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Berry-cluster thinning to prevent bunch compactness of 'BRS Vitoria', a new black seedless grape

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ABSTRACT

The objective of this study was to evaluate techniques, such as flower-cluster and berry-cluster thinning at different times, to prevent bunch compactness of 'BRS Vitoria', a new black seedless grape. The experiment was conducted during two consecutive seasons (2013 and 2014) in a commercial vineyard located in Marialva, PR, Brazil. The grapevines were trained in an overhead trellis system, spaced at 2.5 × 5.0 m. The experimental design used was randomized blocks with four replications and six treatments: control (no thinning); flower-cluster thinning or brushing prior to anthesis; and berry-cluster thinning at different times, when berries were 3–6, 7–10, 11–15, or 16–18 mm in diameter. The bunch compactness incidence was evaluated according to the following classification: very loose, medium loose, and very dense bunches. The physicochemical characteristics of bunches and the yield were also evaluated. Data were submitted to analysis of variance, and means were compared using Tukey's test at 5%. Berry-cluster thinning when 'BRS Vitoria' berries are between 7 and 18 mm in diameter is efficient for reducing bunch compactness, as it results in a higher incidence of medium loose and a lower incidence of very dense bunches with optimum yield, while flower-cluster thinning or brushing prior to anthesis should be avoided because it promotes higher incidence of very loose bunches with reduced yield.

1. Introduction

'BRS Vitoria' (*Vitis* spp.), is a novel cultivar of black seedless table grape recommended for cultivation in tropical and subtropical areas, with excellent horticultural performance, high bud fecundity and tolerance to downy mildew (*Plasmopara viticola*), the most important disease affecting grapevines in tropical and subtropical humid areas. This grape is an excellent option for the overseas market because of its firmness and flavor (Khamis et al., 2015), but it has the inconvenience of presenting very dense and compact bunches (Maia et al., 2014).

Good quality in table grapes represents a combination of medium-sized bunches of uniformly large, perfect berries with the characteristic color, pleasing flavor, and texture of the variety. Thus, production focused on the quality seedless grape market is increasingly demanding skilled labor, specialized services and the use of new technologies, such as specific thinning techniques (Leao and Soares, 2010; Winkler et al., 1974).

The removal of flower clusters before blooming and of immature clusters or parts of such berry clusters after the fruit has set is called thinning. This process consists of the removal of living parts and concentrates the activities of the vine into the remaining parts, preventing bunch compactness (Pastore et al., 2011). Therefore, maximum berry sizes can be achieved with no compaction between them, avoiding the resulting flaws (Herrera et al., 1973).

For some varieties of seedless grapes, chemical thinning can be accomplished with the use of the plant growth regulator gibberellic acid (GA_3), applied during flowering (Gonzaga and Ribeiro, 2009; Hanni et al., 2013). However, this technique does not allow the extraction of the berries in a uniform and systematic manner. Flower-cluster thinning or brushing prior to anthesis, is widely used for seeded table grapes, but its use for seedless grapes can be limited (Kishino and Roberto, 2007) due the natural abortion of berries that usually occurs after fruit set (Mullins et al., 1992).

Recently, another technique called berry-cluster thinning has been proposed to prevent over compactness of table grapes, saving time and labor costs. Unlike berry thinning, a time consuming and

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expensive operation in which individual berries are removed, this technique is applied after fruit set and consists of the removal of four or five berry-clusters located in the more compact portions along both sides of the rachis, followed by bunch tipping (Rodríguez et al., 2013). This technique could be very useful for preventing compactness of 'BRS Vitoria' seedless grapes, but the best timing for performing it after fruit set is not yet known.

Thus, the objective of this research was to evaluate the berry-cluster thinning technique at different times after fruit set to determine the time it can be successfully performed to prevent bunch compactness of 'BRS Vitoria' seedless grapes, with a minimum loss of yield.

2. Material and methods

2.1. Grapevines and growing conditions

This study was conducted in a commercial vineyard of 'BRS Vitoria' seedless grape (*Vitis* spp.) from 3-year-old vines grafted on 'IAC 766 Campinas' rootstock, located in Marialva, state of Paraná (PR), Brazil (23° 29′52,8″S, 51° 47′58,0″W, altitude 570 m), in two consecutive crop seasons, 2013 and 2014. The vines were trained on overhead trellises and spaced 2.5 × 5.0 m apart (800 vines ha^{-1}).

According to the Köppen classification, the climate is type Cfa, i.e., subtropical climate with an average temperature in the coldest month below 18 °C and average temperature in the warmest month above 22 °C. The maximum temperature is 31 °C, and the average annual rainfall is 1596 mm, with a tendency for concentrated rainfall in the summer months.

Pruning was performed to leave 4 buds per cane, and subsequently, 3% hydrogen cyanamide was applied to the buds to induce and standardize sprouting.

2.2. Treatments and experimental design

The following thinning treatments were evaluated, aiming to prevent bunch compactness of 'BRS Vitoria' seedless grape, performed by just one trained worker:

a Control (no thinning);
b Flower-cluster thinning or brushing, prior to anthesis;
c Berry-cluster thinning, when berries were 3–6 mm in diameter;
d Berry-cluster thinning, when berries were 7–10 mm in diameter;
e Berry-cluster thinning, when berries were 11–15 mm in diameter; and
f Berry-cluster thinning, when berries were 16–18 mm in diameter.

To aid in understanding, the main parts of a grape bunch are illustrated in Fig. 1 (Dokoozlian, 2000).

The randomized blocks design was used as a statistical model, with six treatments and four replicates, with two vines per plot.

The flower-cluster thinning or brushing prior to anthesis was performed using a plastic brush (Hanni et al., 2013), brushing the rachis 6–8 times, resulting in a removal of approximately 55% of the flower buds from each rachis.

Berry-cluster thinning was performed after fruit set at different times, starting when berries were 3–6 mm in diameter, until three later phases, with a seven-day interval between each one, resulting in a removal of approximately 60% of berries from each bunch. The first four berry-clusters located at the top of the raquis were kept intact, and then, using a thinning-scissor, four or five berry-clusters located in the more compact portions along both sides of the rachis were completely removed, followed by bunch tipping (Rodríguez et al., 2013). Additionally, small, deformed or damaged berries were also removed, especially in later treatments, when berries were 11–15 or 16–18 mm in diameter.

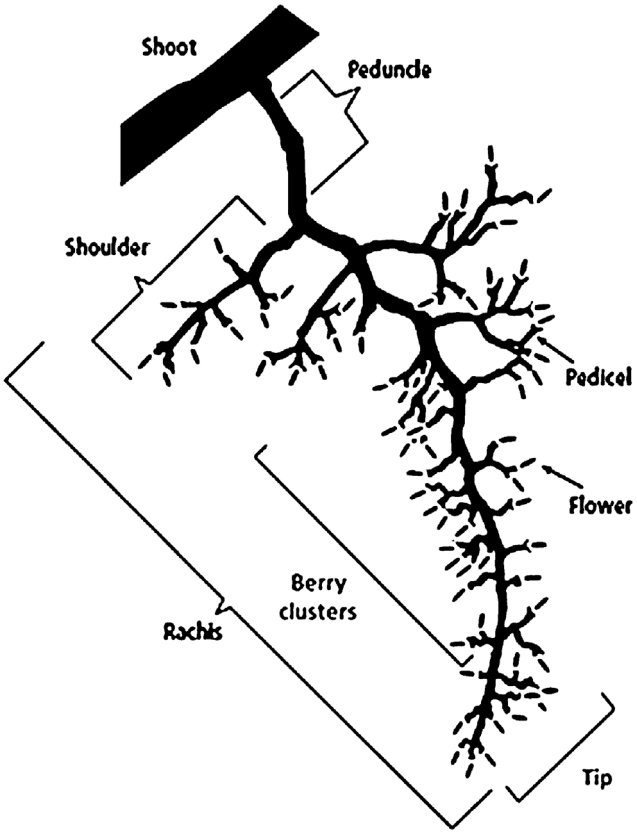

Fig. 1. The main parts of a grape bunch.
Adapted from Dokoozlian, (2000).

The duration or time necessary to apply each thinning treatment (seconds per bunch) was also determined.

2.3. Berry sampling and fruits analysis

In both crop seasons, the clusters of each plot were manually harvested when the total soluble solids content of berries was approximately 16 °Brix.

The bunch compactness was evaluated by means of visual observations of 30 bunches per plot, 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) (Fig. 2). For 'BRS Vitoria' seedless grape, bunches classified as medium loose were considered ideal for the table grape market.

For physicochemical analysis of grapes, ten clusters were sampled from each plot, and three berries were extracted from each cluster, from the upper, middle and lower portions, totaling 30 berries per plot.

The physical characteristics of the berries were evaluated by determinations of their weight (g) and length (mm) and the weight of the clusters (kg). The yield per tree (kg) and productivity (t ha^{-1}) were estimated as functions of the number of clusters per tree and their weight.

The chemical characteristics of the berries were assessed according to determinations of soluble solids (SS), titratable acidity (TA) and maturation index (SS/TA). The SS was determined using a digital refractometer with automatic temperature compensation

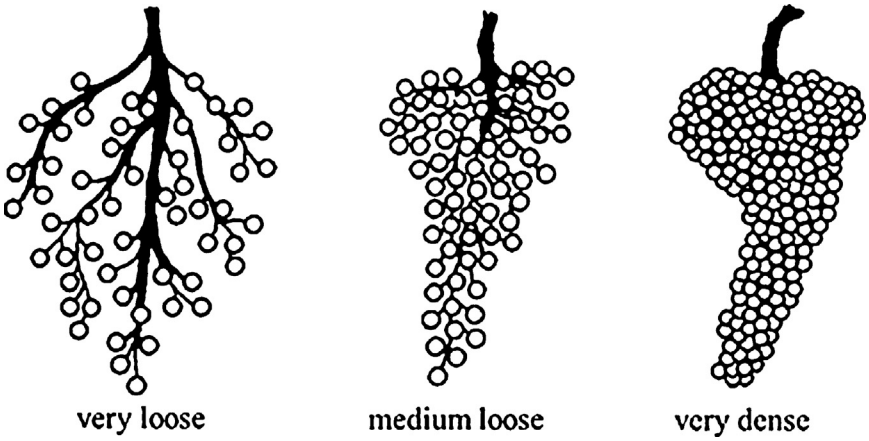

Fig. 2. Classification of table grape compactness.

Adapted from OIV, 2001 and Albuquerque, (1999)

(DR301-95 Model, Krüss Optronic, Germany), and the result was expressed in °Brix. The determination of TA was conducted via titration of the grape must with a standard 0.1 N NaOH solution in a semi-automatic titrator, adopting pH 8.2 as the end point of titration, and the result was expressed in percent of tartaric acid (Khamis and Roberto, 2014).

Means were subjected to analysis of variance (ANOVA) and were compared using Tukey's test at 5% probability.

3. Results and discussion

It was observed that the time required for performing each thinning technique increased as grape phenological stages advanced (Fig. 3). As the thinning to promote decompaction is an activity that requires skilled labor, the time spent for such an operation allows cost estimate and planning of the activity as a function of the amount of skilled labor available for each production system.

Regarding bunch compactness, the berry-cluster thinning treatments influenced this characteristic in both seasons. When performing berry-cluster thinning when berries were 3-6 mm in diameter, an incidence of medium loose bunches greater than 50% was obtained (Fig. 4). However, when berries were between 7 and 18 mm in diameter, berry-cluster thinning resulted in the highest incidence of medium loose bunches, above 70 and 80% in the 2013 and 2014 seasons, respectively. Thus, during this phenological stage, this technique can be successfully used for the decompaction of 'BRS Vitoria' grape bunches. In addition to improving the bunches' appearance, which is essential for obtaining higher prices, less compaction allows the applied fungicides to better reach the clusters' interiors and to protect them against attack by pathogenic fungi or saprophytes, resulting in a better product quality (Kishino and Roberto, 2007).

When no thinning was applied (control), the highest incidence of very dense bunches was observed in both seasons, higher than 80%. When flower-bud thinning or brushing was performed, even it is considered a fast operation (Fig. 3), the highest incidence of very loose bunches was observed, especially in the 2013 season (90.6%), what is also an undesired characteristic for 'BRS Vitoria' bunches. Thus, flower-bud thinning or brushing, even widely used in several seeded grapes, has to be avoided because its negative impact on 'BRS Vitoria' bunches.

Considering the time required to perform berry-cluster thinning in large scale in a vineyard, beginning this technique should be avoided in the most advanced phenological stage of the clus-

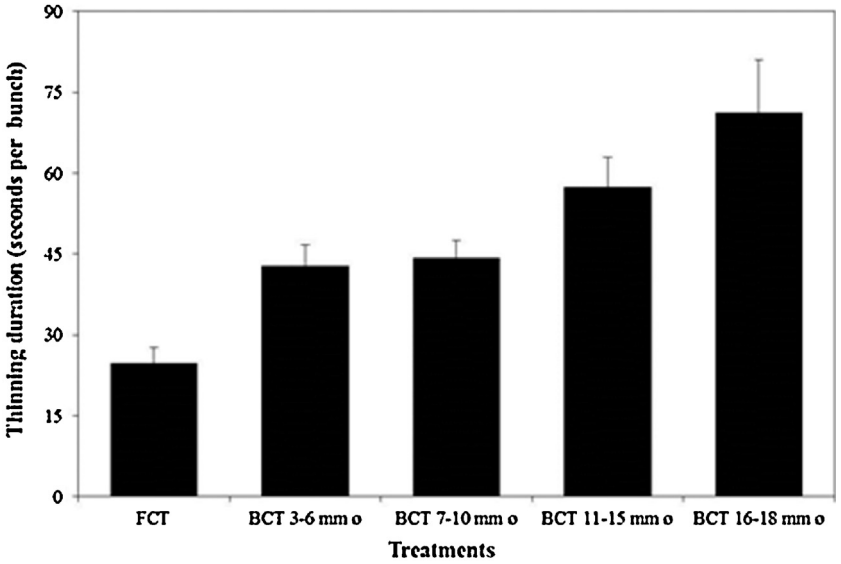

Fig. 3. Thinning duration (seconds per bunch) to apply thinning techniques on 'BRS Vitoria' seedless grape. Bars indicate standard deviations. FCT: Flower-cluster thinning or brushing; BCT: Berry-cluster thinning. ⌀ = diameter of berries.

ter after fruit set and before berry softening. As 'BRS Vitoria' grape phenological stage advanced, the time spent to perform it also increased, requiring a greater availability of labor (Fig. 3). Berry-cluster thinning when berries were 3–6 mm in diameter required less execution time but was subject to limitations, such as the difficulty in perceiving the more compacted cluster portions at that stage. This limitation hinders the protocol's execution, and because it is not yet possible to remove small berries at this point, resulting in clusters with a poorer final appearance, another thinning operation is necessary before or after the harvest. In contrast, when

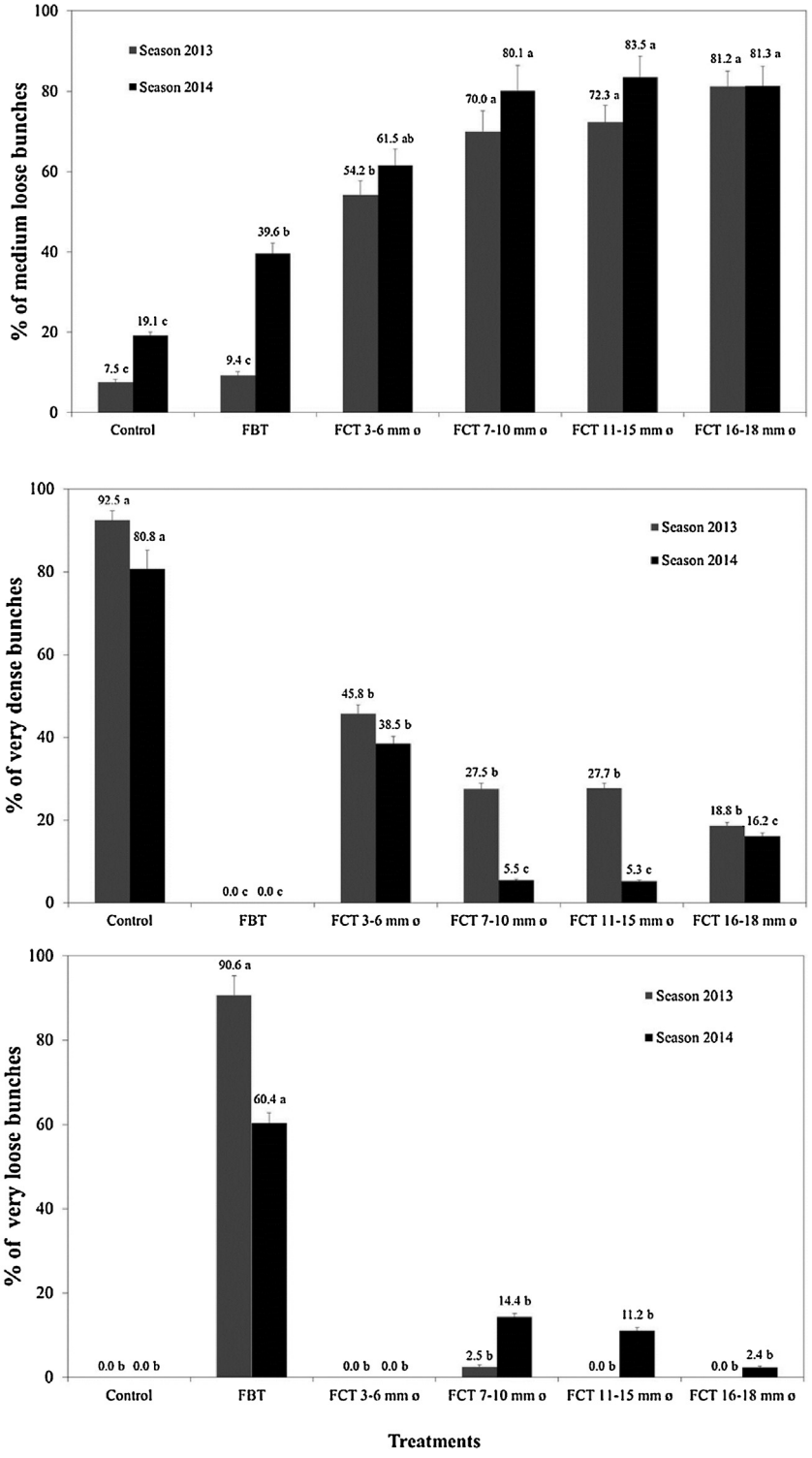

Fig. 4. Percentages of medium loose, very dense and very loose bunches of 'BRS Vitoria' seedless grape submitted to different thinning techniques. Seasons 2013 and 2014. FCT: Flower-cluster thinning or brushing; BCT: Berry-cluster thinning. Means followed by the same letters within each individual crop do not differ according to Tukey's test ($p < 0.05$). ⌀ = diameter of berries.

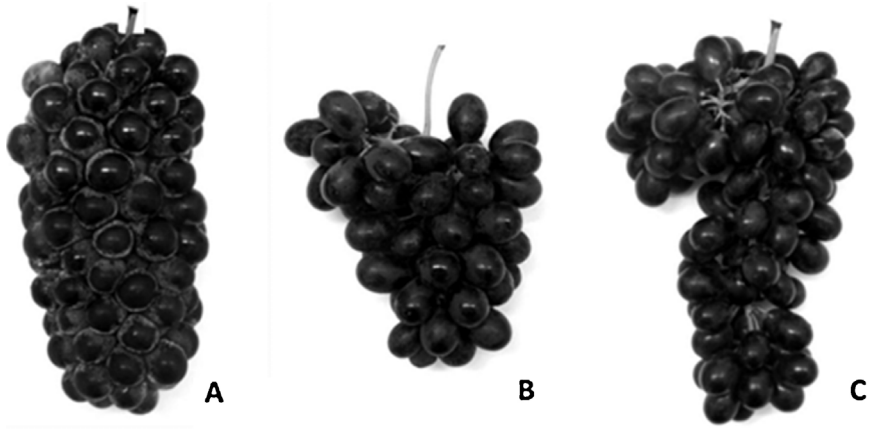

Fig. 5. Bunches of 'BRS Vitoria' seedless grape submitted to different thinning techniques. Control (A); Flower-cluster thinning or brushing prior anthesis (B); Berry-cluster thinning when berries were 7–18 mm in diameter (C).

berry-thinning was initiated in subsequent phenological stages, when berries were at least 7 mm in diameter, although a longer execution time was required, better final cluster appearance was achieved (Fig. 5) because the berries are bigger at this stage, which facilitates decompaction and removal of small, deformed and damaged berries, reducing significantly the need of bunch cleaning operation in the packing house.

Thus, berry-cluster thinning can be preferably initiated when the berries are at least 7 mm in diameter and can be terminated when they are approximately 18 mm in diameter. Therefore, there is a period of approximately 21 days to perform this procedure so that the work can be better planned and performed without the need for hiring extra labor. Different from berry thinning, a time consuming and expensive operation in which individual berries are removed, berry-clusters thinning showed to be a very easy and fast technique to prevent bunch compactness of 'BRS Vitoria' seedless grape.

Regarding the chemical characteristics of the berries (Table 1), differences were identified regarding the soluble solids (SS) content. The highest SS content was observed for flower-cluster thinning or brushing in both seasons, and this result can be associated with lower cluster weight (Table 2), which changed the distribution of assimilates in the clusters due to the higher source/sink ratio. Pastore et al. (2011) reported a similar situation: bunch thinning of the 'Sangiovese' grape increased two-fold the source/sink ratio, which resulted in turn in an increase of the SS content.

Based on the international commerce standards, the minimum SS content for table grapes can range from 14.0 to 17.5 °Brix, depending on the cultivar and crop conditions (Maia et al., 2014), and the SS averages obtained in this study for all of the berry-cluster thinning treatments were within the commercial standards.

Regarding the titratable acidity (TA) of the berries (Table 1), there were no significant differences between the treatments in the two crop seasons. However, Weaver and Winkler (1952) reported that thinning leads to a decrease in acidity, as verified by Gil et al. (2013) in juice and wine produced from 'Syrah' grape when thinning was performed.

As the fruit flavor is mostly derived from the balance between sugars and organic acids (SS/TA or maturation index), a high value of this index is considered desirable by the market. The SS/TA ratio provides a good evaluation of the fruits and is more representative than the isolated measurement of sugars or acidity. In this study, there were significant difference in the SS/TA ratio in both seasons, with the highest averages observed when flower-cluster thinning or brushing was applied, but this treatment resulted in the lowest yield for 'BRS Vitoria' grape (Table 1).

For the 2013 season, flower-cluster thinning or brushing caused a lower cluster weight than the other treatments (Table 2). It is known that in seedless grapes, a natural abortion of berries usually occurs after fruit set, and in this case, flower-cluster thinning or brushing had a negative impact on 'BRS Vitoria' bunch. Similar behavior was observed in the 2014 season, but the bunch weight was not significantly different from that in the berry-cluster thinning treatments applied when berries were at least 7 mm in diameter. These results may be associated with a fewer number of berries present in the bunch after brushing, due to the bunch weight being related to the number of berries per bunch and the weight of the berries.

Cheema et al. (1997) did not observe significant differences between thinning and control treatments related to bunch weight for 'Perlette' grape; however, significant differences were observed for the weight of the berries, with lower-weight berries in the control treatment. Corroborating these authors, Karoglan et al.

Table 1
Soluble solids (SS), titratable acidity (TA), and SS/TA ratio of 'BRS Vitoria' seedless grape submitted to different thinning techniques. Seasons 2013 and 2014.

Treatments	Soluble solids—SS (°Brix)		Titratable acidity—TA (%)		SS/TA	
	2013	2014	2013	2014	2013	2014
Control	16.0 b	15.4 b	0.6[ns]	0.9[ns]	26.7 b	17.1 b
Flower-cluster thinning or brushing	17.4 a	18.3 a	0.6	0.8	29.1 a	22.9 a
Berry-cluster thinning (3–6 mm ⌀)[a]	15.9 b	15.8 b	0.6	0.9	26.5 b	17.5 b
Berry-cluster thinning (7–10 mm ⌀)	16.5 ab	16.3 b	0.6	0.9	27.5 ab	18.1 b
Berry-cluster thinning (11–15 mm ⌀)	16.8 ab	16.2 b	0.6	0.9	28.0 ab	18.0 b
Berry-cluster thinning (16–18 mm ⌀)	16.3 ab	16.2 b	0.6	0.9	27.3 ab	18.0 b

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

[a] ⌀ = diameter of berries.

Table 2
Berry mass and length and bunch mass of 'BRS Vitoria' seedless grape submitted to different thinning techniques. Seasons 2013 and 2014.

Treatments	Berry mass (g)		Berry length (mm)		Bunch mass (kg)	
	2013	2014	2013	2014	2013	2014
Control	5.6 ab	3.7 ns	26.2 ns	21.6 ns	0.5 a	0.4 a
Flower-cluster thinning or brushing	6.1 a	3.8	26.1	21.7	0.3 b	0.2 b
Berry-cluster thinning (3–6 mm ⊘)[a]	5.7 ab	3.9	25.3	21.6	0.5 a	0.4 a
Berry-cluster thinning (7–10 mm ⊘)	5.6 ab	4.2	24.9	22.4	0.4 a	0.3 ab
Berry-cluster thinning (11–15 mm ⊘)	5.9 ab	4.1	25.7	21.6	0.4 a	0.3 ab
Berry-cluster thinning (16–18 mm ⊘)	5.5 b	3.8	25.4	21.2	0.4 a	0.3 ab

Means followed by same letters within columns do not differ according to Tukey's test ($p < 0.05$), ns: non-significant.
[a] ⊘ = diameter of berries.

Table 3
Yields per tree and per hectare of 'BRS Vitoria' seedless grape submitted to different thinning techniques. Seasons 2013 and 2014.

Treatments	Yield per tree (kg)		Yield per hectare (t ha^{-1})	
	2013	2014	2013	2014
Control	37.7 a	35.6 a	30.2 a	28.5 a
Flower-cluster thinning or brushing	19.5 c	16.7 c	15.6 c	13.4 c
Berry-cluster thinning (3–6 mm ⊘)[a]	35.3 ab	31.2 ab	28.2 ab	25.0 ab
Berry-cluster thinning (7–10 mm ⊘)	32.1 b	27.4 b	25.7 b	22.0 b
Berry-cluster thinning (11–15 mm ⊘)	33.5 b	25.6 b	26.8 b	20.5 b
Berry-cluster thinning (16–18 mm ⊘)	33.1 b	28.1 b	26.5 b	22.5 b

Means followed by same letters within columns do not differ according to Tukey's test ($p < 0.05$).
[a] ⊘ = diameter of berries.

(2014) reported similar results for 'Merlot' and 'Cabernet Sauvignon' grapes.

Regarding the yield characteristics of 'BRS Vitoria' grape (Table 3), in both seasons, the highest averages of yield per tree and per area were found in the control treatment when no thinning was applied. However, it should be noted that thinning is an essential operation for the 'BRS Vitoria' grape because it has compact bunches, which are not commercially desirable for table grapes, especially for the export market.

Unsatisfactory yield averages were observed for flower-cluster thinning or brushing in both seasons because this technique increases the incidence of very loose bunches, which are lower in weight. However, good yield levels were obtained when berry-cluster thinning was applied. These results are also in agreement with other authors who reported lower grape yield when thinning was applied for 'Syrah' and 'Recel Uzumu' grapes (Gil et al., 2013; Ozer et al., 2012).

In summary, the decompaction of 'BRS Vitoria' seedless table grape is a mandatory activity to obtain high quality bunches. If the operation is not performed, although higher yield averages are obtained, the bunches become compact, depreciating their commercial value. Flower-cluster thinning or brushing prior to anthesis should be avoided, as this process results in a high incidence of very loose bunches with reduced yield. Berry-cluster thinning applied when berries are between 7 and 18 mm in diameter, despite the fact that yield is reduced compared to non-thinned grapes (control), presents good yield levels and results in a high incidence of medium loose bunches and a low incidence of very dense bunches.

4. Conclusion

Berry-cluster thinning on 'BRS Vitoria' seedless grapes when berries are between 7 and 18 mm in diameter is efficient to reduce bunch compactness by presenting a higher incidence of medium loose and a lower incidence of very dense bunches with optimum yield, while flower-cluster thinning or brushing prior to anthesis should be avoided because it promotes higher incidence of very loose bunches with reduced yield.

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