	11.79b	27.09b	51.63b	37.06b	319.50b	532.50b
Troyano	26.38a	30.25b	48.67b	39.55b	798.12a	1,330.20a
CV (%)	35.74	6.58	3.40	3.23	40.13	40.13
LSD	11.35	5.19	4.04	3.02	426.89	711.49

(1)Means followed by equal letters, in the columns, do not differ by Tukey’s test, at 5% probability. CV, coefficient of variation; LSD, least significant difference.

such as PI-189 and Troyano, as their extended harvest period coincides with the end of fruit production in São Paulo state (Table 3).

Troyano showed higher production and yield, followed by 'Roxo de Valinhos' (Table 3). This result can be attributed to the higher general growth of Troyano that may have allowed of a higher-carbohydrate accumulation later used for fruit development, which has already been shown for the lower-chlorophyll a/b ratio of this cultivar. Souza et al. (2018) obtained similar results for yield and production at 240 DAP; however, these authors obtained 1455.25 kg ha^{-1} and 909.75 g $plant^{-1}$ in nonirrigated 'Roxo de Valinhos'.

In Brazil, the maximum yield can reach 20 to 30 Mg ha^{-1} in well-managed orchards, in fig with six to nine branches at the age of six years, according to Maiorano et al. (2018). It is noteworthy that plants were still being formed in the second production cycle, which does not allow of a comparison of productions.

Even producing larger fruit, White Genova showed a lower productive performance. However, both White Genova and Troyano had an excellent vegetative performance. Also, White Genova had a high-chlorophyll a/b ratio, unlike Troyano. This characteristic is related to lower-photosynthetic efficiency, which resulted in lower-fruit yield and, consequently, in low yield. Thus, the high-number of leaves may have caused some shading that reduced total photosynthesis of the White Genova because the progressive shading resulted from the increased leaf number, and promoted a decrease of carbonic gas assimilation, according to Kaiser et al. (2017).

Similarly, Rodrigues et al. (2009) reported that Troyano was one of the most productive (3.23 Mg ha^{-1}) genotypes, and White Genova was among the least productive (1.95 Mg ha^{-1}) ones. Differently, the authors reported a higher yield in PI-189. Crop yield is associated with the genetic potential of varieties, but it is strongly affected by climate change and management. Therefore, the PI-189 potential should not be totally disregarded.

In the present study, Troyano showed more fruit per plant, but production and yield values were equal to 'Roxo de Valinhos' due to 'Roxo de Valinhos' fruit production with higher weight and size than those of Troyano (Table 3).

Conclusions

1. *Ficus carica* Troyano shows the largest diameter and branch length, and produces more fruit per plant with smaller diameter, length, and mass than fig 'Roxo de Valinhos'.

2. Troyano also shows a similar yield 'Roxo de Valinhos', but a longer and later harvesting than the other cultivars, as well as a higher thermal need that occurs only in the off-season period, in the state of São Paulo, Brazil.

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