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Cultivars performance and blackberry pruning management

Desempeño de cultivares y manejo de podas en mora

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Abstract

There was increased fruit consumption with potential health benefits in the last years, being blackberry one of these fruits. The objective of this work was to evaluate the performance of Blackberry cultivars and the influence of main stem management on BRS-Tupy cultivar. The first experiment assessed the cultivars: BRS-Tupy, Cherokee, Xavante, and Guarani; in the second experiment the evaluated prunings were: drastic winter pruning, 2, 3, and 4 main primocanes. The variables analyzed were: green and dry leaf mass, leaf area, number and average fruit mass, production per plant, average size and percentage of fruit moisture, and soluble solids. In relation to average weight, fruit size and yield, BRS-Tupy cultivar was superior in both cycles evaluated. As for soluble solids the Cherokee cultivar was superior, but only in the 2016/17 cycle. In the second experiment, in terms of number of fruits and production, pruning of 4 primocanes in the 2016/17 cycle was superior, but in the next cycle the pruning of 3 primocanes equaled it in the production variable. The drastic pruning in these variables is shown to be lower in the two cycles evaluated. Concerning the variable size of fruit, a significant difference was found only in the 2017/18 cycle, where drastic pruning presented smaller fruits. Thus, it can be concluded that, in general, BRS-Tupy cultivar presents the best productive results and that pruning with 4 primocanes initially stands out alone.

Keywords: climate, primocanes, production, *Rubus* sp., small fruits.

Resumen

El consumo de frutas con beneficios potenciales para la salud ha aumentado en los últimos años, siendo la mora (*Rubus* sp.) una de estas. El objetivo de este trabajo fue evaluar el desempeño de los cultivares de mora y la influencia del manejo de los tallos principales en el cultivar BRS-Tupy. En el primer experimento se evaluaron los cultivares: BRS-Tupy, Cherokee, Xavante y Guaraní; en el segundo experimento las podas evaluadas fueron: 0 tallos (poda drástica de invierno), 2, 3 y 4 tallos principales. Las variables analizadas fueron: masa foliar verde y seca, área foliar, número y promedio de masa frutal, producción por planta, tamaño y porcentaje de humedad de la fruta, y sólidos solubles. Con respecto al peso promedio, al tamaño del fruto y la producción a cultivar, BRS-Tupy fue mayor en los dos ciclos evaluados. En cuanto a los sólidos solubles, la variedad Cherokee fue superior en el ciclo 2016/17. En el segundo experimento, en términos de número de frutas y producción, la poda de 4 tallos en el ciclo 2016/17 fue superior; en el siguiente ciclo, la poda de 3 tallos fue igual. La poda drástica en estas variables se muestra inferior en los dos ciclos evaluados. En la variable de tamaño de fruta, se encontró una diferencia significativa solo en el ciclo 2017/18, donde la poda drástica mostró frutas más pequeñas. Con esto se puede concluir que existen diferencias entre los ciclos productivos evaluados, pero que, en general, el cultivar BRS-Tupy presenta los mejores resultados productivos y que la poda con 4 tallos se destaca inicialmente.

Palabras claves: clima, tallos, producción, *Rubus* sp., frutas pequeñas.

Introduction

The introduction of fruits into the diet, such as blackberry (*Rubus* sp.), either *in natura* or processed form has become an almost worldwide trend for beneficial effects on human health. The benefits are related to the antioxidants present in fruits, among which the most frequent are phenolic compounds that can sequester free radicals (Jacques & Zambiazi, 2011).

Blackberry is temperate fruiting, therefore, so that budding and flowering occur without anomalies, it is necessary that plants accumulate certain number of hours at low temperatures. Since the number of cold hours required is specific to each cultivar, when not achieved, it can affect the resultant productivity (Leonel & Mota-Segantini, 2015).

The phenological aspects of the blackberry may vary from cycle to production cycle, which depends on the fulfillment of cold hours required (Corrêa-Antunes, 2002). Consequently, there will be amendments in production. The latter demonstrates the importance of studying diversified cultivars in different regions and productive cycles.

The presence of thorns in cultivars make some cultural practices difficult, especially pruning (Campagnolo & Pio, 2012a). An alternative is pruning the primocanes close to the soil, called drastic pruning, or using cultivars without spines, such as the cultivar Xavante (Villa *et al*., 2014). However, it should be noted that the number of main primocanes left after winter pruning influences the productive variables (Tullio & Ayub, 2013).

Therefore, the objective of this work was to evaluate the performance at four blackberry cultivars and the influence of the main primocanes number on BRS-Tupy cultivar in two production cycles.

Materials and methods

The experiments were done according to the geographical coordinates Latitude 27°07'11'' S, Longitude 52°42'30'' E, and altitude 610 m. The climate according to Köppen's classification is category C, subtype Cfa (Wet Subtropical Climate), and the local soil is classified as Dystropheric Red Latosol (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2004, p. 745).

The orchard was implanted in 2014 and evaluations occurred in the productive cycles of 2016/17 and 2017/18, second and third productive years, respectively. The cultural treatments adopted were the removal of weed plants when necessary, and the pruning as described below. Two experiments were evaluated.

Experiment 1

Four mulberry, BRS-Tupy, Cherokee, Xavante, and Guarani cultivars, each with three primocanes evaluated.

Experiment 2

The second experiment consisted of different numbers of evaluations at productive primocanes in the cultivar BRS-Tupy. The treatments were: drastic winter pruning (zero primocane), two, three and four productive primocanes selected in winter pruning.

The experimental design adopted was completely randomized, with five replicates, each replicate being represented by one plant. The spacing used was 3 meters between rows and 1.5 meters between plants (22.222 plants ha^{-1}).

Summer pruning was done by removing the primocanes that were productive, and by shortening those that grew 15 cm above the wire during the cycle. In the winter, pruning the number of productive primocanes per plant was selected; in the case of those that had received drastic pruning, all their aerial part was reduced to 10 cm in height. The other plants received the number of primocanes corresponding to their treatment; excess rods were reduced to 10 cm.

Vegetative and productive parameters were evaluated. Five leaves were collected by the middle third of each plant for mass measurement; in addition, the percentage of mass of leaf dry matter and leaf area was evaluated by using a digital leaf area meter.

The fruits were harvested every three days; counting to obtain the number of fruits and weighing to obtain average fruit weight and total production per plant was performed in all harvests. In addition to these variables, fruit size was evaluated with the aid of a 100 mL graduated column (± 1 mL), where the displaced volume of water after the addition of five fruits per harvest was divided by the number of fruits added. It was also evaluated the soluble solids content using a bench refractometer, and the moisture by drying the fruits in a forced air circulation oven.

The fruit harvest time was between the months of October to January in both production cycles. The harvest was carried out throughout the productive period of the plants every three days. Climatic data from the pruning period to the end of the harvest in the 2016/17 cycle and in the 2017/18 cycle are available in Figure 1(A) and (B), respectively.

The data obtained in each production cycle were evaluated separately in order to isolate the climatic factor. The data were submitted to analysis of variance, and when significant were compared by the Tukey test at 5 % probability.

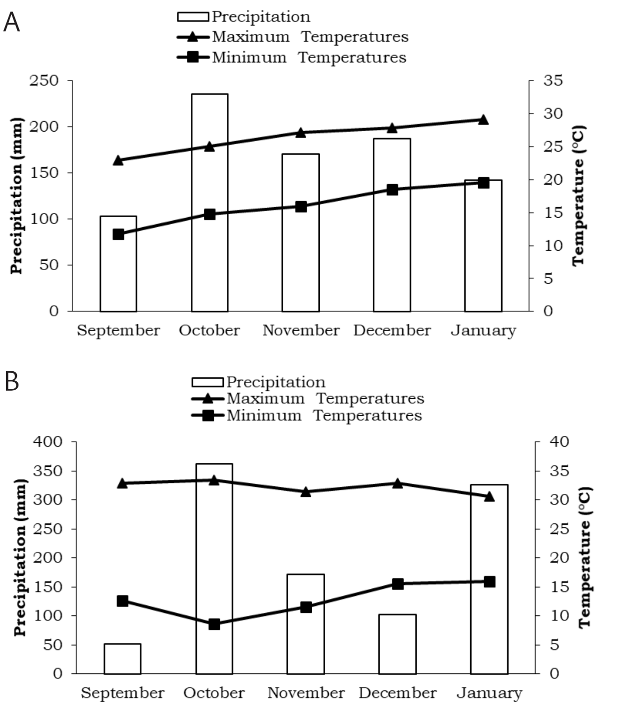

Figure 1. Climate data for the 2016/17 cycle (A) and for the 2017/18 cycle (B).

Results and discussions

Experiment 1

Concerning the mass of leaf dry matter variable, it was observed that in the 2016/17 production cycle the plants of the cultivar Cherokee presented lower dry mass accumulation in their leaves, and therefore, a greater amount of water (Table 1). In the 2017/17 cycle, the cultivar Xavante presented a lower mass of leaf dry matter but without significant difference of cultivar BRS-Tupy and Guarani.

For fresh leaf mass and average leaf area in the 2016/17 cycle, BRS-Tupy and Xavante plants presented the highest values. The latter, related to the largest fresh leaf mass, plants of these cultivars present a result of the larger leaf area. In the 2017/18 cycle these results were not repeated (Table 1).

In the 2016/17 production cycle the cultivar Xavante produced a lower number of fruits per plant. This also occurred in the 2017/18 cycle but there was no difference for the Cherokee cultivar (Table 2). Corrêa-Antunes *et al.* (2010) when evaluating blackberry cultivars in Pelotas-RS, found a higher number of fruits produced in comparison to the one found in this study. Under these conditions, BRS-Tupy plants produced 2878 fruits, cv. Guarani 3018 and cv. Cherokee 3283 fruits.

In the two productive cycles evaluated, BRS-Tupy cultivar was the one that produced fruits of higher average weight, in contrast to the Cherokee cultivar which was among the ones that produced lower fruits in both cycles (Table 2). A study by Ferreira *et al.* (2016) in Pelotas-RS, in different productive cycles, found average fruit mass ranging from 7-7.5 g in cv. BRS-Tupy, 4.8-3.7 g in cv. Guarani and the cultivar Xavante with fruits of 5.7-6.0 g. Values higher than those are found in this work.

The yield per plant was higher in the BRS-Tupy cultivar in the two cycles evaluated (Table 2); as a result, its large number of fruits and superiority in the average weight of the fruits. It can be noticed a production decrease in the cultivars of the cycle 2016/17 to 2017/18 which was variable in each cultivar. In the BRS-Tupy cultivar this decrease was 11.5 %; in cv. Cherokee 48.8 %; in cv. Xavante was 69.9 %, and in cv. Guarani was the lowest reduction (0.3 %).

Table 1. Vegetative parameters in different cultivars of blackberry.

Cultivars	Leaf Dry Matter (%)		Leaf Fresh Mass (g)		Mean Leaf Area (cm²)	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
BRS-Tupy	43.25 a*	58.61 ab	7.16 a	11.04 a	65.15 a	68.98 a
Cherokee	37.68 b	61.47 a	3.31 b	9.34 a	29.69 b	49.00 a
Xavante	46.10 a	53.50 b	7.68 a	10.75 a	62.61 a	68.65 a
Guarani	43.02 a	58.84 ab	3.75 b	10.34 a	35.57 b	67.49 a
CV (%)	4.55	6.58	19.20	13.47	19.00	18.55

*Values followed by the same letter in the column do not differ significantly (Tukey's test, $P \leq 0.05$).

Table 2. Productive parameters in blackberry cultivars.

Cultivars	Number of fruits		Average Fruit Weight (g)		Yield (Kg)	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
BRS-Tupy	737.2 a*	828.2 a	6.69 a	5.28 a	4.96 a	4.38 a
Cherokee	671.8 a	402.8 b	3.73 c	3.15 c	2.52 b	1.29 c
Xavante	469.2 b	266.6 b	5.32 b	3.61 bc	2.52 b	0.96 c
Guarani	771.8 a	845.2 a	4.09 c	3.71 b	3.17 b	3.16 b
CV (%)	11.81	16.45	10.68	7.52	18.25	18.09

* Values followed by the same letter in the column do not differ significantly (Tukey's test, $P \leq 0.05$).

Oliveira *et al*. (2017) evaluated some cultivars in an altitude region of the Minas Gerais State, among which there were. Tupy, Cherokee, and Guarani cultivars. In this case, the cultivar with greater production per plant was cv. Guarani. In addition, according to the same authors, the differences observed in Blackberry cultivars were related to the temperature variations of each region and the density of planting.

The data related to average size, moisture, and soluble solids can be observed in Table 3. Regarding the average fruit size, cv. BRS-Tupy presented larger fruits in relation to the other cultivars. In a study conducted by Campagnolo and Pio (2012b) in Marechal Cândido Rondon-PR, the cultivars that presented the largest fruit size were BRS-Tupy and Guarani.

Concerning moisture, it was observed that in the 2016/2017 cycle, the BRS-Tupy cultivar presented a higher percentage but without significant difference for the Xavante cultivar, which in turn did not differ from the other cultivars. In the later cycle, the superiority in moisture in the cultivar BRS-Tupy was fulfilled. These results agree with Hirsch *et al*. (2012), in where it is mentioned that blackberry fruits have high water content in fruits.

In the 2016/17 production cycle, cv. Cherokee presented 14 % more soluble solids in comparison to the average of the other cultivars, but in the following productive cycle, no significant difference between the cultivars was found. A data to be observed is that in the 2017/18 cycle the °Brix content of fruits was lower than in the previous cycle.

A study conducted by Hirsch *et al*. (2012) in Pelotas-RS, found for cv. BRS-Tupy content of 10.1 °Brix, 10.2 °Brix in cv. Guarani and 8.4 °Brix in cv. Cherokee. Caldas-MG Aymoto-Hassimotto *et al*. (2008) found values on soluble solids of 6.93 °Brix in cv. BRS-Tupy and 9.23 for cv. Guarani. This difference can be explained by the fact that climate conditions may influence the chemical and fruit quality parameters of Berries, mainly due to the thermal difference and the intensity of solar radiation (Ali *et al*., 2011; Caproni *et al*., 2016).

Experiment 2

For the mass of leaf dry matter, it was observed that in the 2016/17 cycle, plants submitted to 2 main primocanes presented greater dry mass accumulation but without significant difference for those submitted to 3 primocanes, which did not differ from the plants submitted to the other treatments (Table 4). While in the 2017/18 cycle it was observed that, the higher the number of productive rods, the greater the dry mass accumulation in the leaves.

For the variable fresh leaf mass in the two productive cycles evaluated, plants submitted to drastic pruning presented greater leaf fresh weight. This result can be explained by the necessity of the plants to emit new primocanes and, according to Campagnolo and Pio (2012a), to possibly destine good part of their energies to form part of the area. This may have produced leaves with greater weight and larger size, as occurred in the 2017/2018 cycle.

The average leaf area of the plants was also influenced by the pruning applied in the two evaluated cycles: the higher the pruning intensity, the higher the leaf area of these plants.

In the productive variables (Table 5), the drastic pruning presented the lowest results. In the two cycles evaluated, the pruning of four primocanes revealed superiority in the number of fruits.

Table 3. Size, moisture and soluble solids fruits in blackberry cultivars.

Cultivars	Size (cm³)		Moisture (%)		Soluble Solids (°Brix)	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
BRS-Tupy	7.18 a*	6.06 a	85.77 a	84.04 a	10.38 b	6.89 a
Cherokee	4.73 b	3.61 b	84.04 b	79.97 b	11.88 a	8.15 a
Xavante	5.57 b	3.71 b	85.56 ab	80.96 b	10.45 b	8.33 a
Guarani	4.77 b	4.40 b	86.75 a	80.84 b	9.78 b	6.88 a
CV (%)	11.80	12.96	1.11	1.99	4.37	15.33

*Values followed by the same letter in the column do not differ significantly (Tukey's test, $P \leq 0.05$).

Table 4. Vegetative parameters in blackberry cultivar BRS-Tupy submitted to different numbers of primocanes.

Primocane Number	Leaf Dry Matter (%)		Leaf Fresh Mass (g)		Leaf Area Mass (cm²)	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Drastic (0)	40.16 b*	52.21 b	9.99 a	15.06 a	80.00a	102.72 a
2	43.80 a	57.71 ab	7.38 b	11.43 b	67.02 b	75.24 ab
3	43.25 ab	58.61 a	7.19 b	11.04 b	65.19 b	68.98 b
4	39.40 b	60.22 a	7.17 b	9.90 b	66.18 b	60.57 b
CV (%)	5.59	6.05	13.58	16.80	4.80	19.35

*Values followed by the same letter in the column do not differ significantly (Tukey's test, $P \leq 0.05$).

According to Broetto *et al.* (2009), whose study evaluated long pruning and short pruning, plants with long pruning showed a higher number of fruits, which can be explained by the fact that they possess a higher number of flower buds, agreeing with the results obtained in this experiment.

In the 2017/18 cycle, plants with drastic pruning produced a higher number of fruits compared to the first cycle. According to Campagnolo and Pio (2012a), this may be due to the maturity of the plants throughout the cycles. However, in both cases, this was not sufficient to reach the same productivity of plants that remained with a number of primocanes after winter.

For the average weight, the drastic pruning did not differ statistically in fruits of plants with two primocanes in the cycle 2016/17, but in the following cycle, the drastic pruning presented fruit with less weight. In a study conducted by Nogueira-Curi *et al.* (2015) in Lavras-MG, the fruits of cv. Tupy presented a fresh mass higher than that found in this study, 8.6 g and 6.8 g, in the respective cycles studied.

For the production per plant the quantity produced increased according to the number of plant primocanes, but in the cycle 2017/18, plants with three primocanes matched their production to plants with four primocanes. According to Ferreira *et al.* (2016), due to the larger leaf area, consequently, greater capacity to perform photosynthesis, plants with higher stem density obtain a higher production load.

In a study done by Villa *et al.* (2014), plants submitted to four primocanes began to have a reduced productive trend in relation to those submitted to three primocanes. However, in this case, the plants were in a higher population density, and this may be the reason why, with four primocanes, one can already perceive a productive decrease in the plants.

The greater production due to the increase of the primocanes number is related to the increase in the number of fruits in these plants. The fact that plants with drastic pruning produced the lowest values in the productive characteristics can be due to the fact that these plants, after winter, before starting the production, need to emit shoots, unlike the other treatments where their aerial part was previously defined previous cycle (Lugaresi *et al.*, 2018).

The results presented in Table 6 show that in the first productive cycle evaluated no significant difference was found for the average fruit size. However, in the later cycle, drastic pruning plants produced fruits of about 24 % smaller size. An explanation for this result could be that, as these plants in their second cycle produced more fruit than in the first one, part of their energy previously used in the formation of a smaller number of fruits, this time was applied in the production of more fruits but reducing their size.

The percentage of moisture decreased according to the number of primocanes present in the plants in the 2016/17 cycle. However, this fact did not occur in the following year, where no significant difference was found for the percentage of moisture.

Soluble solids content also changed between the two cycles. In the 2016/17 cycle, fruits of drastically pruned plants presented lower soluble solids content, but in the latter cycle, there was no significant variation in soluble solids of fruits from different prunings. According to Tullio and Ayub (2013), they found on average 5 °Brix for cv. BRS-Tupy independent of the number of primocanes. According to the authors, these differences can be justified by

Table 5. Productive parameters Yield in blackberry cultivar BRS-Tupy submitted to different numbers of primocanes.

Primocane Number	Number of fruits		Average Fruit Weight (g)		Yield (kg)	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Drastic (0)	175.0 c*	229.8 d	5.75 b	3.79 c	0.99 c	0.87 c
2	678.6 b	673.0 c	6.45 ab	4.56 b	4.39 b	3.07 b
3	737.2 b	828.6 b	6.69 a	5.28 a	4.96 b	4.38 a
4	932.2 a	931.8 a	6.73 a	5.01 ab	6.26 a	4.66 a
CV (%)	15.93	3.40	7.04	7.41	15.98	11.99

*Values followed by the same letter in the column do not differ significantly (Tukey's test, P ≤ 0.05).

Table 6. Quality parameters in fruits in blackberry cultivar BRS-Tupy submitted to different numbers of primocanes.

Primocane Numbers	Size(cm³)		Moisture		Soluble solids (°Brix)	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Drastic	6.25 a*	4.64 b	87.86 a	80.79 a	8.86 b	7.46 a
2	6.90 a	6.13 a	86.19 ab	81.39 a	10.43 a	7.22 a
3	7.18 a	6.06 a	85.64 b	84.04 a	10.39 a	6.89 a
4	7.38 a	6.11 a	84.79 b	84.41 a	10.83 a	6.95 a
CV (%)	11.30	6.91	0.87	3.49	4.03	10.36

*Values followed by the same letter in the column do not differ significantly (Tukey's test, P ≤ 0.05).

the variations in the climatic conditions, as much to the regions, as from year to year.

Climatic variations, especially the volume of precipitation during the productive period, possibly influenced the productive results of the plants, especially the average fruit weight, yield, and fruit size. The lower pluviometric precipitation identified in the 2017/18 cycle may have influenced that, in general, these variables were lower in this cycle than in the first production cycle, in both experiments.

Conclusion

Under experimental conditions, in this region cv. BRS-Tupy is the most promising in terms of production and larger size fruit. Winter pruning where four primocanes remain in the cv. BRS-Tupy, at first, seems to be the most productive, with no loss in fruit quality. But with advancing cycles, pruning of three primocanes eventually equals. Drastic winter pruning affects production, it also interferes with fruits quality in some cycles, so it is not indicated.

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