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Research Paper

Bunch sizing of 'BRS Nubia' table grape by inflorescence management, shoot tipping and berry thinning

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ABSTRACT

'BRS Nubia' is a new seeded table grape with dark black color, high yield, neutral flavor, and crunchy large berries. However, this cultivar frequently presents very dense bunches, limiting its commercialization. The aim of this work was to obtain uniform and loose bunches of 'BRS Nubia' table grape by means of inflorescence and bearing shoot management associated to berry thinning. The trial was conducted during two consecutive seasons of 2015 and 2016, in a 2-year old commercial vineyard located in Marialva, Parana, Brazil. The vines were trained in an overhead trellis system and spaced at 2.5 × 9.0 m distance. The experimental design was randomized block with four replications in a 2-factor arrangement with two additional treatments (factorial 2 × 2 + 2). The following factors were evaluated: inflorescence management (with tipping before anthesis and without tipping), bearing shoot tipping (before or after anthesis), and two additional treatments consisted of two controls (with or without berry thinning). The berry thinning was performed in all treatments, except in control without berry thinning, by means of picking when berries were at pea size. Physico-chemical analysis of the berries as well as bunch compactness and yield were evaluated at harvest time. Means were subjected to analysis of variance and compared using Tukey's test at 5% probability. Additionally, the Principal Components Analysis (PCA) was used to describe the relation of physico-chemical and productive characteristics of grapes with the inflorescence and shoot management. The inflorescence tipping before anthesis is a useful practice by facilitating and saving time to perform berry thinning of 'BRS Nubia' table grapes, while the bearing shoot tipping after the anthesis may accelerate the bunches ripening. Combined to these practices, berry thinning is a mandatory procedure in order to obtain medium loose bunches of 'BRS Nubia' table grape, with larger and uniform berries.

1. Introduction

The demand for good quality table grapes is increasing all over the world (Leao, 2010), and in order to meet the demands of growing market, new table grape cultivars such as 'BRS Nubia' have been developed to overcome the predicaments faced by the table grapes industry worldwide (Verneque, 2015).

'BRS Nubia' is a "vinifera-like" new seeded hybrid table grape with dark black color, large berries and good adaptation to tropical and subtropical climates, however, this cultivar frequently presents very dense bunches, demanding specific traits to overcome this problem (Maia et al., 2013).

The appearance and homogeneity as well as color of the berries are very important factors for table grapes due to its fresh consumption, unlike winemaking grapes where grapes are processed (Pommer et al., 1995).

The main purpose of inflorescence or bunch management, also known as bunch sizing, is to improve the visual appearance of the bunches, bring uniformity in shape, size and color of the berries, and also to increase its total soluble solids along with elimination of small, deformed or damaged berries, eventually making handling and harvest of the grapes more simpler (Roberto et al., 2015; 2017). Thinning is the most frequent technique used for this purpose, which can be performed in different ways, such as by brushing prior to anthesis, by berry-cluster thinning and by berry thinning (picking), which involves removal of individual berries along the bunch (Roberto et al., 2015). However, as berry abortion is frequent and inconsistent for 'BRS Nubia' after flowering, brushing prior anthesis is not used for this cultivar, even though

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it is considered a fast and easy thinning technique.

There are other techniques used for bunch sizing, such as the inflorescence and bearing shoot tipping or trimming. The inflorescence tipping is the method of removing its terminal portion (Gil et al., 2013). Removing the apical dominance of the rachis induces the higher development of the shoulders and the side berry-clusters, especially when performed before the anthesis, improving of the size and shape of bunches, turning them longer and with more spaced berry-clusters, facilitating the prospective berry thinning labor to avoid bunch compactness (Leao, 2010). The bearing shoot tipping involves removing a small portion of its tip in order to suppress temporarily its apical dominance, deflecting more quantity of assimilated compounds to the inflorescences or bunches. Enhancing the elongation of inflorescence and uniform development of the grapevine branches are also among its key features (Kishino and Roberto, 2007).

As 'BRS Nubia' is a new table grape and there is limited information available regarding the effectiveness and the best time to perform bunch sizing to prevent compactness, the aim of this work was to obtain uniform and loose bunches of this cultivar by means of inflorescence and bearing shoot management associated to berry thinning under subtropical conditions.

2. Material and methods

2.1. Grapevines and growing conditions

The study was conducted on 2-year-old vines of 'BRS Nubia' grape (*Vitis* spp.) grafted on 'IAC 766 Campinas' rootstock, in a commercial vineyard located in Marialva city, state of Parana, Brazil (23°29′06" S, 51°47′31" W, elevation 602 m), during two consecutive seasons of 2015 and 2016. The vines were trained using an overhead trellises system and spaced at a distance of 2.5 × 9.0 m apart.

According to the Köppen classification, the climate of the region is Cfa, i.e. subtropical with an average temperature in the coldest month below 18 °C and average temperature in the warmest month above 22 °C. Maximum temperature is approximately 31 °C, and the average annual rainfall is 1596 mm, with concentrated rainfalls during the summer season.

Vines were pruned with four buds left per cane and afterwards, 6% hydrogen cyanamide was applied to the buds in order to induce and standardize the sprouting. For load adjustment, 48 canes per vine were left to achieve a density of six bunches per m^2. However, since this was the first crops of the vineyard which were being evaluated, therefore the density of maximum two and four bunches per m^2 were achieved for 2015 and 2016 seasons, respectively.

2.2. Treatments and experimental design

The experimental design was randomized block with four replications and two vines per plot, in a 2-factor arrangement with two additional treatments (factorial 2 × 2 + 2). The following factors were evaluated: inflorescence management (with tipping before anthesis and without tipping), bearing shoot tipping (before or after anthesis), and the two additional treatments consisted of two controls (with or without berry thinning). Only one trained worker performed all techniques.

The inflorescence tipping consisted of a removal of around 40% of its length, two days before anthesis using a thinning-scissor (Fig. 1), while the bearing shoot tipping consisted of the manual removal of the its tip, two days before anthesis or 10 days after this phase (Fig. 2). Both techniques were considered easy and fast to perform, as the time required to perform each one was around 5 s per inflorescence or shoot. The berry thinning was performed in all treatments, except in control without berry thinning, by means of picking using a thinning-scissor when berries were at pea size, removing around 45% of berries of each bunch, followed by bunch tipping, if necessary. The time required to perform this technique was around 60 s (0.0166 h) per bunch, but when applied to bunches which inflorescences had been previously tipped, the time was reduced to half. During the trial, all the cultural practices of the area like fertilization, weed, pest and disease control were carried out as usual.

2.3. Berry sampling and fruits analysis

For bunch mass (g), length (cm) and width (cm), 10 bunches per plot were collected at harvest of each season, while for berry mass (g), length (mm) and width (mm), two berries were collected from each bunch, totaling 20 berries per plot. The number of berries per bunch was estimated by the relation bunch mass/berry mass.

For chemical evaluation of berries, such as total soluble solids (TSS), titratable acidity (TA) and maturity index − MI (TSS/TA), 20 berries per plot were evaluated. The TSS was determined using a digital refractometer with automatic temperature compensation (DR301-95 Model, Krüss Optronic, Germany), and result were expressed in °Brix. Titratable acitidy (TA) of the berries was calculated via titration of the grape juice with a standard 0.1 N NaOH solution in a semi-automatic titrator, adopting pH = 8.2 as the end point of titration, and results were expressed in per cent of tartaric acid (Youssef and Roberto, 2014).

The production per plant (kg) and yield (ton ha^{-1}) were estimated from the number of clusters per vine and their mass.

The compactness distribution of bunches (%) was calculated by visual observations of bunches, using the following classification based on descriptor code #204 for *Vitis* cultivars proposed by OIV (2001) and Albuquerque (1999): very loose (rachis very visible), medium loose (separated berries, well distributed and non-visible pedicels) and very dense bunches (berries completely compact, deformed). For 'BRS Nubia' grape, bunches classified as medium loose were considered ideal for the table grape market.

Means were subjected to analysis of variance (ANOVA) and compared using Tukey's test at 5% probability using the Assistat® software (Silva de and Azevedo, 2002).

Additionally, data were subjected to Principal Component Analysis (PCA) aiming to describe the relation of physico-chemical and productive characteristics of grapes with the inflorescence and shoot management. The PCA was performed using the Software R (R Development Core Team, 2012) and the FactoMineR package. For this analysis, the treatments were distributed throughout the principal component axis, i.e., the closer a treatment of the other, the more similar they were, while the treatments that were more distant from the axis of the main components were the most discrepant.

3. Results and discussion

From the data analysis of both seasons, it has been observed that there is no interaction between factors and the evaluated variables, indicating their self-reliance. However, berry mass and number of berries per bunch differed significantly with control treatments, either with or without berry thinning (Table 1). The berry thinning resulted in higher berry mass for both seasons, whereas the number of berries per bunch were lower, which was to be expected since berries were removed during thinning process.

Thinning procedure performed on 'Black Star' table grapes, in order to reduce its compactness, in response increased the berries size (Roberto et al., 2017). Similarly, berry thinning in 'Perlette' grapes resulted in higher berry mass, compensating berries loss caused by thinning procedure and therefore not affecting total yield (Cheema et al., 1997). On the other hand, there was no difference in the berry mass of 'Recel Uzumu' table grapes subjected to thinning (Özer et al., 2012). It can be noticed that depending on a cultivar and the characteristics of its berries, the effect of thinning on their mass may be different, since 'BRS Nubia' table grape has large berries and it is clear that the development of these berries is reduced due to excessive

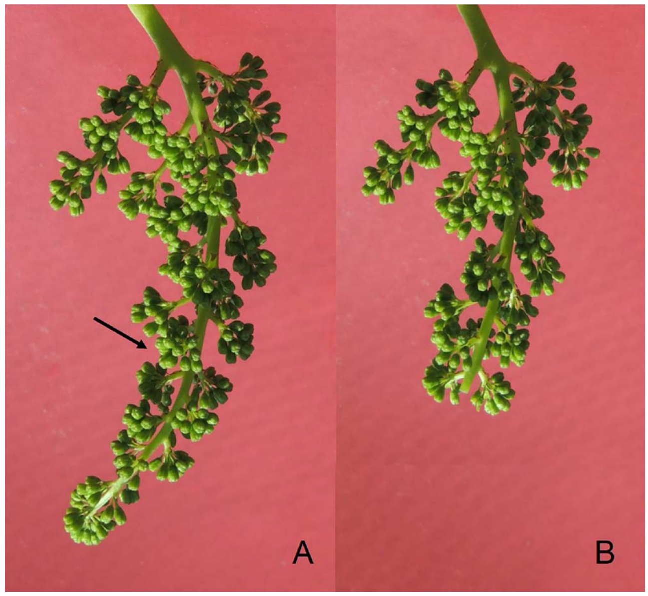

Fig. 1. Inflorescence management of 'BRS Nubia' table grape before anthesis. A: before tipping (arrow indicates the position of tipping); B: after tipping.

amount of fruits in the bunches.

In both seasons, there was no difference in the berry length and width regarding inflorescence and bearing shoot thinning (Table 2), indicating that these practices had no influence over these variables. However, control treatments showed some effect during both crop seasons. Control with berry thinning resulted in berries with higher length and width (Table 2), probably due to better distribution of berries along the bunch.

The quality of table grapes is very important for its commercialization, and berry size is one of the most important quality attribute that is valued by the consumers (Roberto et al., 2017). Table grapes are divided into different classes according to their bunch mass and in subclasses according to the berry quality (Mapa, 2002), where medium loose bunches with large berries have a higher market value. Current results strengthen the importance of berry thinning among 'BRS Nubia' table grapes in order to obtain high profitability.

Regarding bunch mass, it has been observed that bearing shoot tipping before anthesis during 2015 season showed slightly higher values as compared to after anthesis (Table 3), whereas, no such effect was observed for 2016 season. Among additional treatments, control with berry thinning had significant lower bunch mass. The bunch mass is directly related to the number of berries per bunch and the berry mass. However, this increase in the mass of remaining berries was not sufficient enough to overcome the deficit that was being created due to the reduction of berries during thinning process; although this response may be distinct

Table 1
Berry mass and number of berries per bunch of 'BRS Nubia' table grape subjected to inflorescence management, bearing shoot tipping and berry thinning. Seasons 2015 and 2016.

Treatments	Berry mass (g)		Number of berries per bunch	
	2015	2016	2015	2016
Inflorescence management (IM)				
With tipping	11.2^{ns}	11.2^{ns}	64.0^{ns}	63.0^{ns}
Without tipping	11.0	11.4	66.0	64.0
Bearing shoot tipping (ST)				
Before anthesis	11.2^{ns}	11.2^{ns}	69.0^{ns}	63.0^{ns}
After anthesis	11.0	11.4	60.0	64.0
Additional treatments (AT)				
Control without thinning (CWoT)	10.0 b	8.6 b	123.0 a	105.0 a
Control with thinning (CWT)	11.1 a	10.7 a	57.0 b	61.0 b
F (IM x ST)	0.17^{ns}	0.01^{ns}	0.03^{ns}	1.37^{ns}
F (factorial x AT)	3.25^{ns}	43.93^{**}	15.07^{**}	22.69^{**}
F (CWoT x CWT)	5.07^{*}	30.37^{**}	37.52^{**}	41.64^{**}

Means followed by same letters within columns do not differ according to Tukey's test ($p < 0.05$), ns: non-significant.
* $p < 0.05$.
** $p < 0.01$.

Fig. 2. Bearing shoot tipping of 'BRS Nubia' table grape. A: before tipping (arrow indicates the position of tipping); B: after tipping.

Table 2
Berry length and width of 'BRS Nubia' table grape subjected to inflorescence management, bearing shoot tipping and berry thinning. Seasons 2015 and 2016.

Treatments	Berry lenght (mm)		Berry width (mm)	
	2015	2016	2015	2016
Inflorescence management (IM)				
With tipping	29.5^{ns}	30.2^{ns}	24.4^{ns}	23.6^{ns}
Without tipping	29.3	30.0	24.0	23.9
Bearing shoot tipping (ST)				
Before anthesis	29.6^{ns}	29.8^{ns}	24.3^{ns}	23.8^{ns}
After anthesis	29.3	30.3	24.0	23.7
Additional treatments (AT)				
Control without thinning (CWoT)	28.7 b	26.9 b	23.4 b	21.9 b
Control with thinning (CWT)	30.0 a	29.5 a	24.4 a	23.6 a
F (IM x ST)	0.25^{ns}	0.01^{ns}	0.10^{ns}	0.01^{ns}
F (factorial x AT)	0.02^{ns}	24.17**	0.68^{ns}	27.59**
F (CWoT x CWT)	5.34*	17.72**	4.82*	27.67**

Means followed by same letters within columns do not differ according to Tukey's test ($p < 0.05$), ns: non-significant.
* $p < 0.05$.
** $p < 0.01$.

among different grape cultivars. Thinning of 'Perlette' grapes did not show any difference in bunch mass regarding to control treatment (Cheema et al., 1997), however length and mass of 'Recel Uzumu' grape bunches decreased in response to thinning (Özer et al., 2012).

In both seasons, the length of bunches was reduced by inflorescence tipping (Table 3), due to fact that the apical portion was removed from the inflorescence. However, it is worth mentioning that the difference was small, around 0.75 cm, which shows that even if tipped at 40% of its length; subsequently the inflorescence grows enough to balance out the removed portion.

In 2015 season, bearing shoot tipping before anthesis resulted in bunches slightly longer than those tipped after anthesis. The slight difference observed only in 2015 is possibly due to the lower yield observed in the same season, as it was the first bearing season of the vineyard. Control with berry thinning significantly reduced bunch length just during 2015 season, whereas bunches width was as well significantly influenced in both seasons. In addition, there was no effect on bunch width when the inflorescence or bearing shoot tipping were performed (Table 3). It has been observed that the bunch length and width of 'Recel Uzumu' grapes were not affected by thinning procedure (Özer et al., 2012).

No significant effect of inflorescence management has been observed on total soluble solids (TSS) content of the berries (Table 4),

Table 3
Bunch mass, length and width of 'BRS Nubia' table grape subjected to inflorescence management, bearing shoot tipping and berry thinning. Seasons 2015 and 2016.

Treatments	Bunch mass (kg)		Bunch lenght (cm)		Bunch width (cm)	
	2015	2016	2016	2015	2016	2015
Inflorescence management (IM)						
With tipping	0.7^{ns}	0.7^{ns}	19.7 b	19.0 b	12.1^{ns}	14.2^{ns}
Without tipping	0.7	0.7	20.5 a	20.7 a	11.9	14.3
Bearing shoot tipping (ST)						
Before anthesis	0.8 a	0.7^{ns}	20.4 a	19.5^{ns}	12.1^{ns}	14.2^{ns}
After anthesis	0.7 b	0.7	19.8 b	20.1	11.8	14.3
Additional treatments (AT)						
Control without thinning (CWoT)	1.2 a	0.9 a	22.0 a	20.8^{ns}	13.9 a	15.3 a
Control with thinning (CWT)	0.6 b	0.9 a	19.5 b	19.8	11.8 b	14.1 b
F (IM x ST)	0.24^{ns}	2.70^{ns}	1.07^{ns}	0.51^{ns}	0.45^{ns}	0.94^{ns}
F (factorial x AT)	30.06**	3.47^{ns}	8.63*	2.68^{ns}	3.02^{ns}	3.29^{ns}
F (CWoT x CWT)	100.08**	19.72**	41.11**	3.48^{ns}	6.79*	9.30**

Means followed by same letters within columns do not differ according to Tukey's test ($p < 0.05$), ns: non-significant.
* $p < 0.05$.
** $p < 0.01$.

Table 4
Total soluble solids (TSS), tritratable acidity (TA) and maturation index (TSS/AT) of 'BRS Nubia' table grape subjected to inflorescence management, bearing shoot tipping and berry thinning. Seasons 2015 and 2016.

Treatments	Total soluble solids TSS (°Brix)		Titratable acidity TA (%)		Maturation index TSS/AT	
	2015	2016	2015	2016	2015	2016
Inflorescence management (IM)						
With tipping	14.5^{ns}	13.9^{ns}	0.7^{ns}	0.8 a	20.2^{ns}	17.5^{ns}
Without tipping	14.6	14.0	0.7	0.7 b	20.4	18.9
Bearing shoot tipping (ST)						
Before anthesis	14.2^{ns}	13.6 b	0.7^{ns}	0.8 a	19.6^{ns}	17.0 b
After anthesis	14.9	14.6 a	0.7	0.7 b	21.0	19.4 a
Additional treatments (AT)						
Control without thinning (CWoT)	14.4^{ns}	11.9 b	0.8^{ns}	0.8^{ns}	18.8^{ns}	14.1 b
Control with thinning (CWT)	14.7	14.0 a	0.7	0.8	20.9	17.8 a
F (IM x ST)	0.00^{ns}	0.13^{ns}	0.53^{ns}	0.48^{ns}	0.38^{ns}	0.73^{ns}
F (factorial x AT)	0.00^{ns}	18.38**	0.93^{ns}	4.81*	0.46^{ns}	12.54**
F (CWoT x CWT)	0.50^{ns}	28.26**	3.56^{ns}	3.21^{ns}	3.30^{ns}	12.57**

Means followed by same letters within columns do not differ according to Tukey's test ($p < 0.05$), ns: non-significant.
* $p < 0.05$.
** $p < 0.01$.

indicating that this practice has no effect on this variable. However, bearing shoot tipping during 2016 season resulted in higher TSS content when carried out after anthesis. While the shoot is vigorous, the assimilated compounds flow more toward the vegetative tip whereas bunches are left scarce, which leads to its poor development and ripening (Fregoni, 1998), and fruit exhaustion seems to be more evident in bearing shoots tipped after full flowering (Mota et al., 2010).

Regarding the additional treatments evaluated, the control with berry thinning during 2016 season showed higher TSS content. Due to the lower fruit density in 2015 (two bunches per m^2), this variable was not affected, which is common in the first productive cycle of the vine. During 2016 season, where higher bunch density was achieved (four bunches per m^2), the non-thinned bunches did not reach the desired ripening, showing lower TSS contents compared to the ones that had been thinned (11.9 and 14.0°Brix, respectively).

In 'Crimson Seedless' table grapes, berry thinning increased TSS content and accelerated ripening process (El-Razek et al., 2010). Similar results were obtained when 'Sangiovese' grapes were thinned, which increased the source/drain ratio from 0.6 to 1.2 m^2 leaf area per kg of berries as well as increased the TSS content (Pastore et al., 2011). Increase TSS contents were observed when 'Recel Uzumu' grapes were thinned by removing 50% of the berries from bunches (Özer et al., 2012).

During 2015 season, no significant difference was observed among the treatments regarding the titratable acidity (TA). However, in 2016 season both inflorescence management and the bearing shoot tipping showed some effect, where a low content of TA was recorded for non-tipped inflorescence as well as bearing shoot tipping after anthesis. However, the observed differences were small, indicating insignificant role of these treatments on TA of berries.

Vines with high yields and low source/drain ratio produce bunches with higher TA content (Mota et al., 2010), however, during the current study, no such behavior has been observed. Similarly, when 'Thompson Seedless' grapes were subjected to berry thinning during different phenological phases, no difference was observed in the TA (Weaver and Pool, 1973).

In 2015 season, maturation index (MI) among treatments did not show any significant effect. However, in 2016 season the bearing shoot tipping after anthesis resulted in a higher MI with similar results being observed for control with berry thinning, thus explaining higher TSS content among these treatments. In general, the MI was relatively higher in 2015 season, and the difference between the seasons may have occurred due to the lower fruit density, since it was the first bearing season of the vineyard.

No significant effect was observed for inflorescence management over estimated production per plant and yield (Table 5). Nevertheless,

Table 5
Production per plant and yield of 'BRS Nubia' table grape subjected to inflorescence management, bearing shoot tipping and berry thinning. Seasons 2015 and 2016.

Treatments	Production per plant (kg)		Yield (ton ha^{-1})	
	2015	2016	2015	2016
Inflorescence management (IM)				
With tipping	30.0^{ns}	54.0^{ns}	13.3^{ns}	24.0^{ns}
Without tipping	30.2	53.6	13.4	25.0
Bearing shoot tipping (ST)				
Before anthesis	32.6 a	54.3^{ns}	14.5 a	24.1^{ns}
After anthesis	27.6 b	56.1	12.3 b	24.9
Additional treatments (AT)				
Control without thinning (CWoT)	48.4 a	68.7 a	21.5 a	30.6 a
Control with thinning (CWT)	26.5 b	50.8 b	11.7 b	22.6 b
F (IM x ST)	0.24^{ns}	2.70^{ns}	0.24^{ns}	2.70^{ns}
F (factorial x AT)	30.06**	3.47^{ns}	30.06**	3.47^{ns}
F (CWoT x CWT)	100.08**	19.72**	100.08**	19.72**

Means followed by same letters within columns do not differ according to Tukey's test ($p < 0.05$), ns: non-significant.
* $p < 0.05$.
** $p < 0.01$.

during 2015, the bearing shoot tipping treatment before anthesis showed higher production per plant and, consequently, higher yield. There was also a significant difference between the additional treatments, where the control with berry thinning resulted in lower production per plant and yield.

The productivity of vines is directly related to the mass of bunches, number of bunches per plant and density of plants. Considering that the last two characteristics were pre-determined and homogeneous during the trial, this explains why control with berry thinning resulted in lower mass of bunches and, subsequently, lower production per plant and yield. Similar results have been observed by Özer et al. (2012) and Roberto et al. (2017).

Although control without berry thinning resulted in higher yield, this treatment resulted in 100% of very dense bunches, with non-uniform ripening and onset of rotten berries due the presence of cracked berries, making them unfavorable for commercial purpose. On the other hand, remaining treatments of inflorescence management and/or bearing shoot tipping associated with berry thinning resulted in 100% of medium loose bunches, with uniform bunch and berry size as well as ripening (Fig. 3).

Thus, the berry thinning is a mandatory practice for improving the quality attributes, such as color and uniformity among berries of 'BRS Nubia' table grape, as these factors determine the marketing value of table grapes (Choudhury, 2000; Almeida, 2003). This practice enables production of medium loose bunches with larger and uniform berries, suppressing berry cracking and fungal decay incidences by improving the aeration and the distribution of fungicides inside the bunches, as observed in 'Rhine Riesling' grape, where the berry thinning enabled lower decay incidence than non-thinned bunches (Barbetti, 1980). Many wholesalers have pointed out that poor quality of fruit is the main cause of fruit loss which accelerates the deterioration, ultimately causing lower sales (Carrer and Alves, 2010).

The Principal Component Analysis (PCA) was successfully applied to identify groupings in relation to the physico-chemical and productive characteristics of grapes with the inflorescence and shoot management. According to the criterion of Cliff (1958), the first two principal components were selected, which together explained 84.33% of the total variation (63.13% and 21.20% for PCA1 and PCA2, respectively).

Besides, the PCA allowed the identification of four distinct groups, being these separated mainly according to the season (Fig. 4A). The first group represents treatments applied in 2016 season, except for inflorescence without tipping and shoot tipping after anthesis (IWoT + STAA/2016), and the second group is characterized by treatments applied in 2015 season, whereas control without berry thinning (CWoT) formed the two other groups, one in 2015 and one in 2016.

The treatments applied in 2015 season favored the berry width (BrW), TSS and MI, while the ones applied in 2016 were associated with the TA content, bunch width (BW) and yield (YLD). This behavior justifies the yield difference observed during the two seasons. Lower load during 2015 improved TSS contents and MI. In 2016, due to high load, low TSS content and MI were observed, but high YLD and TA were recorded. The CwoT was associated with the number of berries per bunch (NBB) and to the bunch length (BL) in both seasons. The result of PCA indicates that the higher the yield, higher is the TA and BW, and lower is the TSS content, MI and BrW (Fig. 4B). The berry length and mass (BrL and BrM, respectively) were not associated with YLD, and had a negative correlation with NBB and BL.

Although the inflorescence tipping before the anthesis did not clearly influence most of the analyzed variables, it is an easy and fast operation that may be beneficial for 'BRS Nubia' grapes, since it facilitates the prospective thinning when berries are at pea size, a laborious and time-consuming practice which represents around 22% of the production costs (Kishino, 2007). In other words, as the time required for berry thinning is around 0.0166 h per bunch, this time is reduced approximately to half if the inflorescence is tipped before the anthesis. Considering that in 1-ha vineyard of 'BRS Nubia' there are around

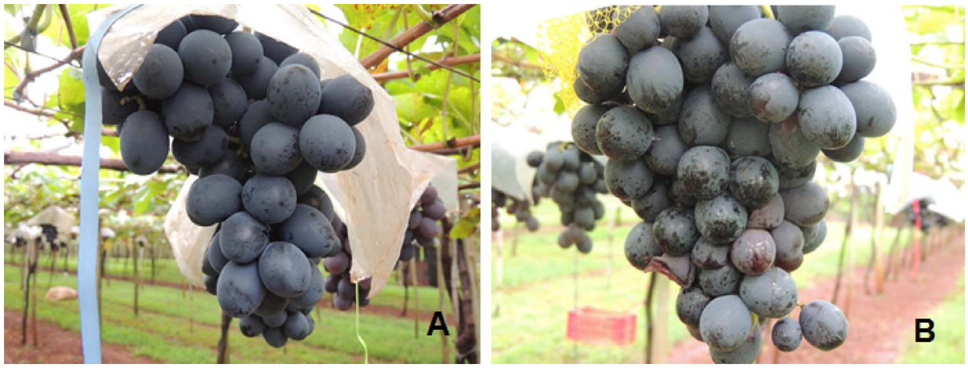

Fig. 3. Visual appearance of 'BRS Nubia' table grape subjected to management of inflorescence, bearing shoot tipping and berry thinning. A: Medium loose bunch subjected to inflorescence and bearing shoot tipping showing uniform ripening; B: Very dense bunch (control non-thinned) showing non-uniform ripening and onset of rotten berries.

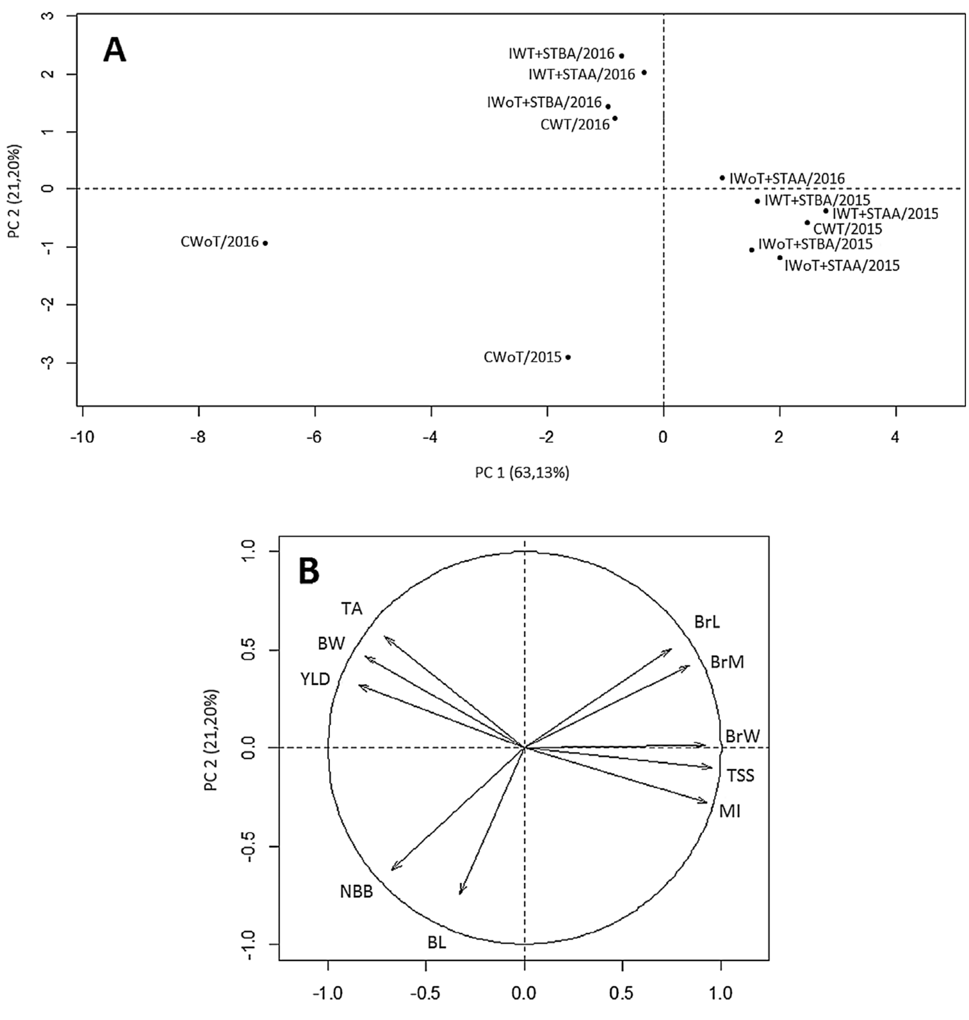

Fig. 4. Principal Component Analysis (PCA) of physicochemical and productive characteristics for 'BRS Nubia' table grape subjected to inflorescence management, bearing shoot tipping and berry thinning. Seasons 2015 and 2016. A: treatments dispersion according to the scores of the principal components. B: variables arrangement according to the scores of the principal components. IWT + STBA: Inflorescence with tipping and bearing shoot tipping before anthesis; IWT + STAA: Inflorescence with tipping and bearing shoot tipping after anthesis; IWoT + STBA: Inflorescence without tipping and bearing shoot tipping before anthesis; IWoT + STAA: Inflorescence without tipping and bearing shoot tipping after anthesis; CWT: Control with thinning; CWoT: Control without thinning; BrM: Berry mass; BrL: Berry lenght; BrW: Berry width; BL: Bunch lenght; BW: Bunch width; NBB: Number of berries per bunch; TSS: Total soluble solids; TA: Tritratable acidity; MI: Maturation index; YLD: Yield.

60,000 bunches (density of six bunches per m^2), this would mean saving about 460 labor-hours per ha, or approximately, 2-month paycheck of a single field worker.

The bearing shoot tipping before the anthesis, is also considered an easy and fast technique, although it had little effect on productivity characteristics during 2015 season, possibly due to the low fruit density during the season. However, in 2016 season, this practice increased TSS contents significantly and improved the MI, which is very helpful since bunches reach the desirable commercialization index more quickly.

In summary, berry thinning is a mandatory practice in order to achieve the desired attributes of 'BRS Nubia' table grapes, such as medium loose, uniform and high quality bunches. Failure to perform this practice results in very dense bunches with no commercial value, and cracked berries of non-uniform size, color and ripening.

4. Conclusion

The inflorescence tipping before anthesis is a useful practice, facilitating time efficient procedure of berry thinning for 'BRS Nubia' grapes, while the bearing shoot tipping after anthesis may accelerate ripening of the bunches. Combined to these practices, berry thinning is a mandatory procedure in order to obtain medium loose bunches of 'BRS Nubia' table grape, with larger and uniform berries.

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