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Phenology, production and quality of blueberry produced in humid subtropical climate

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Abstract - Studies on adaptation to the cultivation site are necessary for the recommendation of new cultivars. The aim of this study was to evaluate the phenological development, productivity and fruit quality of eight blueberry cultivars from the rabbiteye group (Aliceblue, Bluebelle, Bluegem, Briteblue, Climax, Delite, Powderblue and Woodard) and two from the highbush group (Georgiagem and O'Neal) under humid subtropical conditions in the 2012/2013, 2013/2014 and 2014/2015 cycles. Beginning and end of flowering, beginning and end of harvesting, fruit set, production, mass, diameter, pH, content of soluble solids, titratable acidity, ratio and coloring were evaluated. The evaluated cultivars presented flowering in the period from July to September, concentrating harvest in the months of November and December. The highest fruit set was observed in Delite, Climax, Briteblue and Powderblue cultivars. There were differences among cultivars regarding fruit mass, size, pH, content of soluble solids and acidity. The results showed that the cultivars exhibited blue color with few variations over the evaluation years. Cultivars with the best productive performance under humid subtropical climate conditions are Bluegem, Delite, Climax and Powderblue.

Index terms: *Vaccinium* sp., small fruits, fruit set.

Fenologia, produção e qualidade de mirtilos produzidos em clima subtropical úmido

Resumo - Para a recomendação de novas cultivares, são necessários estudos quanto à adaptação no local de cultivo. Logo, objetivou-se avaliar o desenvolvimento fenológico, a produtividade e a qualidade de frutos de oito cultivares de mirtileiro do grupo rabbiteye (Aliceblue, Bluebelle, Bluegem, Briteblue, Climax, Delite, Powderblue e Woodard) e duas do grupo highbush (Georgiagem e O'Neal) em condições de clima subtropical úmido, nos ciclos de 2012/2013, 2013/2014 e 2014/2015. Foram avaliadas as datas do início e do final de floração, início e final de colheita, frutificação efetiva, produção, massa, diâmetro, pH, teor de sólidos solúveis, acidez titulável, *ratio* e coloração. As cultivares avaliadas apresentaram floração no período de julho a setembro, concentrando a colheita nos meses de novembro e dezembro. As maiores frutificações efetivas foram observadas nas cultivares Delite, Climax, Briteblue e Powderblue. Houve diferenças entre as cultivares quanto à massa do fruto, tamanho, pH, teor de sólidos solúveis e acidez. Os resultados demonstraram que as cultivares exibiram coloração azul, com poucas variações ao longo dos anos de avaliação. As cultivares com melhor desempenho produtivo, em condições de clima subtropical úmido, são Bluegem, Delite, Climax e Powderblue.

Termos para indexação: *Vaccinium* sp., pequenas frutas, frutificação efetiva.

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Introduction

Blueberry (*Vaccinium* spp) is a fruit species originated from North America and Europe, where it is much appreciated for its taste and functional properties. The world's interest in cultivation is due to the high profitability and high antioxidant capacity, attributed to the wide range of polyphenols present in fruits, mainly anthocyanins, flavonoids and cinnamic acid derivatives (ENGLAND, 2015, KANG et al., 2015, CARDEÑOSA et al., 2016, LI et al., 2016).

The production of blueberries has increased considerably in recent years. Between 1998 and 2011, world production increased from 143,704 tones to 467,048 tones. In South America, an increase of 478% in the area cultivated with blueberries in the period from 2003 to 2008 was observed (RETAMALES et al., 2015). Commercial production of blueberries occurs mainly in North America (United States and Canada), Europe (Poland, Germany) and also in countries of the Southern Hemisphere such as Argentina, Uruguay, Australia and Chile, which have the largest planted area and production in the European and North American off-season, becoming the largest world exporters (RETAMALES et al., 2014).

In Brazil, it was introduced in the 1980s, being cultivated in approximately 400 ha; mainly in the states of Rio Grande do Sul, where it was firstly introduced, and Santa Catarina, with a smaller area in São Paulo, Minas Gerais and Paraná. Most planted cultivars belong to the rabbiteye group, which requires less cold than the highbush group, but do not produce adequately with less than 200 hours of cold (CANTUARIAS-AVILÉS et al., 2014).

The cultivars introduced in Brazil require studies on their adaptation in the different regions, which present different climate and soil conditions. There are no national cultivars adapted to our climate and soil conditions, and studies on the improvement of this species are recent (FISCHER et al., 2014).

According to NeSmith (2006b), flowering and ripening times may vary, depending on the year and location. NeSmith (2006a) reports that, depending on the cultivar, accumulation of cold hours and year of evaluation, the flowering period of blueberry can vary within 24 days. If the accumulation of winter cold hours is insufficient, depending on the need of the cultivar, it can result in deficient sprouting and flowering and, consequently, lower yield (ANTUNES et al., 2008). Therefore, studies that evaluate the response of growth and field production of cultivars are very important, since they allow observing the behavior of these genotypes against the interaction of all climatic factors simultaneously.

In view of the above, the aim of this study was to evaluate the phenological development, production and fruit quality of blueberry cultivars from the rabbiteye and highbush group under humid subtropical climate conditions.

Material and methods

The research was conducted in three productive cycles: 2012/2013, 2013/2014 and 2014/2015 in the collection of blueberry trees installed at the Experimental Station of the Agronomic Institute of Paraná - IAPAR located in the municipality of Cerro Azul-PR, "Vale do Ribeira" region, (24°53'S and 49°14'W and 659 m a.s.l.), whose climate, according to Köppen, is humid subtropical (Cfa). The climatic data of the three evaluation years were obtained from the SIMEPAR Meteorological Station located inside the Experimental Station where this work was carried out.

The soil had the following characteristics: pH $CaCl_2$ = 4.0; Al^{+3} = 5.8 $cmol_c.dm^{-3}$; $H^{+}+Al^{+3}$ = 14.7 $cmol_c.dm^{-3}$; Ca^{+2} = 0.85 $cmol_c.dm^{-3}$; Mg^{+2} = 1.15 $cmol_c.dm^{-3}$; K^{+} = 0.15 $cmol_c.dm^{-3}$; P = 2.4 $mg.dm^{-3}$; C = 25.35 $g.dm^{-3}$ and base saturation = 12.75%.

The collection was composed of the following cultivars: Aliceblue, Bluebelle, Bluegem, Briteblue, Climax, Delite, Powderblue and Woodard from the Rabbiteye group and Georgiagem and O'Neal from the Highbush group. Planting was carried out in September 2011 with seedlings acquired from a commercial nursery with one year and a half of age. The spacing was 3 m between rows and 0.7 m between plants in slopes with drip irrigation system. Vegetation between rows was performed with forage peanuts. Liming was not performed and fertilization was done according to recommendations of the Brazilian Society of Soil Science (SBCS, 2004). No chemicals were applied for phytosanitary management.

Phenological evaluations were performed considering the beginning of flowering (more than 5% of open flowers), and end of flowering (90% of open flowers), beginning and end of harvest.

Fruits were harvested when fully ripe, with a typical black color of the species, evaluating the yield per plant (g $plant^{-1}$), fresh fruit mass (g), fruit cross-sectional diameter (mm), hydrogen ionic potential (pH), content of total soluble solids, titratable acidity and skin color. For chemical and coloring evaluations, fruits were selected regarding sanity and absence of injuries and defects, with each plot consisting of 36 fruits.

The content of soluble solids was obtained by means of a refractometer after adding a drop of fruit juice to the prism of the apparatus. Acidity, expressed as citric acid percentage, was determined by neutralization titration according to methodology described by Reyes-Carmona (2005).

The fruit skin color was determined by colorimetry, using the CIELAB scale, with direct reading of L * (luminosity), a * (red contribution) and b * values (yellow contribution). The hue chroma angle (h *) and color saturation, chroma (C *) were calculated from a * and b * values, according to equations: h * = arctang (b * / a *) and C * = [(a *) + (b *)] $^{1/2}$.

Fruit set (FS) was evaluated in the year 2014 with the selection of four plants per cultivar and the marking of two productive branches per plant. The evaluation was determined by quantification of the number of flowers and subsequent counting of fruits by branch and use of the following formula: FS (%) = (No. of formed flowers / No. of flowers) x 100.

The experimental design was randomized blocks with four replicates, six plants per plot and four useful plants. Data were submitted to analysis of variance and means were compared by the Scott-Knott test at 5% probability.

From the averages of the features evaluated in the third productive cycle and the matrix of variance and residual covariance, the matrix of genetic dissimilarity among cultivars was obtained from the Mahalanobis distance and then grouping was performed using the UPGMA method. Group validation was determined by the cophenetic correlation coefficient (CCC).

Results and discussion

Flowering period varied between cultivars and years. In 2012/2013, flowering began at the end of July and ended in August, with flowering period ranging from 21 to 23 days. In the 2013/2014 cycle, the flowering period ranged from 35 to 53 days, beginning in early July and ending in the second week of September. In the 2014/2015 cycle, flowering was later for most cultivars, with flowering period ranging from 29 to 43 days (Figure 1). The flowering dates of cultivars studied in Cerro Azul-PR were similar to those found in the region of Pelotas-RS (ANTUNES et al., 2008). In Pelotas, greater accumulation of cold hours was observed, compared to Cerro Azul, which may facilitate the dormancy of cultivars. However, the city of Rio Grande do Sul has lower temperatures, which may delay sprouting, compensating for the effect of higher cold hours and causing flowering period similar to that found in Cerro Azul.

Flowering was earlier in the second cycle for most cultivars, which may be related to the greater accumulation of cold hours below 7.2°C in 2013 (Table 1). This year, longer flowering period was also observed for almost all cultivars, possibly due to lower temperatures in July and August (Table 1), affecting mainly Bluebelle, Climax and Woodard cultivars, which were the earliest and started flowering on July 5, presenting a period of 53 days of flowering (Figure 1).

The difference presented by cultivars may be a consequence of factors intrinsic to the adaptation itself, such as the need for cold and local climatic variations. The Cerro Azul region is characterized by high temperatures throughout most of the year, including during the winter, with low cold accumulation. In 2013, the lowest temperatures were recorded and still the cold accumulation was only 109 hours (Table 1). This climatic behavior may have been one of the reasons for the inexpressive production of Georgiagem and O'Neal cultivars, both belonging to the Southern Highbush group, which is more cold demanding than the Rabbiteye group, which includes the other cultivars evaluated. In the region of Alapaha - GA (USA), where blueberries from the Rabbiteye group show good productivity, average of 680 cold hours below 7.2 ºC during a 6-year period was observed (NESMITH, 2006b). The results obtained in Cerro Azul show plasticity of adaptation of blueberries from the group Rabbiteye, that even in regions of subtropical climate with little cold accumulation during the winter, are able to flourish and produce. This behavior has already been observed in Taiwan, where blueberry trees from the Rabbiteye group cultivated under subtropical conditions and without frost do not lose leaves during the winter and changes in photoperiod and temperature are sufficient for floral induction (HUANG; LI, 2015).

The harvest period also showed variation between cultivars and years, with a concentration from December to mid January in the 2012/2013 cycle, from November to January in the 2013/2014 cycle and November to December in the 2014/2015 cycle (Table 1). The harvest period of cultivars evaluated in Cerro Azul-PR was similar to that found in the region of Pelotas-RS by Antunes et al. (2008).

The harvest concentration in December is favorable to the supply of the domestic market, since the offer of fruits occurs in the month of the Christmas holidays, a time when there is great demand for fresh blueberries. In addition, the harvest in December is particularly important in Cerro Azul, as the harvest of the main fruit of the region, 'Ponkan' tangerine, has already finished, thus avoiding the competition for labor in rural properties.

Fruit set, evaluated in 2014, ranged from 42.51% to 69.39% (Table 2). These values are similar to those found by Silveira et al. (2010) when evaluating fruit set in blueberry plants of the advanced selection from the "Embrapa Clima Temperado" breeding program, Pelotas-RS.

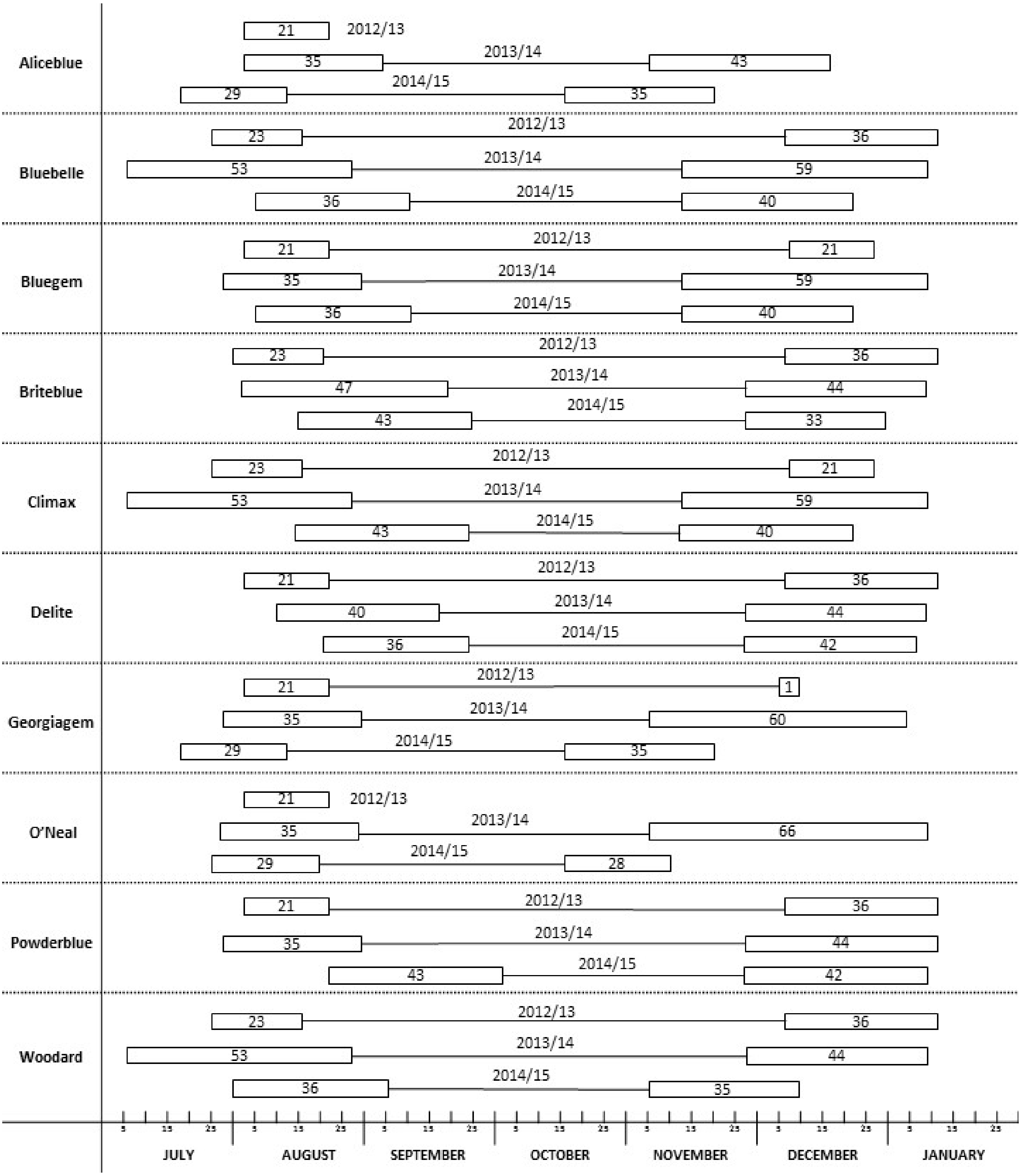

Figure 1 - Flowering period and harvest of ten blueberry cultivars in three productive cycles (2012/2013, 2013/2014 and 2014/2015). The numbers inside the boxes represent the flowering period in days in the first box and harvest in the second box. Cerro Azul, PR, Brazil.

Table 1. Climatic characteristics in years 2012, 2013 and 2014. Cerro Azul, PR, Brazil [1].

CHARACTERISTICS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2012												
Maximum temperature (°C)	31.90	35.00	32.72	28.06	25.12	21.41	21.67	27.64	28.68	30.64	30.92	33.64
Mean temperature (°C)	22.91	24.54	22.49	20.84	17.54	16.24	14.90	18.11	19.43	22.14	23.07	24.79
Minimum temperature (°C)	18.04	19.06	16.53	16.23	13.48	13.26	11.25	12.26	13.67	16.78	17.30	20.48
Precipitation (mm)	--	169.60	97.00	135.00	67.20	189.60	100.60	9.40	72.00	76.80	18.00	260.40
Chilling hours (<7.2°C)	0	0	0	0	1	0	28	0	0	0	0	0
2013												
Maximum temperature (°C)	30.77	31.15	29.20	28.58	25.30	22.12	21.64	25.24	26.32	29.05	30.23	32.74
Mean temperature (°C)	23.21	23.60	22.46	20.12	17.70	16.80	14.66	15.78	18.11	20.83	22.25	24.28
Minimum temperature (°C)	18.51	19.94	18.56	15.02	13.47	13.86	10.68	10.00	12.71	15.12	17.20	18.92
Precipitation (mm)	98.80	121.40	9.40	18.00	64.20	270.20	102.00	18.20	206.20	80.60	222.60	105.20
Chilling hours (<7.2°C)	0	0	0	0	30	0	32	47	0	0	0	0
2014												
Maximum temperature (°C)	33.78	33.76	30.46	27.73	24.49	23.36	22.95	25.08	26.88	30.60	29.77	32.30
Mean temperature (°C)	24.91	24.76	22.98	21.14	17.93	17.05	15.60	16.63	19.75	21.90	22.60	24.05
Minimum temperature (°C)	19.94	19.52	18.84	17.50	13.89	13.32	11.36	11.45	15.19	15.89	17.62	18.85
Precipitation (mm)	123.60	112.80	217.20	38.80	83.00	110.20	45.80	71.40	143.00	44.20	95.80	161.00
Chilling hours (<7.2°C)	0	0	0	0	0	0	34	9	0	0	0	0

(1) Source: SIMEPAR. Due to technical problems, there was no rainfall record in January 2012.

Table 2. Fruit set (FS) in the 2014 production cycle and production, fresh mass and fruit size of ten blueberry cultivars in the 2012/2013, 2013/2014 and 2014/2015 productive cycles. Cerro Azul, PR, Brazil.

Cultivars	FS (%)	Production (g pl^{-1})			Fresh mass (g)			Fruit size (mm)		
	2014	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15
Aliceblue	42.51 d	-	15.70 g	21.10 i	-	0.80 b	1.12 d	-	12.82 a	11.49 d
Bluebelle	59.21 b	84.77 c	83.66 d	390.60 e	1.80 a	1.66 a	1.70 c	15.08 a	14.50 a	13.45 c
Bluegem	61.13 b	46.48 f	330.48 a	1091.94 a	1.86 a	1.44 a	1.46 c	14.91 a	13.78 a	13.18 c
Briteblue	65.57 a	46.69 f	97.48 c	268.34 f	1.34 b	1.50 a	2.26 a	13.28 b	14.02 a	15.65 a
Clímax	68.58 a	55.29 e	58.11 e	589.75 c	1.41 b	1.43 a	1.81 b	14.06 a	13.47 a	14.62 b
Delite	69.39 a	94.91 b	144.62 b	712.14 b	1.42 b	1.58 a	1.95 b	13.27 b	14.40 a	14.98 b
Georgiagem	54.22 c	1.41 g	43.83 f	188.03 g	0.78 d	1.46 a	1.52 c	11.09 d	14.50 a	12.92 c
O'Neal	43.90 d	-	43.91 f	97.45 h	-	1.42 a	1.46 c	-	13.87 a	12.84 c
Powderblue	63.50 a	106.45 a	102.50 c	517.57 d	1.19 c	1.45 a	1.59 c	12.32 c	13.26 a	13.26 c
Woodard	55.08 c	77.04 d	59.32 e	180.56 g	1.53 b	1.54 a	1.63 c	14.53 a	14.72 a	12.83 c
Average	58.40	64.13	97.96	405.75	1.42	1.43	1.65	13.57	13.94	13.53
CV (%)	6.01	6.13	10.56	9.95	5.18	5.18	8.47	4.05	6.93	3.83

(1) Means followed by the same letters in the columns do not differ by the Scott-Knott test ($p \leq 0.05$).

The low fruit set of the O'Neal cultivar (43.90%), whose main pollinating agent is the *Apis mellifera* bee, can be justified by the fact that pollination was carried out only by native pollinator agents. Another factor that may have contributed to reduce the fruit set of cultivars was the damage caused by the occurrence of *Trigona spinipes* in the flowering period. Studies by Silveira et al. (2010) also reported values of 33% for fruit set in blueberry plants damaged by this insect.

Production was low in the first cycle, when cultivars showed on average 64.13 g pl^{-1}, which was expected, since plants had only one year after planting. In the second and third cycles, the difference among cultivars was very marked, highlighting Bluegem cultivar, which was the most productive, reaching 1091.94 g pl^{-1} in the 2014/2015 cycle. Aliceblue and O'Neal cultivars did not produce in the first cycle and were the least productive in the third cycle evaluated (Table 2). Delite and Powderblue cultivars stood out for the good production in the three years of evaluation. Climax cultivar was the third most productive in the 2014/2015 cycle, with production of 589.75 g pl^{-1}, although it is still low, compared to production obtained in colder regions, such as in Alapaha, Georgia, where yield averaged 3.4 kg per plant (NESMITH, 2006b).

The fresh matter mass and cross-sectional diameter of fruits differed among cultivars, evidencing a tendency of larger fruits in less productive cultivars, as observed in the Briteblue cultivar, which showed fruits with higher mass (2.26 g) and larger size (15.65 mm) in the 2014/2015 cycle (Table 2).

The pH, content of soluble solids and acidity determinations contributed to the assumption of fruit acceptability and were distinct among cultivars in the evaluated cycles (Table 3). The response variability of blueberry depending on the cycle was also observed in several experiments with cultivars from the Highbush and Rabbiteye groups in the United States (GÜNDÜZ et al., 2015).

The pH values found for all cultivars evaluated were lower than those reported by Sousa et al. (2006) in the survey of quality factors in blueberry cultivars in Portugal. Regarding the content of soluble solids, there were differences among cultivars. The averages were higher than 10.51 ° Brix found by Sousa et al. (2006), and were within the range from 12.4 to 14.5 ° Brix found by Fischer et al. (2014) in the selection of blueberry genotypes with higher SS levels and were similar to values observed by Antunes et al. (2008) in the evaluation of eight blueberry cultivars in the region of Pelotas-RS.

Bluegem cultivar, which was the most productive, also stood out regarding the content of soluble solids, presenting 13.6 º Brix in the 2014/2015 cycle (Table 3), being higher than the 11.7 ° Brix content determined by Brackmann et al. (2010) in Santa Maria-RS and similar to 13.51 ° Brix obtained by Antunes et al. (2008) for the same cultivar in Pelotas-RS. The ratio, indicator used to determine the sweet: acid taste balance increased over the years, reaching an average of 16.94 in the third cycle. These results are related to the low acidity observed in all cultivars from the second cycle, with averages of 0.73% of citric acid.

The chromatic coordinates L *; a *; b * revealed differences among cultivars in the 2012/2013 and 2014/2015 cycles and no difference in the 2013/2014 cycle (Table 4). The luminosity (L *) values were very close in the three cycles, with average value of 32.5 (Table 4), indicating that the blueberries analyzed showed little luminosity. The low luminosity can be a consequence of the loss of pruine, a wax that recovers fruits when they mature and gives a brighter appearance to them (CANTUARIAS-AVILÉS et al., 2014). The average luminosity (L *) value of 36.5 obtained as the Bluegem cultivar, in the three cycles evaluated, was similar to that found by Concenço et al. (2014) in the same cultivar produced in the municipality of Antônio Carlos-MG. In relation to coordinate a *, which quantifies the variation of green colors (a * <0) for red (a *> 0), no differences were observed in the second year of evaluation. The negative values of b * coordinate indicate the bluish color of blueberries, with small differences among cultivars (Table 4).

Hue (h *), which is a quantity that characterizes the quality of color, allowing them to be differentiated, varied little among cultivars. Saturation (C *), also called purity, describes the intensity or amount of a hue. There was little variation in saturation among cultivars in the first two cycles evaluated, but there was a marked reduction in the third cycle. The higher C * value and the lower h * value represent a more intense color of fruits (Table 5). Color is influenced by the presence of epicuticular wax, which is responsible for the typical blue color of fruits. The color of skin and pulp is conferred by the presence of anthocyanins. In addition to the genetic characteristics intrinsic to each cultivar, the environment in which the fruits develop also affects their coloration (SOUSA et al., 2007).

According to the multivariate analysis performed with data from the third productive cycle, it was possible to separate the 10 cultivars into 4 groups (Figure 2). According to the cophenetic correlation coefficient (CCC = 0.83), there was an adequate grouping, with little distortion in the generated dendrogram.

The first group was composed only of the Bluebelle cultivar, which presented low yield (Table 2) and differed from the other cultivars mainly in relation to the color hue and saturation of fruits (Table 5). Another cultivar that was isolated forming a second group was O'Neal, which presented one of the lowest yields (Table 2) and stood out from the others due to its higher average pH, SS and SS / TA ratio values (Table 3).

The third group included Aliceblue, Georgiagem and Woodard cultivars (Figure 2), which showed low yields and similar means for fresh weight, fruit size, pH, SS, TA and SS / TA ratio (Tables 2 and 3). The fourth group was formed by Bluegem, Briteblue, Delite, Climax and Powderblue cultivars (Figure 2), which presented the highest yields, with the exception of Briteblue, which on the other hand was the cultivar with the largest mass and size of fruits (Table 2).

Although some cultivars from the rabbiteye and highbush group were in a single group according to the multivariate analysis performed, it is important to highlight that the similarity among them is related to the productive performance and capacity to adapt to the climate of the Cerro Azul region, in addition, the best performance cultivars are all from the rabbiteye group.

Table 3. Hydrogen ionic potential (pH), total soluble solids (SS), titratable acidity (TA) and SS / TA ratio of fruits of ten blueberry cultivars in the 2012/2013, 2013/2014 and 2014/2015 productive cycles. Cerro Azul-PR, Brazil.

Culitvars	pH			SS (ºBrix)			TA (% citric acid)			*Ratio* (SS/TA)		
	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15
Aliceblue	-	-	2.8c	-	-	12.0b	-	-	1.0a	-	-	12.0b
Bluebelle	2.7d	3.0a	2.7c	14.3a	10.4b	11.2b	1.7 b	0.71c	0.7b	8.4 c	14.5c	14.5b
Bluegem	2.8c	3.1a	2.5d	13.5b	11.9a	13.6a	1.8 a	0.65c	0.7c	7.2 c	18.3a	19.1a
Briteblue	2.9c	3.0a	2.9b	12.3d	10.3b	12.1b	0.8 d	0.81b	0.7c	14.9a	12.6d	16.7a
Clímax	3.0a	3.1a	3.0b	13.4b	11.5a	12.3b	1.8 a	0.64c	0.5d	7.1 c	17.9a	19.5a
Delite	2.8c	3.1a	2.8c	14.0a	10.9b	12.1b	2.0 a	0.66c	0.6d	6.8 c	16.5b	19.5a
Georgiagem	3.0a	-	2.8c	13.0c	-	12.0b	1.7 b	-	0.8b	7.5 c	-	14.6b
O'Neal	-	-	3.2a	-	-	13.4a	-	-	0.5d	-	-	20.7a
Powderblue	2.9b	3.0a	2.8c	14.1a	10.5b	12.1b	1.6 b	0.67c	0.6d	8.4 c	15.6b	20.0a
Woodard	2.7d	2.9a	2.7c	14.1a	11.3a	12.5b	1.3 c	0.96a	1.0a	11.3b	11.7d	12.4b
Average	2.91	3.08	2.85	13.61	11.01	12.36	1.63	0.73	0.73	8.99	15.33	16.94
CV(%)	1.29	2.79	5.36	1.88	5.22	6.23	7.74	7.21	12.52	12.41	8.46	11.51

(1) Means followed by the same letters in the columns do not differ by the Scott-Knott test ($p \leq 0.05$).

Table 4. Color coordinates of blueberries produced in the 2012/2013, 2013/2014 and 2014/2015 productive cycles. Cerro Azul, PR, Brazil.

Cultivars	L*			a*			b*		
	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15
Aliceblue	-	34.02 a	31.95 a	-	3.83 a	1.00 b	-	-8.08 a	-3.58 a
Bluebelle	32.95 a	30.51 a	27.76 b	2.95 a	4.98 a	3.49 a	-7.73 b	-6.84 a	-1.18 c
Bluegem	38.74 a	36.09 a	34.83 a	2.91 a	4.58 a	0.85 b	-9.70 a	-9.02 a	-4.84 a
Briteblue	24.41 a	33.21 a	33.38 a	3.10 a	4.71 a	0.66 b	-6.59 c	-7.76 a	-4.44 a
Clímax	32.11 a	32.25 a	32.53 a	2.61 b	4.13 a	1.27 b	-7.86 b	-6.87 a	-4.16 a
Delite	33.98 a	31.84 a	32.79 a	2.38 b	4.18 a	0.22 b	-7.37 b	-6.45 a	-4.69 a
Georgiagem	28.98 a	34.08 a	33.31 a	3.09 a	4.79 a	0.32 b	-5.75 c	-7.80 a	-4.68 a
O'Neal	-	34.24 a	30.79 b	-	6.01 a	2.60 a	-	-6.33 a	-4.04 a
Powderblue	33.76 a	34.78 a	34.60 a	2.52 b	3.33 a	0.77 b	-9.07 a	-8.76 a	-4.95 a
Woodard	33.71 a	31.80 a	28.75 b	2.55 b	3.57 a	1.59 b	-6.67 c	-8.00 a	-2.74 b
Average	32.33	33.28	32.02	2.76	4.41	1.28	-7.59	-7.59	-3.93
CV (%)	16.32	9.62	5.69	8.05	32.35	47.02	13.03	19.26	18.07

(1) Means followed by the same letters in the columns do not differ by the Scott-Knott test ($p \leq 0.05$).

Table 5. Hue and color saturation of blueberries produced in the 2012/2013, 2013/2014 and 2014/2015 productive cycles. Cerro Azul, PR, Brazil.

Cultivars	Tonality – (°Hue)[(2)]			Saturation (Chroma)		
	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15
Aliceblue	-	-1.14 a	-1.28 a	-	9.04 a	3.74 b
Bluebelle	-1.20 a	-0.92 a	-0.33 c	8.27 b	8.62 a	3.73 b
Bluegem	-1.27 a	-1.10 a	-1.39 a	10.13 a	10.14 a	4.92 a
Briteblue	-1.12 b	-1.01 a	-1.41 a	7.30 b	9.22 a	4.51 a
Clímax	-1.24 a	-1.02 a	-1.25 a	8.29 b	8.11 a	4.41 a
Delite	-1.24 a	-0.99 a	-1.50 a	7.76 b	7.74 a	4.71 a
Georgiagem	-1.06 b	-1.03 a	-1.49 a	6.55 b	9.20 a	4.70 a
O'Neal	-	-0.83 a	-1.00 b	-	8.80 a	5.00 a
Powderblue	-1.29 a	-1.20 a	-1.41 a	9.42 a	9.41 a	5.01 a
Woodard	-1.19 b	-1.15 a	-1.04 b	7.16 b	8.80 a	3.21 b
Average	-1.20	-1.04	-1.21	8.11	8.91	4.39
CV (%)	5.32	14.41	12.63	11.15	17.56	14.55

(1) Means followed by the same letters in the columns do not differ by the Scott-Knott test ($p \leq 0.05$).
(2) Expressed in radians.

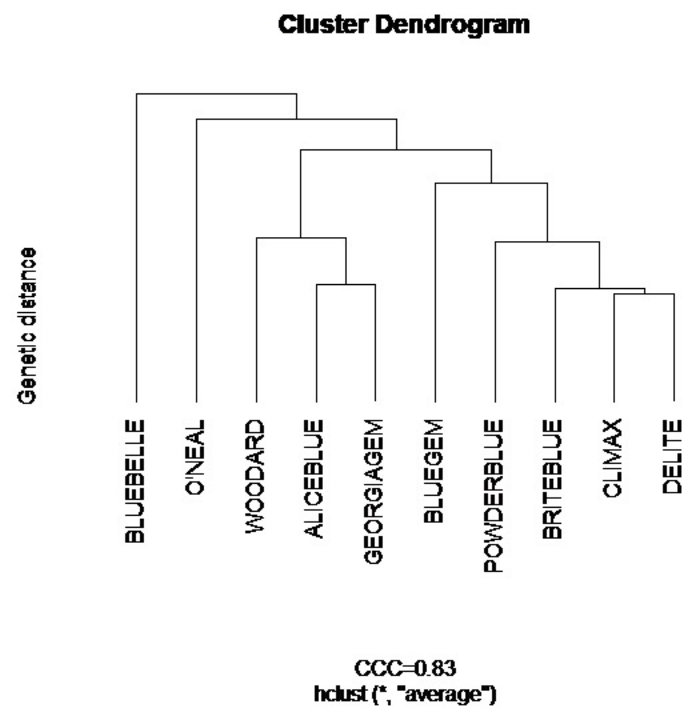

Figure 2. Dendrogram generated from the UPGMA method using the Mahalanobis distance among the ten blueberry cultivars. CCC = cophenetic correlation coefficient.

Conclusions

1- The evaluated cultivars (Aliceblue, Bluebelle, Briteblue, Climax, Delite, Powderblue, Woodard, Georgiagem and O'Neal) showed flowering between July and September, and harvest from November to January in humid subtropical climate.

2- Fruits of cultivars evaluated have characteristics of coloration and physical and chemical attributes similar to blueberries produced in colder regions.

3- Under humid subtropical climate, blueberry cultivars with the best productive performance belong to the Rabitteye group, especially Bluegem, followed by Delite, Climax and Powderblue.

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