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PRODUÇÃO, QUALIDADE FÍSICO-QUÍMICA E COMPOSTOS BIOATIVOS DE FRUTOS DE MIRTILEIRO MISTY SOB DIFERENTES INTENSIDADES DE PODA[1]

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RESUMO - O objetivo do presente trabalho foi avaliar o efeito de intensidades de poda na produção e qualidade dos frutos de mirtileiro. O material vegetal utilizado foi mirtileiro da cultivar Misty. O fator estudado foi poda, em diferentes intensidades: sem poda; poda leve; poda testemunha e poda drástica. O delineamento experimental foi em blocos ao acaso com 4 repetições. Foram avaliadas a produção total de frutos, o tamanho de frutos, as características fisico-química como pH, teor de sólidos solúveis totais (SST) e acidez total titulável (ATT), os compostos bioativos como compostos fenólicos, antocianinas totais e atividade antioxidante. As plantas que receberam poda drástica apresentaram maiores médias em produção e tamanho de frutos. As maiores concentrações de compostos fitoquímicos no mirtilo ocorreram à medida que a poda foi mais drástica. O uso de diferentes intensidades de poda pode modificar o comportamento produtivo e a qualidade pós-colheita dos frutos.
Termos para indexação: *Vaccinium*, manejo, qualidade de fruto, funcionais.

PRODUCTION, PHYSICAL-CHEMICAL QUALITY AND BIOATIVE COMPOUNDS OF MISTY BLUEBERRY FRUIT UNDER DIFFERENT PRUNING INTENSITIES

ABSTRACT -The objective of this study was to evaluate the effect of pruning intensity on yield and quality of blueberries fruits. It was evaluated the cultivar Misty. The treatments were: absence of pruning; light pruning; regular pruning and drastic pruning. The experimental design was randomized blocks with four replications. The variables analyzed were fruit production, fruit size, pH, total soluble solids (TSS) and total titratable acidity (TTA), and the bioactive compounds such as phenolic compounds, anthocyanins and antioxidant activity. The plants that received drastic pruning showed higher averages of production and fruit size. The highest concentrations of phytochemical compounds in blueberry fruits occurred as pruning was more drastic. The use of different intensity of pruning can modify the productive behavior and postharvest quality of fruits.
Index terms - *Vaccinium*, cultural practices, fruit quality, functional.

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The myrtle tree is a shrub and presents a winter rest period, in which important cultural practices are carried out, among them, the winter pruning. Since the implantation of the orchard, the pruning is done to favor better vegetative development, providing production from three years old. Following, pruning interventions are performed in the winter (dry pruning) and in the summer (green pruning) (BOUNOUS, 2009).

The alteration of the natural form of the plant, modifying its architecture has the purpose of making it smaller, with better illumination and aeration inside the canopy, regularity of production, besides maintaining sanity and vigor (SCARPARE FILHO, 2011). In general, for production with satisfactory fruit development, there must be a balance between the vegetative and reproductive buds, so that the yield is maximized and the fruits reach high quality (RUFATO et al., 2012).

The antioxidant and nutraceutical potential in the myrtle tree can be influenced by the pruning severity in the plants, mainly with impact on the production and effects of the increase of the incident solar radiation on the fruits (RADÜNZ et al., 2014).

Pruning influences on fruit yield and size. In young plants, light pruning can be done, but the intensity of pruning increases with plant maturation (TREHANE, 2004). Albert et al. (2010) reported that three-years old plants drastically pruned have the same yield as those not pruned, but after four years the yield of the pruned plant was higher. The intensity of pruning depends on the cultivar, age, number of branches, plant management system, vigor, and vegetation habit, in this sense, the objective of this study was to evaluate the effect of different intensities of pruning in the production and quality of blueberry cultivar Misty.

The experiment was installed in the municipality of Morro Redondo / RS in the month of September, 2010 and repeated in 2011. It was used blueberry Misty cultivar four years old, without formation pruning. The planting spacing was 0.80 m x 3 m. The factor studied was the intensity of pruning, as follows: a) T1: without pruning; b) T2: light pruning (removal of dry and poorly located branches - 10% of the branches); c) T3: pruning witness (performed in the orchard by the owner - 25% of the branches) - intermediate pruning between light and drastic) and d) T4: drastic pruning (removal of low branches, dry, poorly shaped and poorly located, prioritizing larger diameter branches - 50% of the branches).

Production was quantified by weighing the total harvest (harvest period from November to December), carried out in the production cycles 2010/2011 and 2011/2012, and the productivity was estimated. The fruit size was measured in a sample of 10 fruits per plot, and the diameter was evaluated with a digital caliper. For the average mass, 20 fruits per plot were used.

The physical-chemical characterization was carried out in fresh fruits in the 2011/2012 production cycle. PH, total soluble solids (TSS) and total titratable acidity (TTA) were determined in the juice. The pH determination was made through bench pH meter (Metrohm 827 pH Lab) with automatic temperature correction. The total soluble solids content (TSS) was measured through a bench refractometer (Shimadzu Bausch and Lomb MO120634) expressing the result in °Brix. Total titratable acidity (TTA) was determined by the potentiometric method (AOAC, 1997).

In the determination of phenolic compounds, total anthocyanins and antioxidant activity, 200 g of fruits were harvested near the harvest peak in the 2011/2012 production cycle and frozen at -18ºC until the moment of analysis. To prepare the extract the fruits were cut frozen in small pieces and five grams of sample were homogenized in ultra-turrax with 15 mL of methanol acidified with 1.5N of HCl. To obtain the extract, the samples were centrifuged for 20 min at 5.000 rpm, in a refrigerated centrifuge at -4ºC until complete separation of the supernatant.

The quantification of total anthocyanins was performed using the method adapted from Fuleki and Francis (1968). Samples were read at 535 nm in a spectrophotometer (Genisys 10 UV Thermo spectronic). The results were calculated using a standard curve of cyanidin-3-glycoside and expressed in cyanidin-3-glycoside per 100 g of sample.

For total phenolic compounds, an aliquot of 250 µL of extract was diluted in 4 mL of distilled water. Simultaneously, a control was prepared containing 250 µL of methanol. Each sample and the control were combined with 250 µL of Folin-Ciocalteau at 0.25N (SWAIN and HILLIS, 1959) and reacted for 3 minutes before adding 500 µl of Na_2CO_3 at 1N. The reaction occurred for 2 h at room temperature in the absence of direct light and the absorbance was measured at 725 nm. The results were calculated using a standard curve of chlorogenic acid and expressed in mg of chlorogenic acid per 100 g.

The antioxidant activity against the DPPH radical was quantified with a 10 µL aliquot of the extract combined with 3800 µL of the DPPH (2,2-diphenyl-1-picrylhydrazyl) solution (BRAND-

WILLIAMS et al., 1995), completing the volume to 4.0 mL with methanol. One control was prepared simultaneously with 200 μl of methanol. The readings were performed after 24 h of spectrophotometer reaction at 515 nm and calculated through a standard trolox curve and expressed in trolox equivalent mg per 100 g of sample.

The experimental design was in randomized blocks with four replications, two plants per plot. The results were submitted to analysis of variance, and when significant, to the Tukey test for comparison of means.

Production per plant and productivity differed with pruning intensity only in the second productive cycle (2011/2012). In this year, drastic pruning increased production and productivity (Table 1), with 1,074.10 g plant^{-1} and 4,430.66 kg, in the respective variables. An explanation for this fact may be the amount of cold hours, since in 2011 there was colder weather (447 hours) than in 2010 (377 hours). The cold probably best met the plant's needs, responding better to cultural practices such as pruning, and improve flowering and fruiting and consequently the production in 2011.

In blueberry cultivar Northblue the severe pruning is more adequate in order to obtain higher fruits' yields (ALBERT et al., 2010), corroborating with results obtained for the second productive cycle evaluated, in which the drastic pruning presented the best yield. Nevertheless in some cases pruning has no effect. (PESCIE et al., 2011). However, Spiers et al. (2002) affirm that the removal of up to 25% of the upper part of the branches can be carried out without reducing fruit yield. This diversity of results among the studies cited above suggests that, for the definition of pruning intensity, several factors, among them cultivars, must be taken into account.

The pruning intensity in the first cycle influenced the diameter of the fruits (Table 2), being greater in fruits of plants with drastic pruning. In the second productive cycle, no significant difference was observed in relation to fruit diameter. The mean mass of the fruits differed only in the second productive cycle evaluated. Drastic pruning treatment provided higher averages, followed by light pruning and control, with the lowest fruits being produced in not pruned plants. The difference observed for the average fruit mass and the longitudinal diameter of the fruit does not follow the same trend, which can be explained by the lack of uniformity of the fruit shape.

The size and number of fruits produced by the blueberries of various cultivars, among them 'O'Neal', 'Star' and 'Elliott', are affected by pruning, such as types of pruning or intensity, interfering in the fruit load and consequently in their size (BAÑADOS et al., 2009). Possibly more intense pruning favors the distribution of photoassimilates as a function of the lower number of fruits and promotes an increase in fruit size in more productive cultivars, such as Misty used in the present study. Pruning shows a relationship between total yield and fruit size. A decrease in the fruits size with the increase of the productive load is a known fact in blueberries (YARBOROUGH, 2006), that is, when reducing the productive load the tendency is to obtain fruits of larger size, as observed in this study.

The pH was higher in fruits of plants with drastic pruning, but did not differ statistically of fruits produced in plants without pruning and with light pruning, and these did not differ from the control pruning (Table 3). Effect of pruning was also verified by Radünz et al. (2014), but only in some cultivars. On the other hand, the mean pH value observed in the present study is in agreement with the one found by Molina et al. (2008) for the same cultivar, which found an average of 2.80.

For TSS, there was a significant difference, the highest TSS mean occurred in fruits produced in plants that were not pruned, followed by light and drastic pruning, and finally by control (Table 3). Possibly the highest pruning intensity has hampered the accumulation of TSS in the 2010/2011 cycle. It is known that the drastic pruning greatly reduced leaf area which may have compromised photosynthesis and carbohydrates accumulation. Increased yield and leaf reduction may have resulted in a lower accumulation of TSS. Radünz et al. (2014) emphasizes that the pruning intensity modifies the production, a factor that could modify the TSS content in blueberry fruits. The TSS mean is also in accordance with Molina et al. (2008) who stated that the cultivar Misty presents 12.7 °Brix.

For TTA in the fruits, there was a significant difference between the treatments, being the lower acidity verified in the treatment with light pruning (Table 3). One hypothesis, for the lowest acidity, is the greater competition for nutrients between the vegetative and the productive part. Possibly genetic factors are related, since Radünz et al. (2014) verified effects of pruning intensity only in some cultivars.

The ratio between TSS / TTA was higher in fruits produced in plants that were not pruned and the lowest ratio was obtained with the control (Table 3). According to Chitarra and Chitarra (2005), the sweet and acid component of fruit quality is considered as a quality index, but it varies according to the cultivar, declare Rodrigues et al. (2007), when analyzing fruits of six Blueberry cultivars (Woodard, Powderblue, Bluegem, Briteblue, Bluebelle and Delite), the TSS content ranged from 11.8 for Briteblue to 14.0 for Powderblue and the ATT was 0.76 and 0.95 respectively. Being the results obtained in this study within the expected for the blueberry culture.

The concentration of anthocyanins in fruits did not differ with the pruning intensities in the plants. The highest concentration of phenolic compounds in fruits was obtained with drastic pruning, followed by light pruning. The control provided the lowest mean for phenolic compounds. For antioxidant activity, the fruits of plants with drastic pruning presented the highest value, but this did not differ statistically from the control pruning and the light pruning, that is, only differed from the treatment without pruning (Table 4).

The content of total phenolic compounds, including anthocyanins, contributes to the antioxidant activity of the blueberry, as can be observed in table 4. The synthesis of these compounds can be influenced by several factors such as genotype, environmental variations, soil type and cultivation practices (GIOVANELLI and BURATTI 2009). In this context, observing the data found in Tables 4, it is possible to include pruning management as a source of variation.

According to the results obtained and considering the conditions under which this research was developed, it is concluded that: 1) The drastic pruning provides higher averages in production in the second year of the practice use. 2) Fruits produced in pruned plants have higher concentrations of phytochemical compounds when compared to fruits produced in pruned plants.

TABLE 1 - Production and productivity of blueberries fruits cultivar Misty submitted to pruning intensities, productive cycles 2010/2011 and 2011/2012. Pelotas, 2013.

Pruning intensities	Production per plant (g)	Produtivity (kg ha^{-1})	Production per plant (g)	Produtivity (kg ha^{-1})
	2010/2011		2011/2012	
No pruning	141.04±28.09 a	581.79 a	812.01±241.33 ab	3,349.54 ab
Light pruning	147.74±30.34 a	609.43 a	506.88±273.41 b	2,090.88 b
Control pruning*	163.70±38.87 a	675.26 a	790.76± 207.23 ab	3,261.89 ab
Drastic pruning	188.73±25.46 a	778.51 a	1,074.10±173.42 a	4,430.66 a
CV (%)	27.48	27.48	26.31	26.31

Mean (± standard deviation) followed by the same letter in the column did not differ in the column by the Tukey test (P <0.05). * Pruning done in the orchard by the owner.

TABLE 2 - Weight per unit (g) and transversal average diameter (mm) of blueberries fruits cultivar Misty submitted to different intensities of pruning, productive cycle 2010/2011 and 2011/2012. Pelotas, 2013.

Pruning intensities	Weight per unit (g)	Diameter (mm)	Weight per unit (g)	Diameter (mm)
	2010/2011		2011/2012	
No pruning	1.21±0.09 a	13.29±0.70 b	1.04±0.05 b	13.61±0.32 a
Light pruning	1.16±0.11 a	12.96±0.70 b	1.23±0.04 ab	12.89±0.79 a
Control pruning *	1.15±0.06 a	13.22±0.50 b	1.17±0.17 ab	13.15±0.18 a
Drastic pruning	1.25±0.07 a	13.88±0.43 a	1.29±0.10 a	13.06±0.22 a
CV (%)	5.82	1.99	9.88	3.66

Mean (± standard deviation) followed by the same letter in the column did not differ in the column by the Tukey test (P <0.05). * Pruning done in the orchard by the owner.

TABLE 3 - pH, total soluble solids (TSS), titratable total acidity (TTA) and ratio between TSS and TA in blueberry fruits cultivar Misty, submitted to different intensities of pruning. Production cycle 2011/2012. Pelotas, 2013.

Pruning intensities	pH	TSS (°Brix)	TTA (% citric ac.)	TSS/TTA
No pruning	2.90±0.01 ab	13.53±0.35 a	0.71±0.01 ab	19.03±0.50 a
Light pruning	2.88±0.02 ab	12.40±0.13 b	0.68±0.00 b	18.20±0.20 ab
Control pruning *	2.85±0.01 b	11.67±0.31 c	0.73±0.01 a	16.00±0.58 c
Drastic pruning	2.94±0.03 a	12.20±0.13 bc	0.72±0.01 ab	16.97±0.40 bc
CV (%)	0.95	2.07	2.18	3.67

Mean (± standard deviation) followed by the same letter in the column did not differ in the column by the Tukey test (P <0.05). * Pruning done in the orchard by the owner.

TABLE 4 - Concentration of total anthocyanins, phenolic compounds and antioxidant activity in blueberry fruits cultivar Misty, submitted to pruning intensities. Production cycle 2011/2012. Pelotas, 2013.

Pruning intensities	Anthocyanins[1]	Phenolic compounds [2]	Antioxidant activity [3]
No pruning	426.02±26.49 a	637.92±7.07 bc	873.20±110.60 b
Light pruning	443.38±21.91 a	702.30±18.73 ab	1,273.90±166.13 ab
Control pruning *	369.30±16.49 a	568.11±42.92 c	1,280.95±138.86 ab
Drastic pruning	426.97±21.11 a	739.66±9.66 a	1,361.22±82.45 a
C.V. (%)	7.44	4.81	14.82

Mean (± standard deviation) followed by the same letter in the column did not differ in the column by the Tukey test (P <0.05).C.V. coefficient of variation. * Pruning done in the orchard by the owner. [1]Total anthocyanins expressed in mg equivalent cyanidin-3-glycoside 100g^{-1} fresh sample; [2]Total phenolic compounds expressed in mg of chlorogenic acid equivalent 100g^{-1} fresh sample; [3]Total antioxidant activity expressed in µg equivalent trolox g^{-1} fresh sample.

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