



Phenological behavior and agronomic potential of blackberry and hybrids in a subtropical region¹

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10.1590/0034-737X201966060004

ABSTRACT

The purpose of this study was to evaluate the phenological behavior and agronomic potential of blackberry varieties and hybrids in a subtropical region. Blackberry seedlings of four varieties and two hybrids were purchased in April 2015 in the form of stem cuttings and transplanting in July 2015. Winter pruning was carried out on August 18, 2016 and 2017. The experimental design was composed of a randomized complete block design, containing four varieties and two hybrids, four blocks and five useful plants per experimental unit. The harvest was performed every two days to the determination of fresh biomass, longitudinal and transverse diameter, volume, number of fruits per plant, yield and estimated productivity. The average duration of the phenological cycles in the two harvests varies between 109 and 162 days and 114 and 148, respectively. Hybrids Boysenberry and Olallie presented a shorter cycle in both harvests. In the 2016/2017 crop, the harvest lasted from 39 to 88 days. In the 2017/2018 harvest, it lasted 23 to 57 days, starting in mid-November through early January. The Tupy and Chickasaw cultivars were the most productive in the first crop. In the second crop, the Tupy and Navaho cultivars were prominent.

Keywords: *Rubus* sp.; small fruits; phenology; mild climate region; hybrid genotypes.

INTRODUCTION

The cultivation of small fruits with little winter cold demand has become an alternative to grain production in western Paraná. The adoption of cultivars with lower requirements for chilling units, in regions of mild winter, makes it possible to harvest fruits earlier than those carried out in the traditional Brazilian cultivation regions. This fact has a relevant market implication, making marketing possible in times of lower supply (Moura *et al.*, 2012).

This precocity in maturation is due to the warmer winter climate in subtropical regions, which allows the pruning and induction of budding (Antunes *et al.*, 2006). Currently, the interest for the cultivation of small fruits has grown in Brazil, mainly in Paraná State, adapting well to low temperatures and mild summers. Some studies have demonstrated the potential for cultivation of fruit

with a low chilling requirement in Western Paraná (Maro *et al.*, 2012).

Blackberry cultivation is an option for the Paraná State fruit culture, although to date, there is little knowledge about the productive performance of cultivars and hybrids in the Western region of the state (Villa *et al.*, 2014). It is believed that this fruit can present good productive performance in Brazilian subtropical regions, mainly with the adoption of less demanding plants in terms of chilling units. Preliminary results show that some blackberry cultivars grown in Marechal Cândido Rondon have produced good quality fruits. Other species of the genus *Rubus* produce fruits with chemical and productive characteristics similar to blackberry, such as Boysenberry, a hybrid between raspberry and blackberry (Campagnolo & Pio, 2012).

Submitted on October 16th, 2018 and accepted on September 26th, 2019.

¹ Financing source: CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior).

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To recommend a species or cultivar in a region, knowledge is required on the behavior of the species for these conditions. The phenological behavior of cultivars and hybrids of the genus *Rubus* depends on the interaction between genetic, environmental and soil-climatic conditions, as well as the cultural practices used (Surya & Rahman, 2012). Each species presents a different reaction, when submitted to different conditions of the environment. Phenological evaluation may be of crucial importance for the introduction of a culture in the region (Segantini *et al.*, 2015).

Nevertheless, the phenology of temperate fruit trees in subtropical regions has not yet been well elucidated, so the phenological characterization of blackberry in a marginal region can describe the details of the growth cycle of these plants (Tadeu *et al.*, 2015). Because it is a temperate fruit, the phenological aspects of blackberry may vary from year to year, depending on whether or not its chilling hour requirement is satisfactory. In addition to climatic aspects, factors inherent in the varieties or hybrids can affect the behavior of the plant (Antunes *et al.*, 2014).

In view of the above, the purpose of this work was to evaluate the phenological behavior and agronomic potential of blackberry varieties and hybrids in subtropical region.

MATERIAL AND METHODS

The experiment was carried out in an Experimental Farm located in the geographic coordinates 24°33'40" S, 54°04'12" W, with 420 m in altitude. The climate, according to the Köppen classification, is *Cfa*, with hot summers, infrequent frosts and rainfall concentration in the summer months, with no defined dry season, being characterized as a subtropical region (Alvares *et al.*, 2013). The predominant soil is oxisol (USDA, 2010). The mean temperatures of the region are below 18 °C, with maximum means above 22 °C and mean annual precipitation around 1,840 mm.

Blackberry (*Rubus spp.*) seedlings of varieties Arapaho (without thorns), Navaho (without thorns), Tupy (with thorns), Chickasaw (with thorns) and hybrids Boysenberry and Olallie (blackberry x raspberry), both with thorn, were purchased in April 2015 in the form of stem cuttings and placed to be rooted in polystyrene bags. These were kept under cover conditions with 50% shading and irrigated daily, until field transplanting.

In July 2015, the acclimatized seedlings were taken to the field. The management system used was previously mounted in a T shape, containing double parallel wires, with wooden posts spaced at a distance of 12 m and dimensions of 0.15 m (diameter) x 1.20 m (height). After planting, the necessary crop practices related to the crop, including crowning of plants, cutting and weeding, pest and disease control, irrigation, plant fastening, and stem

management were carried out (Villa *et al.*, 2003; Villa *et al.*, 2014).

On August 18, 2016 and 2017, winter pruning was performed by reducing the main stem to a height of 15 cm above the wire and shortening the secondary branches, leaving two or three buds. The experimental design was composed of randomized blocks, containing 4 varieties and 2 hybrids, 4 blocks and 5 useful plants per experimental unit.

The beginning of the evaluation of the phenological behavior of the plants in each experimental plot occurred after winter pruning, through visual observations, as presented in Table 1 (methodology adapted from Hussain *et al.*, 2016).

Fruit harvesting started in October 2016 and November 2017, occurring every two days, extending until January 2017 and January 2018, respectively. The fruits were harvested in polystyrene containers with a lid, separately from each cultivar, when they were in the stage of complete maturation and black coloration.

Immediately after harvest, the fruits were taken to the Unioeste Food Technology Laboratory for execution of the physicochemical analysis. The number of fruits evaluated in the variables fresh mass, longitudinal and transverse diameters and volume of fruits were five per experimental plot in each harvest, which in turn occurred every two days. Thus at the end of the two production cycles the genotype with the shortest harvest time (Boysenberry, 2017/18 crop) had at least 25 fruits evaluated, because 5 harvests were performed; and the genotypes with the most extended productive period had higher number of fruits evaluated, reaching 150 fruits in the genotype with longer crop (Chicasaw, 2016/17 crop). Thus, it was prevented that the difference between fruits throughout the cycle would interfere in the result of the characteristics of each cultivar. The number of fruits per plant, yield (g plant⁻¹) and estimated productivity (t ha⁻¹) were also determined by harvesting, counting and weighing all the fruits of each harvest.

The longitudinal and transverse diameter of the fruits were measured with the aid of a stainless steel digital caliper (brand Stainless Hardened). The volume was estimated by the water displacement method, by initially immersing five blackberry fruits in a graduated cylinder containing 100 mL of water and recording the difference between volume before and after fruit immersion (Costa *et al.*, 2016). The fruits of each block were harvested for the determination of yield and estimated productivity of the fruits, being weighed using a semi-analytical digital scale (model N0 4052E, brand LUXOR).

The data were submitted to analysis of variance and were compared by the Tukey test ($p < 0.05$) using the statistical software Sisvar (Ferreira, 2011).

RESULTS AND DISCUSSION

The phenological stages and cycles (between pruning and final harvest) of varieties Tupy, Arapaho, Chickasaw and Navaho and hybrids Boysenberry and Olallie cultivars are shown in Figures 1 (a, b, c, d, e and f) and 2 (a and b).

In the 2016/2017 crop, the shortest cycle was verified for Arapaho (145 days) and the longest, for Navaho (162

days). This cycle was longer due to the long flowering period observed, beginning in September, with first productions occurring at the end of October and extending until the end of January. The Tupy cvariety presented a cycle of 152 days, similar to that found by Antunes *et al.* (2014) in a tropical climate region of Minas Gerais, diverging from the findings of Campagnolo & Pio (2012).

Table 1: Phenological stages evaluated in blackberry cultivars, in the 2016/2017 and 2017/2018 harvests

Phenological stages	Phenological behavior	Phenological stages	Phenological behavior
A1	Start o budding	F	Fruit swelling without floral remains
A	Closed bud	G	Change of coloration from green to reddish
B	Open bud	H	Fully red
C	Open flower	I	Start of darkening of the drupes: fruits
D	Loss of petals	J	Fully black fruits
E	Fruit swelling of floral remains		

Source: Adapted from Hussain *et al.* (2016). The duration of each phenological stage was presented in days.

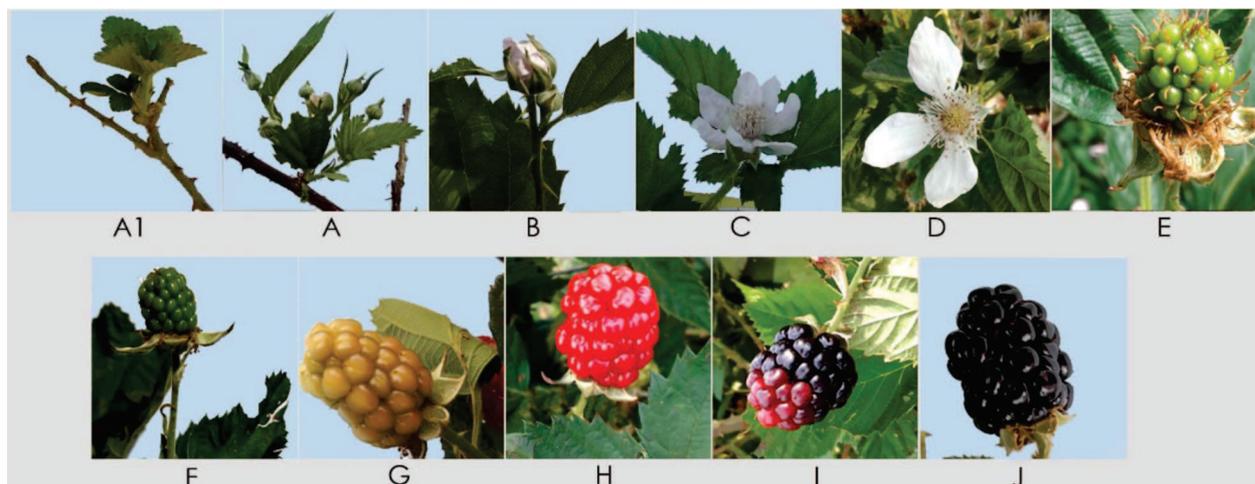


Figure 1a: Phenological stages of the Tupy blackberry cultivar.

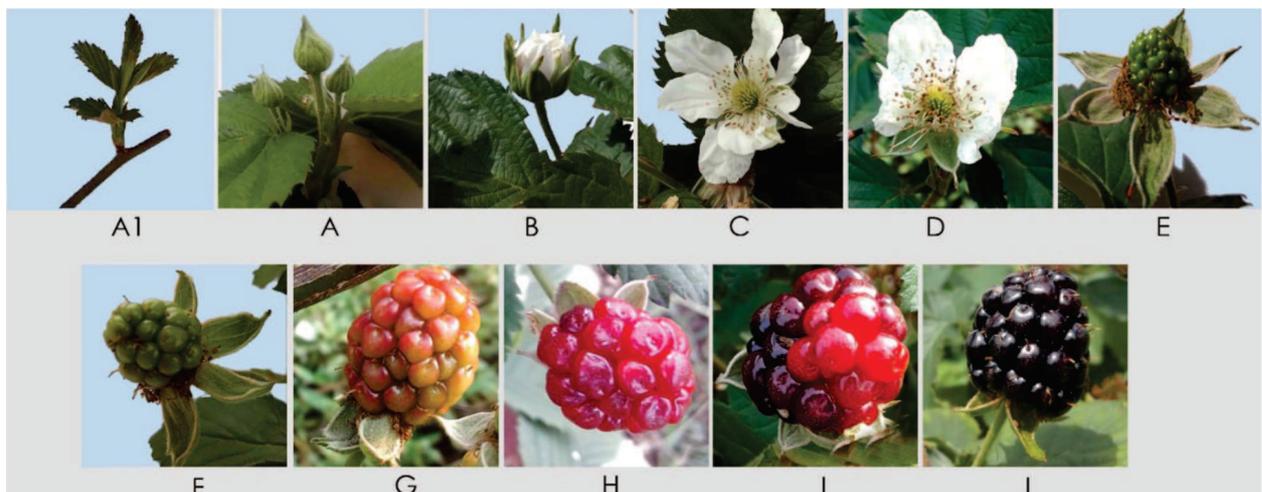


Figure 1b: Phenological stages of the Arapaho blackberry cultivar.

On average, harvests had a duration of 71 and 40 days for blackberry cultivars, respectively (2016/2017 crop). In the second evaluation season (2017/2018), the harvest period was extended for 53 and 27 days, for blackberry cultivars, respectively. These values differ from the ranges found by Brugnara (2016) in Chapecó, (Santa Catarina, Brazil), in which the harvest season was determined by the availability of dark-colored pseudo-fruits, extending for 98 days in the first harvest (2013/2014) and 100 days in the second harvest (2014/2015).

The difference observed in phenological cycles (Figure 1a) in a subtropical region may be due to factors such as the genetic characteristics of each cultivar, types of management system, and soil and climatic conditions (Ferreira *et al.*, 2016), such as soil, temperature and photoperiod, the latter interfering directly with flowering and sprouting after pruning (Antunes *et al.*, 2010).

In the 2017/2018 crop, the shortest cycle was verified for Tupy (136 days) and the longest, for Navaho (148 days), the latter being the same as in the previous harvest. Notwithstanding, the flowering observed in the current harvest was not intense and began in late September, culminating with the dry period that occurred at the same time. Production began only in the first half of November, extending until the beginning of January. The cycle of (109 days) was of Boysenberry and (162 days) for cultivar Navaho.

The difference observed in phenological cycles (Figure 1b) for the second crop may be related mainly to climatic conditions (Ferreira *et al.*, 2016), such as temperature, precipitation and photoperiod, which directly interfere with flowering and sprouting after to pruning (Antunes *et al.*, 2010).

Hybrids Boysenberry and Olallie (2017/2018 crop), showed a similar behavior to the varieties, from the

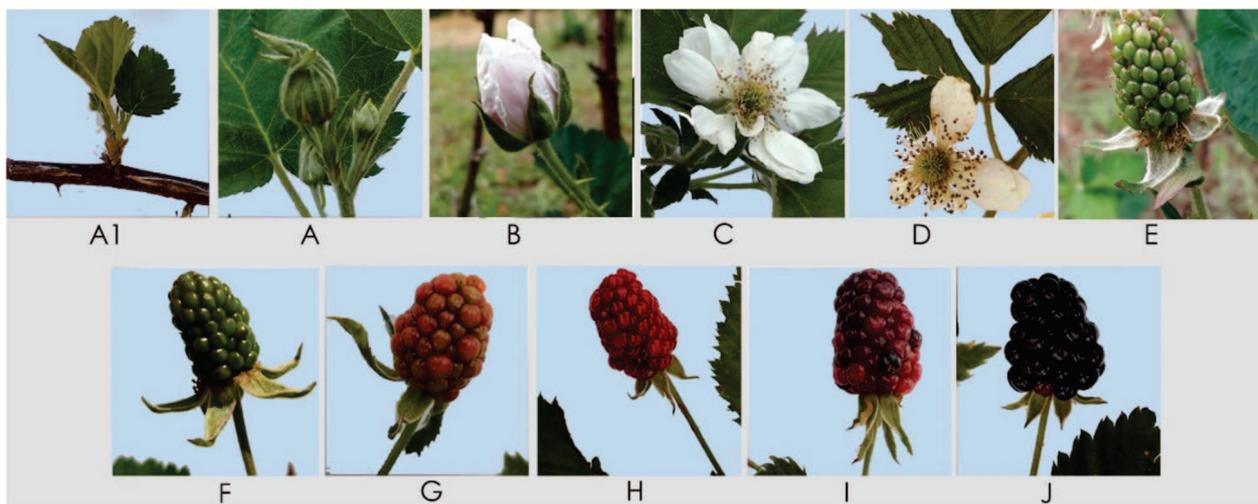


Figure 1c: Phenological stages of the Chickasaw blackberry cultivar.

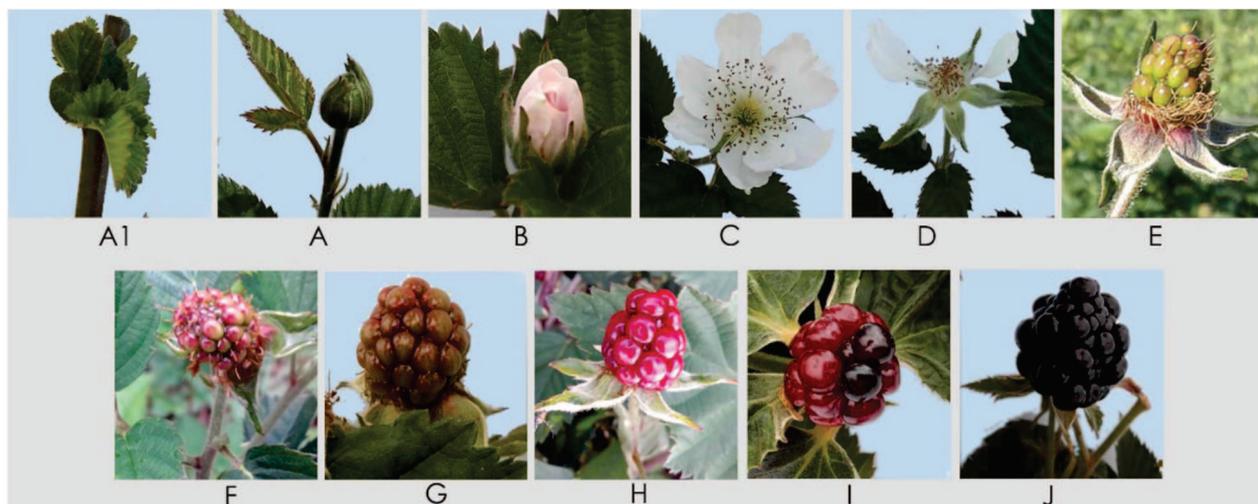


Figure 1d: Phenological stages of the Navaho blackberry cultivar.

beginning of the sprouting to the end of harvest, with 114 and 122 days, respectively (Figure 2b). This agronomic similarity is probably due to the origin of the hybrids, i.e., Boysenberry is a hybrid between blackberry and red raspberry. On the other hand, Olallie is the result of the crossing of blackberry, raspberry and mulberry (Du *et al.*, 2010). Similar results were observed by Moura *et al.* (2012), in Boysenberry a subtropical climate region (Lavras, Minas Gerais, Brazil), presenting a cycle of 110 days.

In subtropical conditions, cultivars of temperate fruit species tend to exhibit significant variability in their growth cycle, and adaptability to this new environment requires more than one year of crop study (Hussain *et al.*, 2016). The characterization of the phenological stages of the small fruit production cycle provides important information for fruit growers, with the knowledge of each phase of development, thereby reducing production costs, making agricultural pesticide expenses more

rational, using fewer inputs, planning the harvest and post-harvest periods, and allowing production at different times in producing states, such as Rio Grande do Sul and Minas Gerais (Villa *et al.*, 2008).

Hussain *et al.* (2016), in studies conducted with blackberry cultivars Tupy and Xavante in the northern region of the state of Paraná, obtained phenological stages of 110 and 121 days, respectively. These results differ from those found in this present work. One of the reasons for this difference in the phenological cycle, in the same state, may be related to the precocious increase of the temperatures at the end of the winter, influencing the precocity of budding, shorter cycles, and anticipated harvest.

Longer phenological cycles were verified in blackberry cultivars Arapaho and Navaho, with 147 and 148 days, respectively (Figure 2b). The occurrence of a winter with less chilling hours (Table 2) and a strong drought in mid-

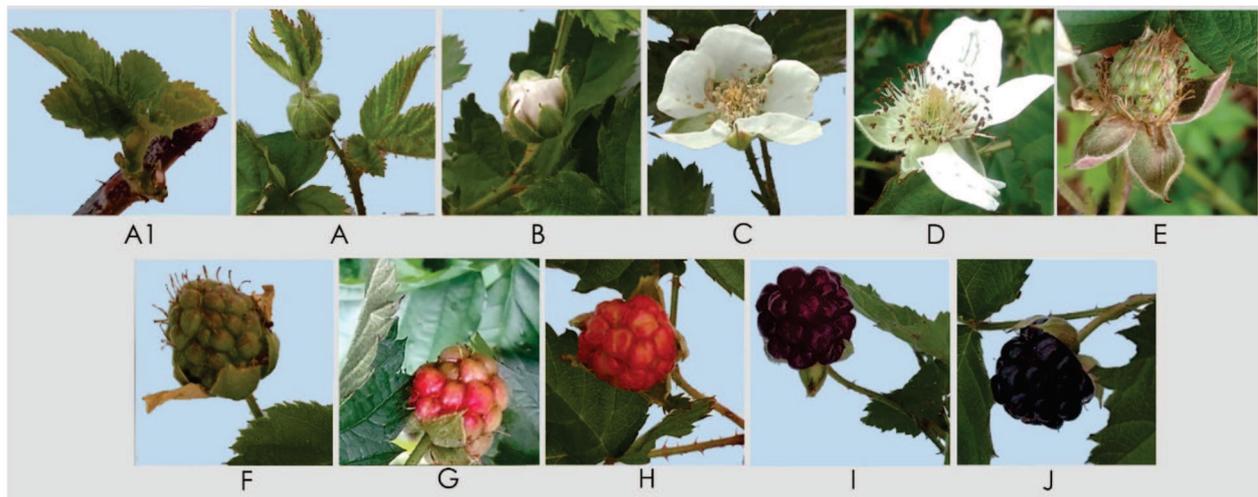


Figure 1e: Phenological stages of the Boysenberry blackberry cultivar.

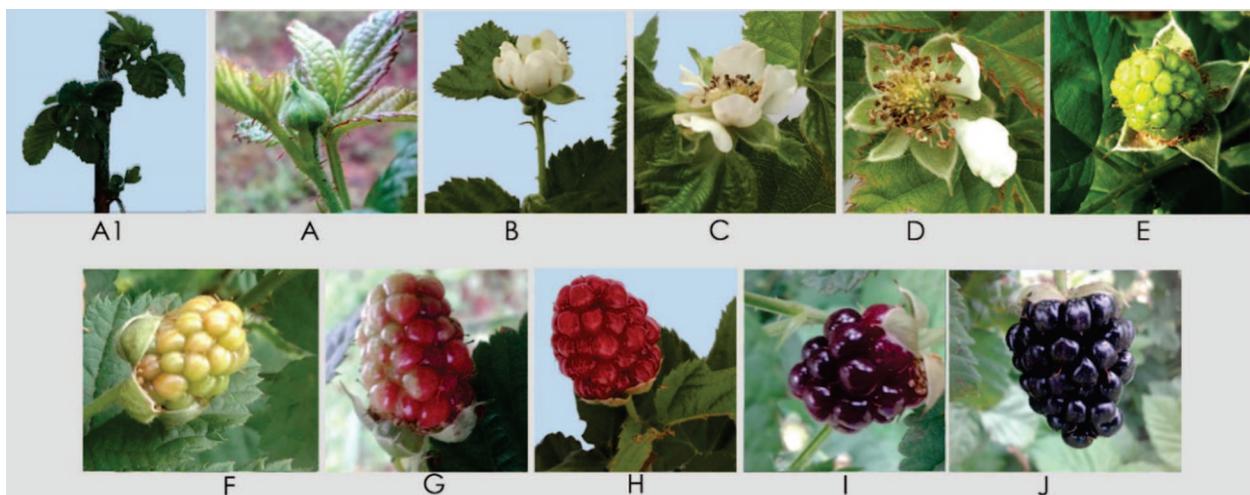


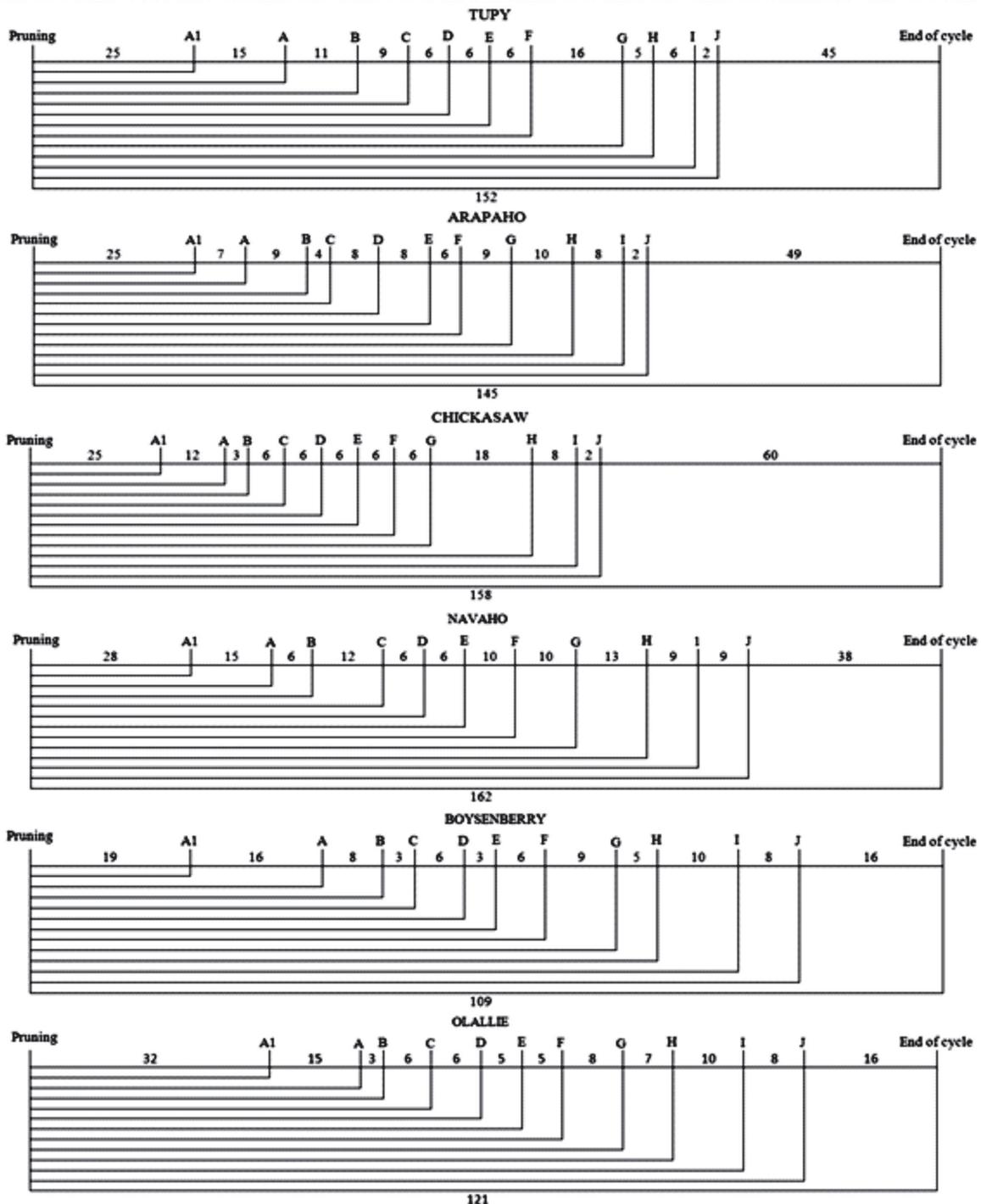
Figure 1f: Phenological stages of the Olallie blackberry cultivar.

August and September 2017, led to a delay at the beginning of the cycle, which resulted in decreased production.

Figure 2b shows day-to-day variations in the buds of cultivars and hybrids, with precocity in Boysenberry and Olallie and late budding in Arapaho, Chickasaw and Navaho. In subtropical regions, the onset of fruit buds

may be related to air temperature (Table 2), directly influencing the crop cycle (Black *et al.*, 2008).

Hybrids that comprise the crossing of blackberry and raspberry, being more demanding in terms of chilling, produced in the 2017/2018 crop less than in the previous crop, given the few chilling hours in this period. In mild



Phenological stages: A1 = start of budding, A = closed bud, B = open bud, C = open flower, D = petal loss, E = fruit swelling with floral remains, F = fruit swelling without flower remains, G = change of color from green to red, H = fully red, I = beginning of darkening of the berry, and J = fully black fruits.

Figure 2a: Phenological stages (days) of the blackberry cultivars in the 2016/2017 crop.

winter conditions, in which chilling requirements are not fully satisfied, cultivars of temperate fruit species with different chilling requirements present great variability in the flowering season from year to year (Curi *et al.*, 2015).

The accumulation of cold during the winter is fundamental so that black mulberry can initiate the budding and bloom normally (Segantini *et al.*, 2015). After the complete application of the cold requirement, there is a need for higher temperatures in relation to the effective ones for cold accumulation, so that metabolic activities are accelerated in the meristematic tissues of the buds, triggering sprouting (Hawerroth *et al.*, 2010).

Considering the start of the flowering period, the appearance of the first open flowers (phenological phase C), there was a large variation among the cultivars studied, ranging from 45 (Arapaho) to 61 (Navaho) days after pruning on August 18, 2017 (2016/2017 crop). This variation was also observed in the 2017/2018 crop, ranging from 49 (Chickasaw) to 69 (Olallie). This change in the flowering pattern in the two harvests is due to the variation and annual requirement in the accumulation of chilling hours of varieties and hybrids and temperature oscillations between April and August in the year evaluated (Table 2).

Table 3 shows the estimated fresh biomass, volume, longitudinal diameter and transverse diameter of fruits of blackberry cultivars and hybrids in the 2016/2017 and 2017/2018 crops, respectively. For fresh fruit biomass, there were significant differences among varieties and hybrids, with higher values in Chickasaw fruits.

In the 2016/2017 crop, the Navaho cultivar and the hybrids performed differently compared to the other cultivars in relation to fresh fruit biomass. For the 2017/2018 crop, only the hybrids showed the same performance. The fresh biomass of the fruits of the current crop was much lower than the previous harvest. One of the possible climatic factors for the observed difference in the biomass of the fruits between the crops may be the little cumulative chilling time recorded during the winter (Brugnara, 2016).

Curi *et al.* (2015) found in Lavras, MG, Brazil values of 4.6 g for the fresh biomass of the Arapaho cultivar. This difference in weight occurs mainly in the genotypes studied in interaction with the environment, mainly temperature. When there is a lower accumulation of winter chill, there is a lower percentage of buds, subsequently reducing the number of inflorescences and fruits.

Volume is a physical attribute that can be used to determine the growth of the fruit, as its increase is related to the accumulation of biomass, being a three-dimensional measure commonly determined by the displacement of the water in a certain graduated container (Peixoto *et al.*, 2011).

Table 3 shows a larger volume of Chickasaw fruits in the two crops and, in the 2017/2018 crop, the Tupy cultivar also stood out. This higher volume is directly related to the size and weight of the fruit, i.e., the heavier the fruit the larger the volume, which causes them to reach the characteristic shape and size of the species.

In the 2016/2017 crop, greater longitudinal and transverse diameter of fruits were found for Chickasaw and Tupy, respectively. In the 2017/2018 crop, the Navaho cultivar was added to these parameters (Table 3). The size of the fruit, represented by the diameters are physical parameters of great utility, being able to assist in the destination of the fruits for fresh consumption and/or processing. The market for fresh blackberry has preference for large fruits, as is the case cultivars Tupy, Chickasaw, and Navaho. Additionally, this size may also be a parameter for determining the harvest point in fruits that should be harvested early processing (Cavichioli *et al.*, 2011).

In both crops, fruits with smaller diameters were observed in the hybrids cultivars. This fact was already expected, as the hybrids are crosses between blackberry and raspberry, with characteristics of diameter and biomass of raspberry fruits (Moura *et al.*, 2012). It should be emphasized that the hybrids had a lower longitudinal and transverse diameter, given the round shape of the fruit. Fruits of cultivars Tupy

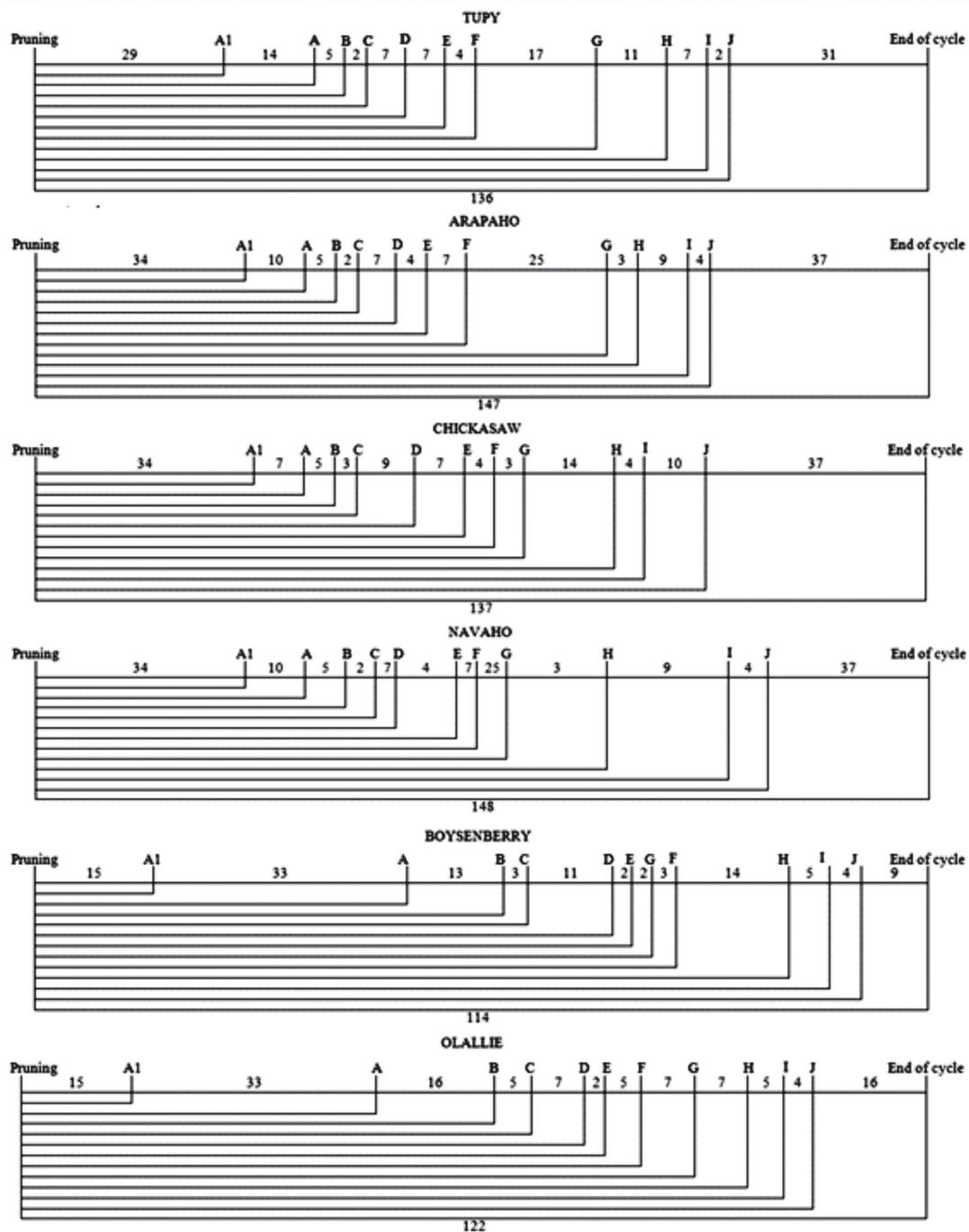
Table 2: Cumulative chilling hours (CH) and air heat oscillation, from April to August 2017. Weather station data

Months	Crops			
	2016/2017	2017/2018	2016/2017	2017/2018
	CH		Air temperature (°C) (min-max)	
April	18*	4	5.1°C - 34.0°C	7.0°C - 30.1°C
May	9	0	3.4°C - 28.3°C	10.4°C - 29.4°C
June	74	22	-0.3°C - 27.9°C	3.0°C - 28.9°C
July	55	43	1.7°C - 31°C	-9.0°C - 30°C
August	11	4	6.5°C - 33°C	3.7°C - 34.7°C
September	15	0	3.8°C - 35.2°C	12.4°C - 37.4°C
Total	182	73		

*Cumulative sum of hours with air temperature $\leq 7.2^{\circ}\text{C}$ during the period from April to September 2016 (relating to the 2016/2017 crop) and April to August 2017 (relating to the 2017/2018 crop), respectively.

and Chickasaw tend to be more elongated, due to the greater longitudinal and transverse diameter, corroborating the findings of Tullio & Ayub (2013). Fruits of the Navaho cultivar tend to have smaller longitudinal diameter (Clark & Finn, 2014) than other cultivars.

Table 4 shows the number of fruits per plant, production and estimated productivity of the cultivars for the two harvests evaluated. In the 2016/2017 crop, in relation to the number of fruits/plant of varieties and hybrids, the highest number was registered for Tupy,



Phenological stages: A1 = start of budding, A = closed bud, B = open bud, C = open flower, D = petal loss, E = fruit swelling with floral remains, F = fruit swelling without flower remains, G = change of color from green to red, H = fully red, I = beginning of darkening of the berry, and J = fully black fruits.

Figure 2b: Phenological stages (days) and cycles of blackberry cultivars in the 2017/2018 crop. Phenological stages: A1 = start of budding, A = closed bud, B = open bud, C = open flower, D = petal loss, E = fruit swelling with floral remains, F = fruit swelling without flower remains, G = change of color from green to red, H = fully red, I = beginning of darkening of the berry, and J = fully black fruits.

which shows superiority in relation to the work developed by Campagnolo & Pio (2012), which found 308 fruits.

In the 2017/2018 crop, the Tupy cultivar presented, along with the Navaho cultivar, superiority in the number of fruits per plant but showed deformed fruits. This was possibly because the plants of this last cultivar were in the second year of production, associated with few chilling hours that occurred during the second harvest. The same phenomenon was observed in the Brazos cultivar in two crops by Cruz *et al.* (2017), in a study conducted in Diamantina, MG, Brazil.

The lowest number of fruits were verified in plants of the Navaho variety and the hybrid Boysenberry in the 2016/2017 crop. In the 2017/2018 crop, this lower number was observed in hybrids. In the production performance (yield and productivity) of blackberry cultivars, the Tupy and Chickasaw varieties stand out in the two crops, as well as Navaho in the 2017/2018 crop.

Similar results were observed by Antunes *et al.* (2006), in Caldas, MG, Brazil, where, when studying the performance of eight blackberry cultivars for three consecutive crops, they confirmed the productivity

Table 3: Estimated fresh biomass, volume, longitudinal diameter and transverse diameter of fruits of blackberry cultivars in the 2016/2017 and 2017/2018 crops

Blackberry cultivars	Fresh biomass (g)		Volume (mL)	
	Crop 2016/2017	Crop 2017/2018	Crop 2016/2017	Crop 2017/2018
Tupy	5.1 b*	4.6 a	4.9 b	4.2 a
Arapaho	3.4 c	2.2 c	3.2 c	1.9 c
Chickasaw	8.3 a	5.1 a	7.4 a	4.9 a
Navaho	2.2 d	3.3 b	2.1 cd	3.2 b
	Longitudinal diameter (cm)		Transverse diameter (mm)	
Tupy	18.0 ab*	19.2b	16.8 a	16.3 a
Arapaho	14.4 bc	11.5 d	14.6 ab	11.1 c
Chickasaw	20.5 a	23.1 a	16.0 ab	17.9 a
Navaho	10.9 c	15.9 c	11.4 bc	14.0 a
CV(%)	7.2	15.1	15.0	16.0
Hybrids	Fresh biomass (g)		Volume (mL)	
	Crop2016/2017	Crop2017/2018	Crop2016/2017	Crop 2017/2018
Boysenberry	1.8 d	0.02 d	2.1 cd	0.2 d
Olallie	1.9 d	0.07 d	1.6 d	0.1 d
	Longitudinal diameter (mm)		Transverse diameter (mm)	
Boysenberry	9.1 c	1.3 e	8.6 c	1.3 d
Olallie	9.6 c	0.9 e	8.1 c	0.8 d
CV(%)	7.2	15.1	15.0	16.0

*Lowercase letters differ from each other on the column by the Tukey test ($p < 0.05$).

Table 4: Number of fruits.plant⁻¹, production and yield of blackberry cultivars and hybrids, in the 2016/2017 and 2017/2018 production cycles

B C*	Number of fruits.plant ⁻¹		Production(g.plant ⁻¹)		Yield(t.ha ⁻¹)	
	Crop 2016/2017	Crop 2017/2018	Crop 2016/2017	Crop 2017/2018	Crop 2016/2017	Crop 2017/2018
Tupy	358.9 a**	137.8 a	1774.0 a	555.9 a	11.83 a	3.71 a
Arapaho	138.9 bc	62.5 b	444.0 b	137.0 b	2.96 b	0.91 b
Chickasaw	187.3 b	53.7 b	1609.0 a	359.45 a	10.73 a	2.40 a
Navaho	86.4 c	195.2 a	214.5 c	526.0 a	1.43 c	3.51 a
Hybrids						
Boysenberry	103.7 c	4.4 c	358.0 bc	11.9 c	2.39 bc	0.08 c
Olallie	137.8 bc	3.4 c	406.0 bc	6.0 c	2.71 b	0.04 c
CV(%)	17.7	14.4	10.8	15.9	9.9	9.3

*B C = blackberry cultivars. **Lowercase letters differ from each other on the column by the Tukey test ($p < 0.05$).

Table 5a: Pearson linear correlation coefficients for the combinations between blackberry cultivars and hybrids for parameters of the 2016/2017 crop

	FFB	LD	TD	Vol.	Product.	Yield	NF
FFB	1						
LD	0.9794	1					
TD	0.8798	0.9433	1				
Vol.	0.9933	0.9582	0.8446	1			
Product.	0.8607	0.8148	0.6970	0.8721	1		
Yield	0.8495	0.8369	0.7654	0.8390	0.9689	1	
NF	0.6465	0.6802	0.6842	0.6183	0.8524	0.9313	1

FFB = fresh fruit biomass, LD = longitudinal diameter, TD = transverse diameter, Vol. = volume, Product. = productivity and NF = number of fruits.

Table 5b: Pearson linear correlation coefficients for the combinations between blackberry cultivars and hybrids for parameters of the 2017/2018 crop

	FFB	LD	TD	Vol.	Product.	Yield	NF
FFB	1						
LD	0.9890	1					
TD	0.9756	0.9917	1				
Vol.	0.9959	0.9883	0.9707	1			
Product.	0.8001	0.7647	0.7853	0.7861	1		
Yield	0.8575	0.8268	0.8352	0.8480	0.9904	1	
NF	0.6465	0.6802	0.6842	0.6183	0.8524	0.9313	1

FFB = fresh fruit biomass, LD = longitudinal diameter, TD = transverse diameter, Vol. = volume, Product. = productivity and NF = number of fruits.

superiority of cultivars Tupy and Guarani. Croge *et al.* (2016) also found superiority in the productivity of Guarani, Xavante and Cherokee in Cerro Azul, PR, Brazil, in two crops evaluated. This occurred because these cultivars adapted to the edaphoclimatic conditions of the region, as well as the adaptation of cultivars Tupy, Chickasaw and Navaho in Marechal C. Rondon. These differences between cultivars may be related to intrinsic factors inherent in their own adaptation to the subtropical region, such as the chill hour requirement interacting with local climatic variations (Raseira & Franzon, 2012).

Table 5 (a and b) presents the Pearson linear correlation coefficients for blackberry cultivars and hybrids, reflecting the degree of similarity between the variations of the signals obtained for the parameters analyzed. The ideal value for this coefficient should be equal to 1.

The highest values of the correlations observed were between LD x FFB (0.9794 and 0.9890 for the 2016/2017 and 2017/2018 crops, respectively), volume x FFB (0.9933 and 0.9959 for the 2016/2017 and 2017/2018 crops, respectively) and production/plant x productivity (0.9904 for the 2017/2018 crop), indicating that the higher the ratio between fruit biomass and longitudinal diameter, the larger the volume.

Therefore, the value of one variable is directly proportional to the value of the other. This observation was recorded in the Chickasaw cultivar, which presented

higher diameter and biomass in relation to the other cultivars. According to Curi *et al.* (2015b), studies carried out in Lavras (Minas Gerais, Brazil), with raspberry trees, in relation to the spacings adopted, less densified plants (3 x 0.50 m) produced more fruits, which resulted in an increase in production per plant than in relation to plants arranged in the smaller spacing.

In general, all genotypes completed their phenological cycle in the two crops, reaching fruit production, with high-quality fruits, although not all of them presented economically feasible productivity, which suggests the need for further studies on factors that influence the production process. Another difficulty presented by hybrids studied was the management system of the plants, due to their more herbaceous size and prostrate growth habit, presenting greater difficulty in harvesting.

CONCLUSIONS

The mean duration of the phenological cycle of blackberry cultivars in the two crops varies between 109 and 162 days and 114 and 148 days, respectively.

Hybrids Boysenberry and Olallie presented a shorter cycle in both crops.

In the 2016/2017 crops, the harvest lasted 39 to 88 days, starting in late October and ending in late January.

In the 2017/2018 crop, it lasted 23 to 57 days, starting in mid-November and ending in early January.

Cultivars Tupy and Chickasaw were the most productive in the first crop. In the second crop, cultivars Tupy and Navaho were prominent.

ACKNOWLEDGEMENTS

The authors acknowledge CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for the scholarship to the first author.

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