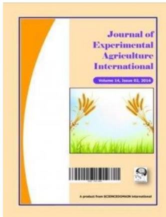

Journal of Experimental Agriculture International

34(2): 1-9, 2019; Article no.JEAI.48019
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Pruning Intensity and Lopping System in Fig Plants in the Brazilian Semiarid Region

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2019/v34i230168
Editor(s):
(1) Dr. Ozlem Sultan Aslanturk, Department of Biology, Faculty of Art and Science, Adnan Menderes University, Turkey.
(2) Dr. Daniele De Wrachien, Professor, State University of Milan, Italy.
Reviewers:
(1) Shadrack Kinyua Inoti, Egerton University, Kenya.
(2) Rahim Foroughbakhch, University of Nuevo Leon, Mexico.
(3) Raúl Leonel Grijalva-Contreras, Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, México.
Complete Peer review History: http://www.sdiarticle3.com/review-history/48019

Original Research Article

Received 15 January 2019
Accepted 03 April 2019
Published 11 April 2019

ABSTRACT

Aims: Fig plants produce fruits in branches of the year, which grow after emission of buds from the leaf armpits. And the lopping system is one of the most common practices among the green fig farmers to increase production. Thus, the present work aimed to improve the physical, chemical and productive characteristics of fig trees in the semiarid region of Brazil.
Study Design: A complete randomized block design was used in a 3x2 factorial scheme (three pruning intensities: 5, 10 and 15 cm in length; and two lopping systems: with and without lopping), constituting six treatments with four replicates. Each experimental plot consisted of five plants, but only the three central plants were used.
Place and Duration of Study: The experiment was conducted in the didactic orchard of the Federal Rural University of Semiarid (UFERSA), Mossoró, RN.
Methodology: The treatments were: 5 cm pruning without lopping; 5 cm pruning with lopping; 10 cm pruning without lopping; 10 cm pruning with lopping; 15 cm pruning without lopping; 15 cm pruning with lopping. The following variables were analyzed: fruit weight (g), fruit length (cm), fruit diameter (cm), pulp firmness (N), soluble solids content (ºBrix), titratable acidity (%), vitamin C content (mg ascorbic acid 100 g^{-1} pulp), fruit yield (number of fruits $plant^{-1}$ and kg $plant^{-1}$). Data

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were submitted to analysis of variance by the F test at 5% probability and means were grouped using the Tukey test at 5% probability. The analysis was performed using R software version 3.5.2.
Conclusion: Pruning intensity 10 cm in length and the use of lopping system influenced the physical, chemical and productive characteristics of fig plants in the Brazilian semiarid region.

Keywords: Chemical characteristics; Ficus carica L.; fruticulture; handling; production; pruning; physical.

1. INTRODUCTION

Fig tree (*Ficus carica* L.) has great importance in the world scenario among temperate fruit trees, but many management techniques need to be improved.

The southern and southeastern regions of Brazil, according to IBGE [1], are the most producers of fig fruits, for in natura consumption and for industry. The planted area corresponds to 2,591 ha, where the South (1,766 ha) and Southeast (825 ha) are the most producers, with an average production of 7,521 and 15,274 kg ha^{-1}, respectively.

Although the fig tree has been cultivated in temperate regions, it has shown good adaptation to tropical regions. Thus, the semiarid becomes an alternative for the productive chain and exploration of new agricultural areas of fig plants.

Pruning intensity is a management technique used to increase production and quality of fruits, but it must consider the edaphoclimatic conditions [2]. In addition, lopping system is another technique widely used by fig producers in order to extend the productive period and to increase fruit production [3]. Cutting off the branch apex favors the emission and growth of new branches, hold the plant canopy, and maintains more luminosity in the canopy interior [4]. However, the first lopping must be done when shoots have eight pairs of leaves and then maintaining two new branches after emission [5].

Fig tree is rustic and can grow, develop and produce in semiarid conditions. However, knowledge about this crop management in the semiarid region is still scarce. In addition, the technologies that have been used in the South and Southeast regions cannot be used in the semiarid, because this region has different conditions of temperature, humidity, insolation, and rainfall. Thus, the present work aimed to evaluate the use of the pruning and lopping system in fig trees in the semiarid region.

2. MATERIALS AND METHODS

2.1 Climatic Data

The experiment was carried out in two production cycles, the first one from April to July 2016 (Cycle 1), and the second from April to July 2017 (Cycle 2), at the didactic orchard of the Federal Rural University of Semiarid (UFERSA). The orchard is located at the municipality of Mossoró-RN, in the potiguar semiarid region of the Brazilian Northeast, at the geographical coordinates 5º 11' South latitude, 37º 20' West longitude, and 18 m altitude from the sea level. The climatic conditions, characterized as hot and dry, during the experimental period were: 27.50°C mean annual temperature, 68.9% mean annual relative humidity, 4.4 tenths mean annual cloudiness, and 673.9 mm mean annual rainfall [6] (Fig. 1). According to the soil analysis, the soil was classified as Eutrophic Red-Yellow Argisol.

2.2 Treatments, Experimental Design, and Plant Growth Conditions

Roxo de Valinhos was used because this cultivar has high economic value, presents rusticity, vigor and productivity characteristics, and is adapted to the drastic pruning system.

The experimental area was composed of 150 plants, spaced 2.0 m between rows and 1.5 m between plants. The plants were irrigated daily by a micro-sprinkler system and the weed control was performed by gas brushers.

A fruiting pruning was performed to start a new production cycle. The plants were conducted with three primary branches throughout the vegetative cycle, and then with two secondary branches, totaling six branches per plant. After that, when new branches emerged from the secondary branches, they were pruned at 5, 10 and 15 cm from the base to apex. When these tertiary branches presented eight pairs of leaves, they were submitted to the lopping system. Others tertiary branches were conducted without the lopping system.

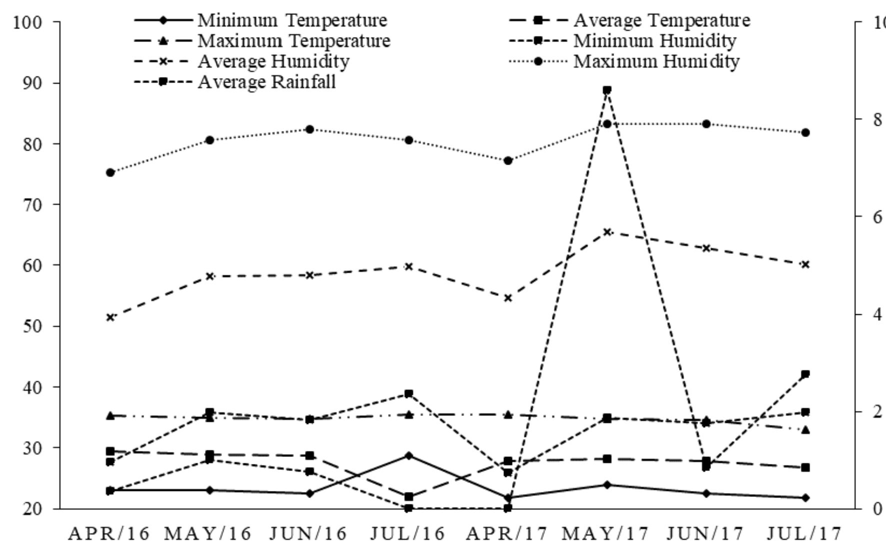

Fig. 1. Climatic data of temperature, relative humidity, and rainfall of Cycle 1 and Cycle 2 of fig production, conducted under different pruning intensities, and with or without lopping. UFERSA, Mossoró-RN, 2018

The experiment was carried out in a completely randomized block design in a 3x2 factorial scheme with four replications. The factors corresponded to the different pruning intensities (5, 10 and 15 cm), and to the lopping system (with or without). Plots corresponded to five plants per treatment, but only the three central plants were used.

2.3 The Physical-chemical Analyzes

The following plant vegetative characteristics were evaluated at the end of the experiment: fruit weight (g), length and diameter of fruits (cm), and yield (number of fruits plant^{-1}, and kg plant^{-1}).

Postharvest evaluations of the fruit were carried out at the Physiology and Postharvest Laboratory of the Department of Agronomic and Forest Sciences of the Federal University of Semiarid (UFERSA). The following physicochemical analyses were performed: soluble solids content, pulp firmness, titratable acidity, and vitamin C content, that were performed according to AOAC [7].

The length and diameter of the fruits, expressed in cm, were evaluated with a digital caliper. And fruit weight was obtained using a semi-analytical balance (Mars model AS 2000).

The number of fruits plant^{-1} was determined by counting fruits in the plant every three days. After harvesting, the fruits were weighed and the yield (kg plant^{-1}) was calculated.

The pulp firmness was measured by a penetrometer (McCormick model FT 327), coupled to a tip of 8 mm in diameter, and the results were expressed as Newton (N).

The titratable acidity was determined by titration with 0.1 M NaOH standard solution, with 1.0% phenolphthalein as indicator, and the results were expressed as g citric acid 100 g^{-1} pulp (Instituto Adolfo Lutz 1985). Data were expressed as %. The soluble solids content (SS) was obtained by a digital refractometer (Atago PR-101 Palette) and the results were expressed as ºBrix (AOAC 1997).

The vitamin C content was obtained by titration with 2,6-dichlorophenolindophenol (DFI), and data were expressed as mg ascorbic acid 100g^{-1} pulp, according to AOAC (1997).

2.4 Statistical Analysis

Data were submitted to analysis of variance by the F test at 5% probability, and the means were grouped by the Tukey test at 5% probability using R software version 3.5.2.

3. RESULTS

Fruit mass, fruit length, fruit diameter, pulp firmness, soluble solids content, titratable acidity, and vitamin C content were not influenced by the different pruning intensity. However, except for titratable acidity and vitamin C, these physical-chemical characteristics were significantly different when the lopping system was used. The number of fruits plant^{-1} and total fruit production were significantly different according to pruning intensity and to lopping system in Cycle 1.

In Cycle 2, pulp firmness, titratable acidity, and vitamin C content were significantly different when the plants were submitted to the different pruning intensity or to lopping system. The other variables were not influenced by the pruning intensity and lopping system.

The results showed that the different pruning intensities did not affect the fruit weight in both production cycles (Table 1). However, fruits became more weighted (+23.8%) when the plants were not conducted with lopping system in Cycle 1. In cycle 2 the lopping system did not affect the fruit weight.

The fruit length and fruit diameter were not affected by the pruning intensity both in Cycle 1 and in Cycle 2, and by the lopping system in Cycle 2. However, in Cycle 1, when the plants were conducted without lopping, maximum values of 3.79 cm and 4.17 cm for fruit length and fruit diameter, respectively, were obtained.

In Cycle 1, the pulp firmness of the fruits was not affected when the plants were submitted to the different pruning intensities. But, in Cycle 2, the plants submitted to the 15 cm pruning intensity produced fruits with higher firmness value (7.17 N). The use of lopping system increased the pulp firmness in Cycle 1, with a maximum value of 13.91 N.

For the soluble solids content, no significant effect was observed considering the pruning intensity treatments in both cycles. However, the plants conducted without lopping produced fruits with SS content 19.4% higher in Cycle 1, which did not occur in Cycle 2.

In Cycle 1, the titratable acidity and vitamin C content (Table 2) were not affected when the plants were submitted to the pruning intensity or to the lopping system. However, in Cycle 2, a significant interaction between the two treatments occurred (Table 2).

In Cycle 2, when the plants were submitted to 5 cm pruning intensity and not to the lopping system, the fruits presented a 44.8% increase in titratable acidity, with a maximum value of 0.30%. The other treatments did not affect the titratable acidity, which reached the mean values of 0.18% (Fig. 2).

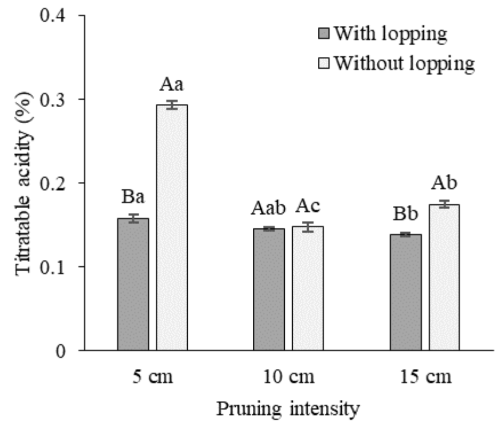

Fig. 2. Titratable acidity in fig fruits cv. Roxo de Valinhos from plants submitted to different pruning intensities and to lopping system in Cycle 2 of production. Uppercase letters compare the lopping system and the lowercase letters compare the means among pruning intensity according to the Tukey test at 5% probability UFERSA, Mossoró-RN, 2018

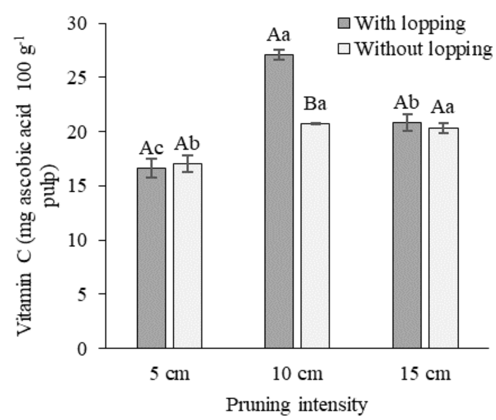

Fig. 3. Vitamin C content in fig fruits cv. Roxo de Valinhos from plants submitted to different pruning intensities and to lopping system in Cycle 2 of production. Uppercase letters compare the lopping system and the lowercase letters compare the means among pruning intensity according to the Tukey test at 5% probability. UFERSA, Mossoró-RN, 2018

The vitamin C content was 30.8% higher in the fruits when the plants were submitted to 10 cm of pruning intensity and to lopping, reaching to 27.0 mg ascorbic acid 100 g^{-1} pulp. Plants pruned at 5 cm, conducted with or without lopping, presented the lowest values of vitamin C content (16.8 mg ascorbic acid 100 g^{-1} pulp average) (Fig. 3).

Table 1. Weight (FW), length (FL), diameter (FD), pulp firmness (PF) and soluble solids content (SS) of fig fruits cv. Roxo de Valinhos from plants submitted to different pruning intensities and to lopping system in two production cycles. UFERSA, Mossoró-RN, 2018

Source of variation	Fresh weight (g)		Length (cm)		Diameter (cm)		Firmness (N)		Soluble solids (°Brix)	
	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2	Cycle 1	Cycle 2
Pruning 5 cm	27.09a	29.90a	3.59a	3.49a	3.96a	4.19a	12.74a	5.03b	19.03a	14.59a
Pruning 10 cm	28.34a	29.24a	3.67a	3.49a	4.08a	4.15a	12.44a	4.06b	18.96a	14.66a
Pruning 15 cm	25.91a	30.44a	3.64a	3.53a	4.00a	4.25a	13.57a	7.17a	18.20a	14.53a
With lopping	24.23b	29.13a	3.47b	3.51a	3.86b	4.13a	13.91a	4.90b	17.07b	14.59a
Without lopping	30.00a	30.58a	3.79a	3.49a	4.17a	4.26a	11.92b	5.94a	20.39a	14.59a
Mean	27.11	29.86	3.63	3.5	4.01	4.2	12.91	5.42	18.73	14.59
CV (%)	13.08	12.37	8.05	4.64	6.32	3.6	9.63	13.86	6.61	2.23
					Mean square					
Block	8.523	13.861	0.251	0.025	0.063	0.036	6.813	0.063	0.304	0.769
Pruning	11.885	2.890	0.012	0.004	0.032	0.022	2.714	20.357	1.688	0.296
Lopping	199.815	12.615	0.608	0.003	0.596	0.101	23.840	6.568	66.334	<0.001
Pruning*Lopping	1.635	8.829	0.141	0.028	0.042	0.002	2.436	0.513	0.691	0.889
Block	NS	NS	NS	NS	NS	NS	NS	NS	NS	**
Pruning	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
Lopping	**	NS	*	NS	**	NS	**	**	**	NS
Pruning*Lopping	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Means followed by different letters in the same column differ significantly according to the Tukey test at 5% probability. NS: not significant; *, **: significant at 5% or 1% probability, respectively, according to the F test*

Table 2. Titratable acidity (%) and vitamin C content of fig fruits cv. Roxo de Valinhos from plants submitted to different pruning intensities and to lopping system in two production cycles. UFERSA, Mossoró-RN, 2018

	Titratable acidity (%)		Vitamin C (mg ascorbic acid 100 g^{-1} pulp)	
	Cycle 1	**Cycle 2**	**Cycle 1**	**Cycle 2**
Pruning 5 cm	0.18a	0.23	22.06a	16.83
Pruning 10 cm	0.19a	0.16	22.51a	20.58
Pruning 15 cm	0.18a	0.15	21.75a	23.88
With lopping	0.18a	0.15	22.05a	21.5
Without lopping	0.18a	0.21	22.16a	19.36
Mean	0.18	0.18	22.11	20.43
CV (%)	13.67	4.68	14.15	6.62
		Mean square		
Block	0.00018	0.000061	24.660	0.524
Pruning	0.00030	0.0154	1.143	99.612
Lopping	0.00050	0.0193	0.062	27.413
Pruning*Lopping	0.00115	0.0092	9.551	27.294
Block	NS	NS	NS	NS
Pruning	NS	**	NS	**
Lopping	NS	**	NS	**
Pruning*Lopping	NS	**	NS	**

*Means followed by different letters in the same column differ significantly according to the Tukey test at 5% probability. NS: not significant; *, **: significant at 5% or 1% probability, respectively, according to test F*

In Cycle 1, a significant interaction between the pruning intensity and the lopping system occurred for the total number of fruits $plant^{-1}$ (TNF) and the total fruit production (TFP). However, no interaction was observed in Cycle 2, and the maximum number of 238.63 and 254.00 fruits $plant^{-1}$ was observed when the plants were pruned at 15 cm and not submitted to looping, respectively, in addition to 4.61 kg $plant^{-1}$ average.

Table 3. Total number of fruits $plant^{-1}$ (TNF) and total fruit production (TFP; kg $plant^{-1}$) in fig plants cv. Roxo de Valinhos submitted to different pruning intensities and to lopping system in two production cycles. UFERSA, Mossoró-RN, 2018

	TNF		TFP	
	Cycle I	**Cycle II**	**Cycle I**	**Cycle II**
Pruning 5 cm	55.13	228.75a	1.445	4.845a
Pruning 10 cm	87.75	230.63a	2.812	4.281a
Pruning 15 cm	84.75	238.63a	2.538	4.715a
With lopping	26.92	211.33a	0.814	4.150a
Without lopping	124.83	254.00a	3.715	5.077a
Mean	75.88	232.67	2.264	4.613
CV (%)	6.63	22.35	28.28	23.64
		Mean square		
Block	19	6673.4	0.290	4.470
Pruning	2601	220.0	4.183	0.691
Lopping	57526	10922.7	50.480	5.162
Pruning*Lopping	3147	3101.0	4.916	1.434
Block	NS	NS	NS	*
Pruning	**	NS	**	NS
Lopping	**	NS	**	NS
Pruning*Lopping	**	NS	**	NS

*Means followed by different letters in the same column differ significantly according to the Tukey test at 5% probability. NS: not significant; *, **: significant at 5% or 1% probability, respectively, according to the F test*

As shown in Fig. 4, fig plants conducted without lopping were more productive. In addition, the plants submitted to 10 cm pruning were more productive (160 fruits plant^{-1}), followed by 15 cm (130 fruits plant^{-1}) and 5 cm pruning (80 fruits plant^{-1}).

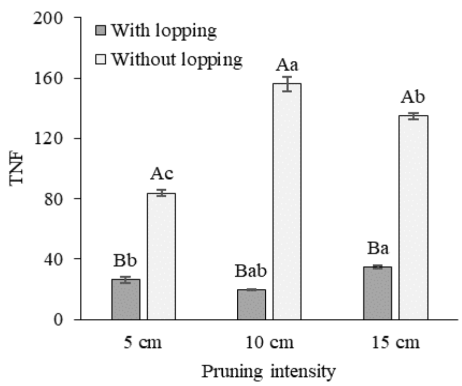

Fig. 4. Total number of fruits plant^{-1} (TNF) in fig plants cv. Roxo de Valinhos submitted to different pruning intensities and to lopping system in Cycle 1 of production. Uppercase letters compare the lopping system and the lowercase letters compare the means among pruning intensity according to the Tukey test at 5% probability. UFERSA, Mossoró-RN, 2018

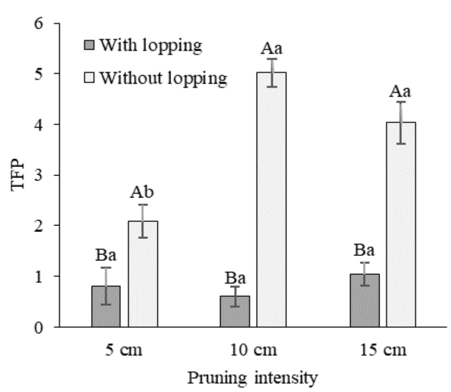

Fig. 5. Total fruit production (TFP; kg plant^{-1}) in fig plants cv. Roxo de Valinhos submitted to different pruning intensities and to lopping system in Cycle 1 of production. Uppercase letters compare the lopping system and the lowercase letters compare the means among pruning intensity according to the Tukey test at 5% probability. UFERSA, Mossoró-RN, 2018

Similarly to the high number of fruits plant^{-1}, the fruit production was higher when the plants were conducted without lopping, and a maximum of 5.07 kg plant^{-1} was obtained in the plants conducted with 10 cm pruning. With lopping, all plants produced less than 1.0 kg of fruits plant^{-1} (Fig. 5).

4. DISCUSSION

The physical characteristics of fig fruits (fresh weight and length) were Studied by Rodrigues et al. [8], who found corresponding values of 38.56 g and 5.30 cm, respectively, when they evaluated mutant selections of cultivar Roxo de Valinhos. These values are higher than those found in the present study.

The values obtained for fruit length (3.63 and 3.79 cm) in the present work are similar to those found by Carvalho et al. [9] when they studied the lopping system in the production of green figs cv. Roxo de Valinhos. These researchers verified that the plants conducted without lopping produced fruits with 3.77 cm in length, and 3.81 cm in length when the lopping was used.

According to Carvalho et al. [9], the fruit size can be influenced by the plant's appearance, that is, as the number of shoots in the plant increases, the average fruit diameter also increases, due to the uniformity generated by this management system. However, results reported in the present study are contrary to Carvalho et al. [9], because of the use of lopping in the semiarid provided fruits with smaller diameters.

For firmness, we verified values high than those found by Lima et al. [10], who found firmness values of 10.58 N.

For soluble solids content, [11] obtained results close to finding in the present study, ranging from 17 to 18.43 ºBrix. Similarly to observed in Cycle 2, [12] did not find a statistical difference on soluble solids content in fruits produced by plants conducted with or without lopping. Thus, the difference on soluble solids content in Cycle 1 can be explained, as shown by Carvalho et al. [9], by different factors, such as cultivar, climatic conditions and harvesting season that may cause changes in the soluble solids content.

The titratable acidity values are like Goncalves et al. [12], who found values ranging from 0.20% to 0.23% when the plants were pruned at different times. In contrast, Rodrigues et al. [8] obtained lower values (0.15%) in mutant selections of fig plants cv. Roxo de Valinhos. According to MIF [13], acidity is modified by changes in the concentrations of organic acids during the fruit growth and it is different in each type of fruit.

In fig plants cultivated under greenhouse conditions and in the field, [14] found vitamin C content values of 12.12 and 10.39 mg ascorbic acid 100 g^{-1} pulp, respectively. According to the authors, fig fruits do not have high levels of vitamin C, like cashew and acerola fruits. Moreover, vitamin C content can reduce during the fruit maturation, due to the action of ascorbic acid oxidase enzymes (ascorbate oxidase) [15]. Thus, because fig fruit ripens rapidly, which make it highly perishable, the vitamin C content also reduces rapidly during ripening.

Regarding the productive aspect, [16] obtained a number of fruits $plant^{-1}$ (ranging from 138.16 to 184.25) higher than those in Cycle 1, but lesser than in Cycle 2. Similarly to Campagnolo et al. [17], who reported 189.94 fruits plant-1 in green fig cv. Roxo de Valinhos. In contrast, [18] obtained a high number of fruits $plant^{-1}$ (203) in the second cycle, when the plants were pruned in August and conducted with eight branches. Such result, compared to the present study, is higher than those in Cycle 1, but less than in Cycle 2.

Furthermore, [16] submitted fig plants to different pruning seasons (from April to September) and obtained less fruit production (1.25 to 2.00 kg $plant^{-1}$) than those obtained in the present study in both cycles. In contrast, [18] reported similar results (4.50 and 5.73 kg $plant^{-1}$ in May and August, respectively) with fig plants submitted to different pruning times in a greenhouse condition.

This high difference in fruit production (number of fruit $plant^{-1}$ and kg $plant^{-1}$) in semiarid conditions may be because the plants that were not submitted to lopping produced more shoots and, consequently, more reproductive buds, which favored the production of fruits.

As mentioned by Campagnolo et al. [17], the plants submitted to lopping present smaller branches in size and shorter internodes (as they bloom) in comparison to plants not submitted to lopping. Moreover, such plants suffer stress and were not able to recover the normal development due to the hardy climatic conditions, such as high temperature (above 35°C, as shown in Fig. 1), which is harmful to fig plants growth. Furthermore, not submitting plants to lopping may result in lower labor costs for fig production [17].

The high rainfall occurred during Cycle 2 favored good water availability for fig plants, which contributed to high yield. In addition, the low production in Cycle 1 avoided exaggerated expenses of photoassimilates accumulated in the plants, which also favored higher production in Cycle 2. Branches that form the plant canopy are reserve organs of these photoassimilates and contribute to an increase in yield, and factors such as water and soil cover also contribute to this increase [19].

Thus, the higher yield in the number of fruits $plant^{-1}$ and kg $plant^{-1}$ in Cycle 2 compared to Cycle 1 may be because the fig plants had more adequate environmental conditions, such as high relative humidity, high temperature and good water availability in the soil (Fig. 1). As mentioned by Figueiredo [20], good availability of water and nutrients in the soil favors the crop growth and development, which consequently increase productivity. And the variable climatic conditions also influence the growth, development, and production of fig plants.

5. CONCLUSIONS

The pruning intensity and lopping system influenced the physical-chemical characteristics of the fig fruits in the Potiguar semiarid conditions.

Fig plants submitted to 10 cm pruning intensity and conducted without lopping in semiarid conditions are more productive in the number of fruits $plant^{-1}$ and kg $plant^{-1}$.

The use of lopping system is inefficient for fig plant management in the Potiguar semiarid region.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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