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Management of blackberry pruning to extend harvest seasonality

Abstract – The objective of this work was to evaluate the pruning management of the BRS Tupy and Brazos blackberry cultivars, in order to extend their harvest seasonality and fruit yield. The experiment was performed in an altitude subtropical region in the state of Minas Gerais, Brazil. Bushes were grown at 3.0x0.5 m spacing. The treatments consisted of the four following pruning seasons: one conventional pruning, with suppression of the produced stems in February and reduction of the stems in July; and three drastic pruning performed in the first two weeks of January, March, and May, with the application of 10% urea and 3% hydrogenated cyanamide five months later. The experimental design was in randomized complete blocks, in a 2x4 factorial arrangement, with two cultivars and four pruning managements, with four blocks. Fruit phenology, yield, and physicochemical quality were evaluated in two production cycles. It is possible to extend the harvest season of blackberry up to five months, in an altitude subtropical region in Lavras, in the state of Minas Gerais, Brazil, with drastic pruning in January and no irrigation. Drastic pruning in January or March increases the yield of the BRS Tupy and Brazos blackberry cultivars. The extended harvest season does not affect the quality of blackberries and does not create challenges for harvesting operations.

Index terms: *Rubus*, drastic pruning, off-season production.

Manejo da poda de amora-preta para aumentar a sazonalidade da colheita

Resumo – O objetivo deste trabalho foi avaliar o manejo da poda das cultivares de amoreira-preta BRS Tupy e Brazos, para prolongar sua época de colheita e produtividade de frutos. O experimento foi realizado em uma região subtropical de altitude, no estado de Minas Gerais, Brasil. Os arbustos foram conduzidos em espaçamento 3.0x0.5 m. Os tratamentos consistiram das seguintes quatro épocas de poda: uma poda convencional, com supressão das hastes produzidas em fevereiro e redução das hastes em julho; e três podas drásticas realizadas nas primeiras duas semanas de janeiro, março e maio, com aplicação de ureia a 10% e cianamida hidrogenada a 3% cinco meses depois. O delineamento experimental foi em blocos ao acaso, em arranjo fatorial 2x4, com duas cultivares e quatro manejos de podas, com quatro blocos. A fenologia, a produção e a qualidade físico-química das frutas foram avaliadas em dois ciclos produtivos. É possível estender a época da colheita da amora-preta para cinco meses, na região subtropical de altitude de Lavras, no estado de Minas Gerais, com poda drástica em janeiro e sem irrigação. A poda drástica em janeiro ou março aumenta a produção das cultivares de amora-preta BRS Tupy e Brazos. O período prolongado de colheita não afeta a qualidade das amoras e não cria desafios para as operações de colheita.

Termos para indexação: *Rubus*, poda drástica, produção fora de época.

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Introduction

Interest in the consumption of blackberry (*Rubus* spp.) has increased in recent years because its fruit confer nutritional health benefits (Raseira et al., 2020). Blackberries are rich in phenolic compounds, such as tannins, stilbenes, and flavonoids (Guedes et al., 2014; Souza et al., 2014a).

Blackberry is traditionally cultivated in temperate regions; it has a deciduous habit and needs low temperatures to overcome the endodormancy of its buds (Campagnolo & Pio, 2012b; Teixeira et al., 2021). To facilitate the exploitation of blackberry in subtropical regions, a series of studies were conducted to select the most promising cultivars and to adapt the cultural management of pruning (Tadeu et al., 2015).

In a study on the selection of blackberry cultivars in the Cfa climate-humid subtropical zone, higher fruit production and yield were observed with the blackberry 'Brazos' (Campagnolo & Pio, 2012b). Conversely, in the conditions of Cwb climate in an altitude subtropical region, the Brazos, BRS Tupy and Guarani cultivars produced fruit with a greater fresh mass. 'Brazos' showed the highest yield, and 'BRS Tupy' had the best balance between soluble solids and acidity (Curi et al., 2015). Importantly, in both studies, the harvest season of the blackberry cultivars was concentrated between the months October and January.

Blackberry pruning in Brazil is performed in two stages: one in the summer (January), with the suppression of stems that emerge near the ground, and the shortening of new stems that emerge from the soil; another pruning is performed in the winter (July), with the shortening of the lateral stems (Pio et al., 2012).

Staggered pruning in winter (from June to September) could be an option to extend the harvest season. However, there is no change of the traditional harvest season, in subtropical regions, when pruning is performed at different times during the late fall and early winter – from May to September (Campagnolo & Pio, 2012d).

In an attempt to improve the pruning management of blackberry in Brazilian subtropical regions, a drastic summer pruning system was developed, and it was applied in January. In this system, at the end of January, the entire canopy structure is eliminated close to the ground (suppression pruning); and, in July, the excess branches are suppressed, and the lateral stems are shortened (Tadeu et al., 2015).

However, the application of hydrogenated cyanamide resulted in the anticipation of budding and harvesting in blackberry grown in a subtropical region (Cwa climate), and subjected to the conventional pruning system (Leonel et al., 2016). Hydrogenated cyanamide (H_2CN_2) is used for the artificial release of bud endodormancy (Petri et al., 2014).

The scaled drastic pruning with the application of hydrogenated cyanamide may promote the off-season production. Blueberry 'BRS Tupy' shows unevenness at the beginning of budding and flowering. However, an effective standardization was observed in this crop, when it was subjected to the application of 3% hydrogenated cyanamide, in cultivation under conventional pruning, in a subtropical region (Segantini et al., 2011).

The objective of this work was to evaluate the pruning management of the BRS Tupy and Brazos blackberry cultivars, in order to extend their harvest seasonality and fruit yield.

Materials and Methods

The experiment was conducted in the municipality of Lavras, in the state of Minas Gerais, Brazil. The experimental area is part of the Department of Agriculture of the Escola de Ciências Agrárias de Lavras, Universidade Federal de Lavras (ESAL/UFLA). The area is located at 21°14'S, 45°00'W, at 918 m altitude. According to the Köppen-Geiger's classification, the region shows a Cwb type – high-altitude tropical climate (mesothermal), with dry winters, and concentrated rains from October to March, with greater intensity between December and February (Alvares et al., 2013).

The soil of experimental area was classified as a Cambissolo Háplico (Guimarães et al., 2021), according to Santos et al. (2018), corresponding to an Inceptisol. The soil acidity in the experimental area was corrected with the application of 2.3 Mg ha^{-1} of dolomitic limestone and the base fertilization was carried out with 5 L organic matter for composting, in addition to mineral sources of P (300 g simple superphosphate) and K (150 g potassium chloride) per linear meter. Soil analysis, conducted at 0–20 cm soil depths, showed the following values: 5.6 pH; 48.9 g dm^{-3} organic matter; 141.1 mg dm^{-3} P; 10.8 $mmol_c$ dm^{-3} Ca; 2.9 $mmol_c$ dm^{-3} Mg; 14.5 $mmol_c$ dm^{-3} sum of bases; and 15.1 $mmol_c$

dm^{-3} cation exchange capacity. The climatic data for the experimental period are shown (Figure 1).

Young nurseries of 'BRS Tupy' and 'Brazos' blackberry were produced by using root cuttings (Campagnolo & Pio, 2012a), and they were brought to the field in November 2017 and planted at 3.0x0.5 m spacing (density of 6,667 bushes per hectare). The young nurseries were conducted using a trellis consisting of treated eucalyptus poles (8–10 cm diameter), with a "T" wire (double parallel galvanized wire) spaced at 60 cm apart, and with 80 cm height. These nurseries were grown following the recommendations by Pio et al. (2012), for the cultivation of blackberry under subtropical conditions.

The treatments consisted of four pruning seasons: one conventional pruning (suppression of the stems produced in February, and reduction of the stems in July, in 2020 and 2021); and three drastic prunings performed in the first two weeks of January, March, or May, in 2020 and 2021.

For the control treatment (conventional pruning), the stems that were produced at the end of the harvest (February) were suppressed close to the ground, and four new primary stems were maintained by pruning apices. At the beginning of June, the four primary rods were reduced to 30 cm above the wire of the spreader, and eight secondary rods were maintained and reduced to 20 cm length.

For the treatments consisting of drastic pruning, performed in January, March, or May, all stems close to the soil, including those that were not producing yet, were removed at 5 cm height from the soil. The bushes subjected to drastic pruning remained in development for five months, after each drastic pruning (January, March, or May). Subsequently, 10% urea was applied to promote leaf burning and falling. After seven days, hydrogenated cyanamide (Dormex, BASF Agro Brazil, Camaçari, BA, Brazil) was applied at 3% a.i. concentration, using a backpack sprayer (Segantini et al., 2011). The control treatment (conventional

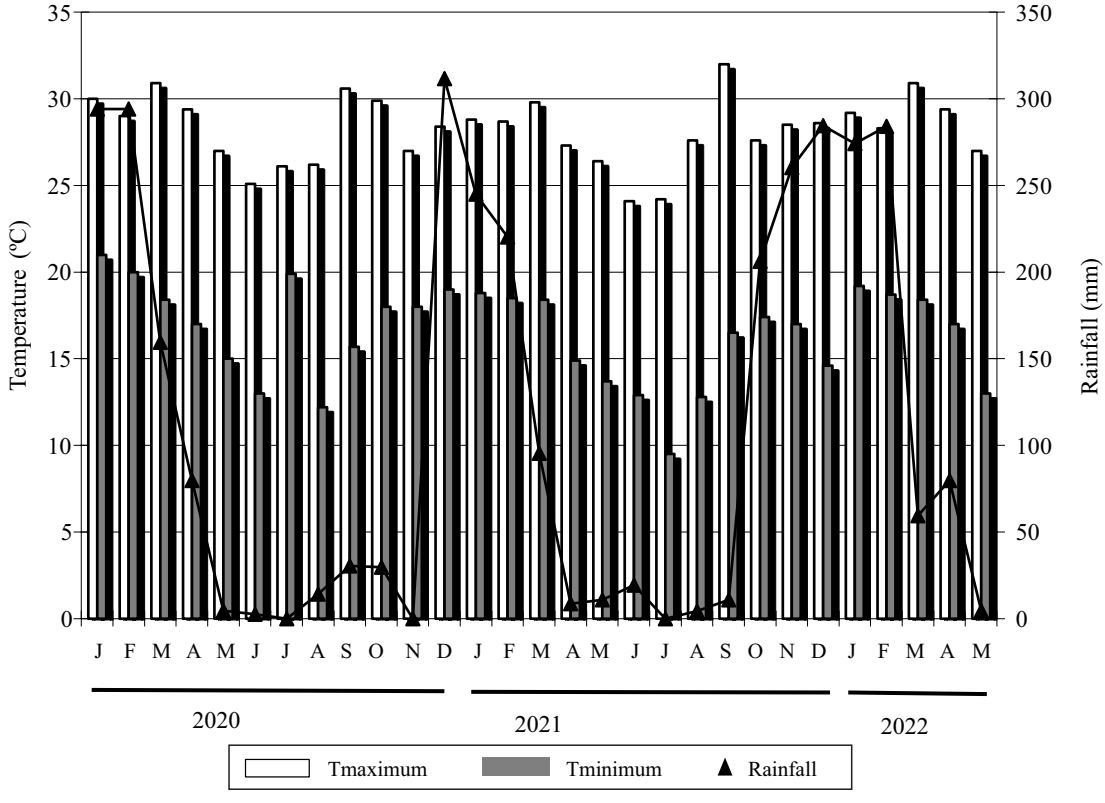

Figure 1. Mean maximum and minimum temperatures and mean monthly cumulative rainfall between January 2020 and May 2022. Universidade Federal de Lavras (UFLA, Lavras, MG, Brazil).

pruning), urea and hydrogenated cyanamide were not applied.

The treatments consisted of four pruning management systems for blackberry 'BRS Tupy' and 'Brazos'. Evaluations were performed in two production cycles, 2020/2021 and 2021/2022. The experiment was carried out in randomized blocks, in a 2x4 factorial arrangement (two cultivars and four pruning times) with four blocks, which contained eight bushes, with six useful bushes per experimental unit.

In the 2020/2021 and 2021/2022 production cycles, the beginning and the end of the phenological stages and the duration of the harvest were recorded (Hussain et al., 2016, 2017). Production variables – number of fruit per bush; production (g per bush) and estimated fruit yield (kg ha^{-1}) – were evaluated during the production phase of each treatment. Every three days, fruit from each plot were harvested, counted, and weighed with the aid of a semianalytical scale Shimadzu SHI-AUX-220 model (Shimadzu Excellence in Science, São Paulo, SP, Brazil). At the end of the production cycle, all fruit and all recorded masses were totaled to determine the production per bush. The estimated yield was obtained by multiplying the production by the population density (6,667 bushes per hectare).

Twenty fruit were collected per block 30 days after the beginning of the harvest, in each production cycle, to determine the following physicochemical characteristics: mean fruit mass, titratable acidity (TA), total soluble solids (TSS), and TSS/TA ratio. Titratable acidity (g 100 g^{-1}) was obtained by titrating the samples with 0.1 N NaOH solution (in % citric acid). Soluble solids (SS, °Brix) were determined with the aid of a portable refractometer (RTD-45 model, Cial, São Paulo, SP, Brazil), at 20°C. The SS/TA ratio was determined by dividing the value of soluble solids by acidity.

Data were subjected to Tukey's comparison test, at 5% probability. The analyses were performed using the computer program for analysis of variance Sisvar, version 5.6. (Ferreira, 2014).

Results and Discussion

The harvest season of 'BRS Tupy' and 'Brazos' was extended up to approximately five months; and these cultivars were subject to drastic pruning in January (harvest start in September), and conventional pruning (harvest end in Febuary) (Table 1).

In comparison with the conventional pruning, the drastic pruning in January anticipated the harvest by 39 days, in both production cycles – 2020/2021 and 2021/2022 (Table 1). Drastic pruning in January made it possible to harvest blackberries at the end of September and throughout October, when rainfall is low in the altitude subtropical region of southern Minas Gerais

Table 1. Beginning of harvest (BH), end of harvest (EH), and duration of harvest (DH) of the BRS Tupy and Brazos blackberry cultivars, in the 2020/2021 and 2021/2022 production cycles, grown under different pruning management systems, in conditions of an altitude subtropical climate: conventional pruning (CP), drastic pruning in January (DP January), drastic pruning in March (DP March) and drastic pruning in May (DP May), in an altitude subtropical region in Lavras, in the state of Minas Gerais, Brazil[(1)].

Pruning management	2020/2021 production cycle			2021/2022 production cycle		
	BH	EH	DH (day)	BH	EH	DH (day)
			BRS Tupy			
CP	11/03/2020	02/17/2021	106a	10/29/2021	02/15/2022	109a
DP January	09/25/2020	12/20/2020	86b	09/20/2021	12/22/2021	93ab
DP March	10/26/2020	12/15/2020	50c	10/26/2021	12/26/2021	61b
DP May	11/15/2020	01/10/2021	56c	10/20/2021	12/29/2021	70b
			Brazos			
CP	11/03/2020	02/17/2021	106a	10/30/2021	02/17/2022	110a
DP January	09/25/2020	12/22/2020	88b	09/15/2021	12/17/2021	93ab
DP March	10/26/2020	12/15/2020	50c	09/20/2021	12/15/2021	86b
DP May	11/15/2020	01/10/2021	56c	10/20/2021	01/10/2022	82b
CV (%)	-	-	3.98	-	-	4.17

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

(Figure 1). According to Campagnolo & Pio (2012c), this anticipation is not related to pruning management, since no differences were observed between the beginning of the harvest for 'BRS Tupy' blackberry bushes subjected to conventional pruning and drastic pruning, both in January, in a subtropical region. The change of anticipation is probably related to the application of hydrogenated cyanamide to bushes that underwent drastic pruning. The dormancy breaking of 'BRS Tupy' blackberry using hydrogenated cyanamide on bushes, in a subtropical region, anticipated and standardized budding and flowering, and generated the highest budding and yield values for this cultivar, according to Segantini et al. (2011).

Another point to be discussed is the anticipation of the beginning of the harvest of the second production cycle, in relation to the first cycle, for bushes that received drastic pruning in March and in May (Table 1). In the first production cycle, rainfall between September and November was lower than that in the second cycle (Figure 1). In the present study, there was no irrigation supplementation; however, there is a need for irrigation for blackberry that will receive later pruning in altitude subtropical regions. This practice can assist in stem growth and anticipate the beginning of harvest.

In the two studied cultivars, the results were inversely proportional for the number of fruit and the average mass of blackberries. In the two evaluation cycles, the drastic pruning, performed in January and March, stimulated an increase of the number of fruit per bush, but the average mass of blackberries was lower than that for bushes subjected to conventional pruning and pruning in May (Table 2). This finding could be related to the balancing of the translocation of photoassimilates. However, this hypothesis is rejected because the fresh vegetative mass of the branches was lower for bushes subjected to conventional pruning and drastic pruning in May than for bushes subjected to drastic pruning in January and March (Table 3). This difference may be related to fruit competition in the bushes because the difference in the number of fruit was very large between bushes subjected to drastic pruning in January and March and those subjected to conventional pruning and drastic pruning in May (Table 2).

The highest production per bush and estimated yield were obtained for bushes subjected to drastic pruning in January, both for 'BRS Tupy' and 'Brazos' (Table 2). Notably, there was no anticipation or prolongation of the harvest for the drastic pruning performed in March, in comparison to the drastic pruning performed in

Table 2. Number of fruit, fresh fruit weight, production per bush, and estimated yield of the BRS Tupy and Brazos blackberry cultivars, in the 2020/2021 and 2021/2022 production cycles, grown under different pruning management systems, in conditions of an altitude subtropical climate: conventional pruning (CP), drastic pruning in January (DP January), drastic pruning in March (DP March) and drastic pruning in May (DP May), in an altitude subtropical region in Lavras, in the state of Minas Gerais, Brazil[(1)].

Pruning management	Number of fruit		Fresh fruit weight (g)		Production per bush (g)		Estimated fruit yield[(2)] (kg ha^{-1})	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
				BRS Tupy				
CP	56.66b	61.00b	9.17a	8.45a	326.16c	311.10c	2,174.50c	2,074.10c
DP January	236.16a	223.75a	7.20b	7.12b	1,536.66a	1,541.13a	10,244.91a	10,274.71a
DP March	230.37a	232.75a	6.15b	7.10b	1,211.67b	1,187.03b	8,078.20b	7,913.92b
DP May	26.66b	54.00b	10.23a	9.11a	275.62c	275.40c	1,837.55c	1,836.09c
CV (%)	15.41		10.87		12.83		12.83	
				Brazos				
CP	41.95b	47.00c	8.56 ab	8.82a	263.75c	239.70d	1,758.42c	1,598.07d
DP January	282.91a	292.50a	7.00c	7.13b	1,739.20a	1,983.75a	11,595.25a	13,225.66a
DP March	260.25a	286.50a	6.00c	6.40b	1,342.66b	1,553.15b	8,951.51b	10,354.85b
DP May	26.54b	100.75b	9.73a	9.61a	260.83c	513.83c	1,738.95c	3,425.70c
CV (%)	15.41		10.87		12.83		12.83	

[(1)]Means followed by equal lowercase letters, in the columns, do not differ by Tukey's test, at 5% probability. [(2)]Calculation considering 3.0x0.5 m spacing, at 6,667 bushes ha^{-1} density. CV, coefficient of variation.

January (Table 1). As the fruit yield was substantially higher in bushes pruned in January, the pruning in March in altitude subtropical regions should not be considered a management option.

The lower production after drastic pruning performed in May, in comparison with those of other pruning management systems, was expected because Campagnolo & Pio (2012c) have already reported that the drastic pruning of blackberry in late autumn and early winter results in lower production.

According to Tadeu et al. (2015), in comparison to conventional pruning, drastic pruning management performed in January generates increased production and yield.

In conventional pruning, only four primary stems per bush are maintained after pruning, at the end of harvest; and in drastic summer pruning, the emitted stems grow freely. Thus, the number of leaves is higher for bushes subjected to drastic summer pruning, to the detriment of the greater number of stems per bush; this occurs probably because there is a greater production of photoassimilates (reserves) and, consequently, higher flower emissions (Campagnolo & Pio, 2012d).

However, there was a great elasticity of production in relation to drastic pruning performed in January and conventional pruning also performed in January. This can be attributed to the defoliation and the use of hydrogenated cyanamide, five months after drastic pruning, which potentiated the emission of shoots and flowers, an effect not observed for conventional pruning. A greater uniformity and consequent production were reported for blackberry, when hydrogenated cyanamide was used to break dormancy (Leonel et al., 2016).

There was no difference for the fruit quality of 'BRS Tupy' and 'Brazos' blackberry in both production cycles, due to the use of different pruning management practices (Table 3), a finding that is consistent with the results reported by Campagnolo & Pio (2012c). The difference of concentration of soluble solids and acidity is associated with the intrinsic characteristics of the cultivar, according to Tadeu et al. (2015).

However, there may be a difference between plants of the same cultivar, when comparing different cultivation sites with different climatic characteristics (Campagnolo & Pio, 2012b, 2012d; Curi et al., 2015). The variations among levels of chemical compounds, based on the location where blackberries are grown, occur due to differences in the intensity of solar radiation and thermal amplitude, which affects the

Table 3. Fresh vegetative mass of shoots (FVMS) emerged from the pruning, and titratable acidity (TA), total soluble solids (TSS), and TSS/TA ratio of the BRS Tupy and Brazos blackberry cultivars, in the production cycles 2020/2021 and 2021/2022, grown under different pruning management systems, in conditions of an altitude subtropical climate: conventional pruning (CP), drastic pruning in January (DP January), drastic pruning in March (DP March), and drastic pruning in May (DP May), in an altitude subtropical region in Lavras, in the state of Minas Gerais, Brazil[(1)].

Pruning	FVMS[(2)] (kg ha^{-1})		TA (g 100 g^{-1})		TSS (°Brix)		TSS/TA ratio	
management	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
				BRS Tupy				
CP	646.45b	662.62b	1.1a	1.1a	8.2a	8.2a	7.4a	7.4a
DP January	1,256.73a	1,371.79a	1.0a	1.1a	8.7a	9.0a	8.7a	8.1a
DP March	1,058.36a	1,101.23a	1.2a	1.2a	8.8a	8.7a	7.3a	7.3a
DP May	661.45b	653.98b	1.2a	1.1a	8.7a	8.4a	7.3a	7.6a
				Brazos				
CP	844.91b	865.98b	1.0a	1.0a	7.3a	7.5a	7.3a	7.5a
DP January	1,521.25a	1,628.98a	1.0a	1.2a	7.9a	8.6a	7.9a	7.2a
DP March	1,190.57 ab	1,255.78 ab	1.0a	1.2a	7.5a	8.5a	7.5a	7.2a
DP May	859.91b	869.09b	1.1a	1.2a	8.2a	8.7a	7.4a	7.3a
CV (%)	13.00	14.45	13.15		15.28		14.17	

[(1)]Means followed by equal lowercase letters, in the columns, do not differ, by the Tukey's test, at 5% probability. [(2)]Calculation considering 3.0x0.5 m spacing, at 6,667 bushes ha^{-1} density. CV, coefficient of variation.

organoleptic characteristics of the fruit (Souza et al., 2014b).

Conclusions

1. It is possible to extend the harvest season of 'BRS Tupy' and 'Brazos' blackberry (*Rubus* spp.) up to five months, by applying drastic pruning in January and no irrigation, in an altitude subtropical region in Lavras, in the state of Minas Gerais, Brazil.

2. The drastic pruning made in January or March increases the yield of 'BRS Tupy' and 'Brazos' blackberry; and extended harvest does not affect the fruit quality and does not create challenges for harvesting operations.

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