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Use of growth regulators to increase the berry size of 'BRS Melodia' grapes

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Abstract: The new 'BRS Melodia' table grape cultivar has attracted the attention of consumers due to the pleasant taste of a mix of red fruits and pink color. This study aimed to determine the ideal gibberellic acid concentration associated or not with plant biostimulants, aiming to improve the physical and physicochemical characteristics of 'BRS Melodia' grapes in the Submédio São Francisco Valley. Two experiments were conducted in a commercial vineyard located in the municipality of Petrolina, PE, Brazil. In the first experiment, treatments were represented by eight gibberellic acid concentrations (GA_3) (12.5; 13; 17.5; 18; 22.5; 23; 27.5 and 28 $mg.L^{-1}$), while in the second experiment, three GA_3 concentrations (13, 18 and 30 $mg.L^{-1}$) were used, associated or not with biostimulants. In both experiments, control did not receive GA_3 and biostimulants. The evaluations of the physical and physicochemical variables of bunches and berries were carried out during two consecutive production cycles, 2021 and 2022. The experimental design was in randomized blocks with four replicates. Treatments used in experiment 1 did not provide significant gains in the characteristics of bunches and berries. In the second experiment, biostimulant A (Benzyladenine 2%) associated with 30 $mg.L^{-1}$ of GA_3, divided into three applications (8 $mg.L^{-1}$ + 10 $mg.L^{-1}$ + 12 $mg.L^{-1}$) promoted increments in variables berry mass and length. These growth regulators should be used to promote the growth of 'BRS Melodia' berries in the Submédio São Francisco Valley.

Index Terms: Gibberellin, Fine grapes, Cytokinin.

Utilização de reguladores de crescimento para o aumento do tamanho da baga de uvas 'BRS Melodia'

Resumo: O novo cultivar de uva de mesa 'BRS Melodia' tem atraído a atenção dos consumidores pelo sabor agradável de mix de frutas vermelhas e pela coloração rosada. O presente trabalho teve como objetivo determinar a concentração ideal de ácido giberélico, associado ou não com bioestimulantes vegetais, visando à melhoria das características fisicas e fisico-químicas de uvas 'BRS Melodia', no Vale do

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Submédio São Francisco. Dois experimentos foram conduzidos em um vinhedo comercial localizado em Petrolina-PE, Brasil. No primeiro experimento, os tratamentos foram representados por oito concentrações de ácido giberélico (GA_3) (12,5; 13; 17,5; 18; 22,5; 23; 27,5 e 28 mg.L^{-1}); enquanto no segundo expertimento, utilizaram-se três concentrações de GA_3 (13; 18 e 30 mg.L^{-1}), associadas ou não a bioestimulantes. Em ambos os experimentos, a testemunha não recebeu GA_3 e bioestimulantes. As avaliações das variáveis físicas e fisico-químicas de cachos e de bagas foram realizadas durante dois ciclos consecutivos de produção: em 2021 e 2022. O delineamento experimental foi em blocos casualizados, com quatro repetições. Os tratamentos utilizados no experimento 01 não proporcionaram ganhos significativos nas características de cachos e de bagas. No segundo experimento, o bioestimulante A (Benziladenina 2%), associado a 30 mg.L^{-1} de GA_3, fracionado em três aplicações (8 mg.L^{-1} + 10 mg.L^{-1} + 12 mg.L^{-1}), promoveu incrementos nas variáveis massa e comprimento de bagas. Estes reguladores de crescimento devem ser utilizados para promover o crescimento de bagas de 'BRS Melodia', no Vale do Submédio São Francisco.

Termos para indexação: Giberelina, Uvas finas, Citocinina.

Introduction

In Brazil, viticulture stands out for its social and economic importance, especially in the irrigated agriculture of Northeastern Brazil, since the soil and climate conditions associated with pruning and irrigation management enabled obtaining more than one production cycle per year (MELLO, 2018). This is one of the main factors that ensure that the Submédio São Francisco Valley region has productivity higher than the national average, exceeding 44t/ha/year (IBGE, 2022). Investment in research, skilled labor and new cultivars also promote increases in the productivity of grapes produced in this region.

The market for grapes with exotic or 'gourmet' flavor has attracted the attention of both national and international producers and consumers. This market niche includes the 'BRS Melodia' cultivar, which has pleasant red fruit flavor and pink color as its distinguishing characteristics (MAIA et al., 2019; RITSCHEL et al., 2021).

The 'BRS Melodia' cultivar was developed by 'Uvas do Brasil' Embrapa Breeding Program and launched in 2019, to be produced at the "Serra Gaúcha" region, under a plastic cover system (MAIA et al., 2019). The recommendation for cultivation in the Submédio São Francisco Valley occurred in 2021 (RITSCHEL et al., 2021). One of the limiting characteristics of 'BRS Melodia' grapes is the small berry size. Therefore, the use of growth regulators is necessary, since it is not always possible to achieve the minimum standard required by the most demanding consumers and markets. Furthermore, increasing berry size is essential to achieve higher average bunch mass and, consequently, higher productivity.

Bunches of 'BRS Melodia' grapes grown in the Submédio São Francisco Valley had average berry diameter of 16 mm (RITSCHEL et al., 2021). In addition to pleasant flavor, good post-harvest conservation, tolerance to handling and transportation and bunches with good visual appearance, berries must have total soluble solids content (ºBrix) ≥ 15.0 and minimum diameter of 15.0 mm (BRASIL, 2002).

The use of growth regulators and commercial biostimulants is among management practices adopted in grapevine cultivation with the aim of increasing bunch and berry size (SANTOS, 2015; CRUPI et al., 2016; SILVA, 2019). Growth regulators such as gibberellic acid (GA_3) and cytokinins act directly on cell division and elongation (WEAVER; MCCUNE, 1959; KERBAUY et al., 2019), and are widely used in viticulture to increase bunch and berry size (SANTOS et al., 2015; SILVA et al., 2019). The combination of gibberellins and cytokinins is also widely used in the production of table grapes, as these growth regulators act with a synergistic effect, favoring berry elongation and growth (RABAN et al., 2013).

Biostimulants, in turn, consist of a mixture of plant regulators and other biochemical compounds such as amino acids, micronutrients and vitamins (VIEIRA, 2001), which bring benefits to the crop, from seed germination to increased productivity.

Scientific studies proposing recommendation of management using growth regulators and commercial biostimulant products to improve the size of bunches and berries of 'BRS Melodia' grapes have not yet been carried out. Therefore, the present study aimed to determine the gibberellic acid concentration associated or not with plant biostimulants, aiming at improving the physical and physicochemical characteristics of 'BRS Melodia' grapes in the Submédio São Francisco Valley.

Material and methods

Two experiments were carried out in a commercial vineyard with the 'BRS Melodia' grape cultivar in the municipality of Petrolina, PE, Brazil (9º 19' 49''S, 40º 20' 36''W and 373 m above sea level). According to the Köppen classification, the local climate is of 'BSWh' type, semi-arid tropical, with rainfall concentrated in three to four months of the year (SILVA et al., 2017). The monthly averages for climatic variables average, maximum, and minimum temperatures, global radiation, and precipitation, obtained at the Agrometeorological Station of the Bebedouro Experimental Field of Embrapa Semiárido, located 40 km from the experimental area, are presented in Figure 1.

'BRS Melodia' grapevines were planted with one plant per pit in trellis system, with spacing of 2.5 m between plants and 4.0 m between planting rows, and drip irrigation. The rootstock used was 'IAC 572'.

Experiment 1 was conducted during two production cycles in 2021, with treatments represented by eight gibberellic acid concentrations (GA_3) (12.5; 13; 17.5; 18; 22.5; 23; 27.5 and 28 mg.L^{-1}) and control without the application of this growth regulator, totaling 9 treatments.

Experiment 2 was also carried out during two production cycles in 2022, using three GA_3 concentrations (13, 18 and 30 mg.L^{-1}) associated or not with biostimulants and control, totaling 13 treatments.

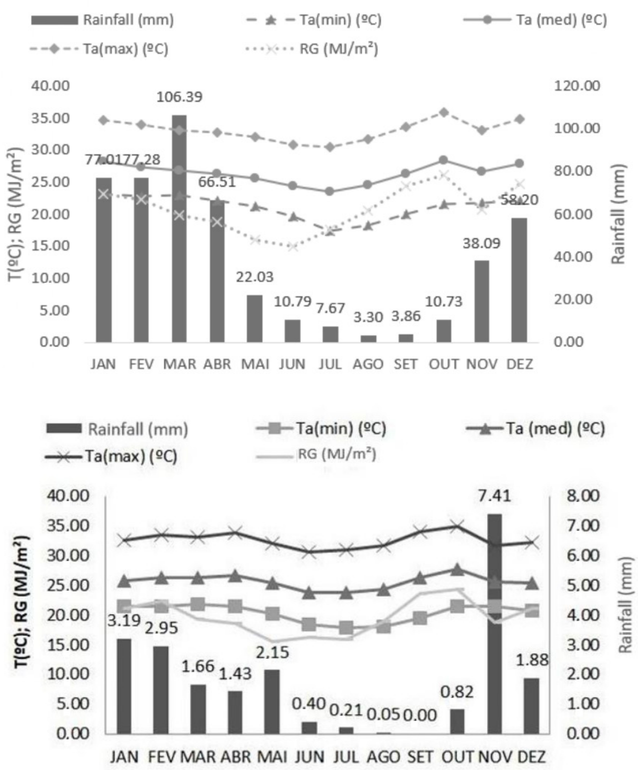

Figure 1. Monthly averages for climatic variables obtained at the Agrometeorological Station of the Bebedouro Experimental Field of Embrapa Semiárido for the years 2021 and 2022.

Commercial product ProGibb® was used as source of gibberellin and biostimulants Stimulate® (100 mL.100L^{-1}), Crop Set® (100 mL.100L^{-1}) and Maxcell® (250 mL.100L^{-1}) were used as source of cytokinin, according to the concentration indicated by the manufacturer for the grapevine crop. Stimulate® is composed of N6-furfuryladenine (kinetin) (0.009%), GA_3 (0.005%) and 4-indole-ylbutyric acid (0.005%). Crop Set®, obtained from seaweed extract, is composed of macro and micronutrients, containing: S (3.62%), Cu (1%), Mn (3%) and Fe (2.5%). Maxcell®

is composed of the active ingredient N6-benzyladenine (benzyladenine) (2%) and adjuvants (98%). All commercial products used are registered for grapevine. The treatments performed in both experiments are detailed in Tables 1 and 2.

Table 1. Gibberellin concentrations and application times in experiment 1 on 'BRS Melodia' grapevines (Petrolina, PE, 2021).

Treatments	GA3 doses (mg.L^{-1})/ Phenological phase		
	Bunches from 3 to 5 cm	Fall of calyptra	Berries from 5.0 to 6.0 mm
Control	0	0	0
T1	0.5	2.0	5.0 + 5.0
T2	0.5	2.0	5.0 + 5.0 + 5.0
T3	0.5	2.0	5.0 + 5.0 + 10
T4	0.5	2.0	5.0 + 5.0 + 5.0 + 10
T5	0. + 0.5	2.0	5.0 + 5.0
T6	0.5 + 0.5	2.0	5.0 + 5.0 + 5.0
T7	0. + 0.5	2.0	5.0 + 5.0 + 10
T8	0.5 + 0.5	2.0	5.0 + 5.0 + 5.0 + 10

Table 2. Gibberellin concentrations and application times and biostimulants in experiment 2 on 'BRS Melodia' grapevines (Petrolina, PE, 2022).

Treatments	Commercial product	GA3 doses (mg.L^{-1})/ Berry diameter (mm)		
		6.0	8.0 -10	12-14
Control	--------	0	0	0
T1 (GA3)	Progibb®	5.0	8.0	0.0
T2 (Biostimulant B)	Stimulate®	5.0	8.0	0.0
T3 (Biostimulant C)	CropSet®	5.0	8.0	0.0
T4 (Biostimulant A)	Maxcell®	5.0	8.0	0.0
T5 (GA3)	Progibb®	8.0	10.0	0.0
T6 (Biostimulant B)	Stimulate®	8.0	10.0	0.0
T7 (Biostimulant C)	CropSet®	8.0	10.0	0.0
T8 (Biostimulant A)	Maxcell®	8.0	10.0	0.0
T9 (GA3)	Progibb®	8.0	10.0	12.0
T10 (Biostimulant B)	Stimulate®	8.0	10.0	12.0
T11 (Biostimulant C)	CropSet®	8.0	10.0	12.0
T12 (Biostimulant A)	Maxcell®	8.0	10.0	12.0

The dates of production pruning and harvesting for experiment 1 were respectively 05/19/21 and 09/01/21 for the first production cycle and 10/22/21 and 02/02/22 for the second production cycle. Experiment 2, in turn, was carried out from 04/01/22 (pruning) to 07/15/22 (harvest) in the first cycle and from 09/14/22 (pruning) to 12/20/22 (harvest) in the second production cycle.

Spraying was carried out with the aid of a manual backpack sprayer, directly on bunches, at intervals of approximately four days.

The experimental design adopted was randomized blocks, with four replicates and four plants per plot, using the bunches of the two central plants (useful plants) for evaluations.

During harvest, five bunches of each treatment were collected from the central plants of the plot (second and third plants). The following variables were evaluated: production per plant, where all bunches of each treatment were weighed and the result expressed in kg; bunch mass, using five bunches per plot as a sample and the result expressed in grams; bunch length and width, determined with the aid of a graduated ruler using the same previous sample, with results expressed in centimeters; stalk mass, using the stalk mass of a sample of five bunches, expressed in grams; berry mass, determined in a sample of 50 berries, with 10 berries collected from each of the five bunches, with result expressed in grams; berry length and diameter, measured with the aid of a graduated ruler in the previous sample and expressed in millimeters; berry firmness, using a sample of 15 berries obtained from three berries of five bunches per plant with the aid of a texture meter, with results expressed in Newton (N); soluble solids content (°Brix) obtained with the aid of a temperature-compensated refractometer (AOAC, 2010); and titratable acidity (TA) obtained by titration with 0.1 M NaOH solution, expressed in g of tartaric acid 100m.L^{-1} (AOAC, 2010).

After the last application of GA_3 and biostimulants, field berry diameter readings were performed on five bunches and three berries per bunch on the useful plant and in two treatments: control and (GA_3 30 mg.L^{-1} + Biostimulants). Berries were identified, one in each portion of the bunch (apical, median and basal), and measurements were performed with the aid of a digital caliper, with an interval of seven days until the week preceding the harvest, thus obtaining the berry growth curve. Results were submitted to analysis of variance and comparison of means by the Tukey test ($p<0.05$) using the SISVAR statistical software (FERREIRA, 2011). The regression model was used to evaluate the berry mass response as a function of the increase in gibberellic acid the dose associated or not with the different biostimulants in experiment 2 (Figure 1), as well as berry length growth curves as a function of time (days after pruning) and the different treatments (Figure 2).

Results and discussion

Gibberellin application did not promote the expected effect of increasing the size of bunches and berries of ‘BRS Melodia’ grapes in two production cycles carried out in 2021. For variables such as bunch mass (BM) and bunch length (BL), no responses to gibberellin application were observed in both production cycles, with average bunch mass values of 172.1 g (1st production cycle in 2021) and 133.1 g (2nd production cycle in 2021) and bunch length values of 14.3 cm and 11.7 cm respectively in the 1st and 2nd production cycles in 2021. In turn, bunch width showed specific differences between treatments in both production cycles, but they do not follow a behavioral trend, and do not seem to be related to gibberellin application, and other factors not controlled in the experiment may be influencing the response of this variable.

Bunch size and mass values observed in the first two production cycles are below those described for the ‘BRS Melodia’ cultivar in the Submédio São Francisco Valley region according to Ritschel et al., (2021), who indicate average bunch size of 16 cm and mass of 200 g for this cultivar, thus demonstrating that other factors related to crop management, such as early date of first pruning, young plants and with few carbohydrate reserves in roots and branches can explain the results obtained.

No effect of gibberellin on stalk mass in the first production cycle was observed (Table 3), but significant differences between treatments were observed in the second cycle, when gibberellin application of 18 $mg.L^{-1}$ promoted increase in stalk mass compared to control (Table 4). However, this increase in mass did not cause damage to fruit appearance or berry ginning. Vieira et al., (2008) observed in ‘Niágara Rosada’ cultivar, a linear increase in stalk size according to the increase in GA_3 dosages, which was not observed in the present study.

Table 3. Means[1] and coefficients of variation for physical and physicochemical characteristics of ‘BRS Melodia’ grapes treated with gibberellic acid during the first production cycle of 2021, Petrolina - PE.

GA3 dose (mg.L-1)	BM (g)	BL (cm)	BW (cm)	SM (g)	BeM (g)	BeL (mm)	BD (mm)	SS (ºBrix)	TA ($g.100mL^{-1}$)	SS/TA
0	168.0^{ns}	14.0^{ns}	6.0ab	2.1^{ns}	2.4^{ns}	18.5^{ns}	14.8^{ns}	19.9^{ns}	0.48ab	41.6ab
12.5	155.5	15.0	6.8a	2.3	2.8	20.0	16.0	17.8	0.51ab	36.6ab
17.5	177.1	15.3	6.5a	2.2	3.0	20.6	16.6	17.9	0.50ab	35.8ab
22.5	172.7	15.5	6.5a	2.5	3.0	19.2	15.7	16.0	0.50ab	32.6b
27.5	190.9	13.5	6.2ab	2.0	2.6	19.3	15.5	17.8	0.54a	33.2ab
13	178.3	13.2	6.7a	1.9	2.7	19.6	14.8	18.5	0.43ab	43.1ab
18	200.1	14.6	7.0a	2.3	3.2	21.8	16.8	18.8	0.53ab	35.6ab
23	139.9	13.8	5.5ab	2.2	2.8	20.2	15.7	19.1	0.44ab	43.6ab
28	167.6	14.0	4.6b	2.0	2.7	20.1	15.4	19.7	0.40b	49.2a
Mean	172.2	14.3	6.2	2.1	2.21	19.92	15.7	18.4	0.48	39.0
C.V(%)	25.3	13.9	11.9	7.10	20.4	12.1	7.31	10.3	11.5	17.4
p:	0.987	0.993	0.032	0.201	0.919	0.118	0.149	0.186	0.018	0.028

[1] Means followed by the same letter in the column do not differ from each other by the Tukey’s test ($p < 0.05$); ns: not significant. BM: Bunch mass; BL: Bunch length; BW: Bunch width; SM: Stalk mass; BeM: Berry mass; BeL: Berry length; BD: Berry diameter; SS: Soluble solids; TA: Titratable acidity; SS/TA: Soluble solids to titratable acidity ratio.

Table 4. Means[1] and coefficients of variation for physical and physicochemical characteristics of 'BRS Melodia' grapes treated with gibberellic acid during the second production cycle of 2021, Petrolina - PE.

GA3 dose ($mg.L^{-1}$)	BM (g)	BL (cm)	BW (cm)	SM (g)	BeM (g)	BeL (mm)	BD (mm)	F (N)	SS (ºBrix)
0	118.7^{ns}	11.6^{ns}	5.9b	2.3c	2.9^{ns}	20.7^{ns}	15.8^{ns}	3.43^{ns}	17.3^{ns}
12.5	132.9	11.6	6.5ab	2.6bc	3.2	21.3	16.2	3.66	17.9
17.5	148.0	12.1	7.16a	3.6ab	3.3	20.9	16.3	3.60	18.7
22.5	113.8	11.0	6.4ab	2.9abc	3.5	21.5	16.6	3.45	17.7
27.5	127.5	11.2	7.1ab	3.3abc	3.3	21.3	16.4	3.44	17.3
13	145.6	11.8	7.0ab	2.8abc	3.3	21.3	16.5	3.85	18.2
18	151.0	12.0	6.6ab	3.8a	3.3	21.2	16.0	3.56	16.8
23	138.2	12.1	6.2ab	3.2abc	3.4	21.8	16.7	3.56	18.3
28	121.8	12.1	6.7ab	3.0abc	3.3	21.5	16.3	3.56	17.2
Mean:	133.1	11.7	6.62	3.12	3.3	21.3	16.3	3.56	17.7
C.V(%):	15.9	10.0	6.11	13.18	6.0	3.02	3.09	6.54	5.68
p:	0.354	0.987	0.025	0.008	0.16	0.988	0.991	0.90	0.419

[1]Means followed by the same letter in the column do not differ from each other by the Tukey's test ($p < 0.05$), ns: not significant. BM: Bunch mass; BL: Bunch length; BW: Bunch width; SM: Stalk mass; BeM: Berry mass; BeL: Berry length; BD: Berry diameter; F: Firmness; SS: Soluble solids; TA: Titratable acidity; SS/TA: Soluble solids to titratable acidity ratio.

The increase in the mass and size of stalks and pedicels is a common response when grapes are treated with gibberellin associated or not with other growth regulators; however, responses vary according to the grapevine cultivar (VIEIRA et al, 2008; LEÃO, 2019). The increase in the mass and diameter of stalks and pedicels may be related to greater stalk lignification, since GA_3 application after flowering increases the activity of peroxidase enzymes in the bunch pedicel, considering that this enzyme acts directly on the synthesis of lignin, causing its accumulation in stalks (PÉREZ; GOMEZ, 1998). These adverse effects may result in bunches that do not meet commercial standards and in depreciation of the final grape value.

There was no response to the use of gibberellic acid to increase berry size and mass in both production cycles carried out in 2021. The average values obtained for berry mass, length and diameter were 2.21 g, 19.92 and 15.7 mm, respectively, in the 1st production cycle and 3.31 g, 21.3 and 16.3 mm, respectively, in the 2nd production cycle. The response in berry growth as a result of the use of gibberellin varies depending on the cultivar. Santos et al., (2015) observed that three GA_3 applications of 10 $mg.L^{-1}$ were able to improve the berry mass of the 'Sweet Celebration' cultivar, which was not observed in this study. 'BRS Melodia' grapes did not respond positively to gibberellin to increase berry mass and size even at the highest concentrations (28 $mg.L^{-1}$). However, a 20% increase in berry mass was observed when using 22.5 $mg.L^{-1}$ compared to control. Despite the little responsiveness to gibberellin, all treatments performed resulted in berries within the expected range for the cultivar produced in the Submédio São Francisco Valley (RITSCHEL et al., 2021).

Berry firmness was not influenced by gibberellin application, obtaining average value of 3.56 N in the second production cycle. This attribute is directly related to post-harvest factors, where berry firmness values may vary according to cultivar and management. Firmness values tends to decrease as the fruit ripens due to changes that occur in the cell wall or even due to water loss. Some enzymes such as β-galactosidase, polygalacturonase and pectatolyase are mainly responsible for these changes in the cell wall (KELLER, 2010).

Physicochemical variables such as soluble solids content, titratable acidity and SS/TA ratio were little influenced by gibberellin. The average soluble solids content values were 18.4 and 17.7ºBrix, respectively, in the first and second production cycles. Some authors observed reduction in SS with the use of gibberellic acid in bunches of 'Brasil' (NACHTIGAL et al., 2005) and 'BRS Clara' (BASTOS et al., 2008) grape cultivars. This negative effect was not observed in the 'BRS Melodia' cultivar, where SS values, even when using maximum GA_3 concentrations, remained close to those of control.

Titratable acidity and consequently the SS/TA ratio showed significant differences between treatments in the first production cycle, but these were not observed in the second cycle, with average titratable acidity of 0.48 and SS/TA ratio of 39.0, meeting the requirements for table grape quality (LIMA, 2009), as well as those described for 'BRS Melodia' grown in the Submédio São Francisco Valley (RITSCHEL et al., 2021).

Considering the lack of response to the increase in the size of bunches and berries of the 'BRS Melodia' cultivar to treatments with GA_3, a second experiment was carried out, adding biostimulants with cytokinin action to observe the responses of the GA_3 + Cytokinin interaction, considering that both growth regulators act on cell elongation and division.

In experiment 2, significant differences in bunch mass were observed only in the production cycle of the first half of 2022, with emphasis on treatment with 13mg.L^{-1} of GA_3 (T1), obtaining bunches with average mass of 322g, which represents an increase of 49% in relation to control. However, no influence of treatments on this variable in the following cycle was observed, obtaining bunches with average mass of 251g. This result is similar to that found by Santos (2015), who observed increase of approximately 32% in the bunch mass of 'Sweet Celebration' grapes treated with GA_3. In turn, the combination of GA_3 (18 mg.L^{-1}) and Crop Set® reduced bunch mass compared to control, differing from results obtained by Leão et al., (2005), where the combination GA_3 + Crop Set® increased the bunch mass of 'Thompson Seedless' grapes. Silva et al (2019) also observed response in the bunch mass of the 'BRS Vitória' cultivar due to the use of biostimulants when working with commercial product Rutter®. The average bunch mass values in all treatments are in accordance with the pattern described for the 'BRS Melodia' cultivar in the Submédio São Francisco Valley (RITSCHEL et al., 2021).

No effects of the combination of gibberellin and cytokinin were observed on variables bunch length and width in both production cycles conducted in 2022. These results were expected because applications of gibberellin and biostimulants were carried out in the post-flowering phase, with less direct influence on bunch elongation (VITERI-DIAZ, 2020).

The average bunch length and width values were respectively 17.30 cm, 7.90 cm in the first-half year cycle and 19.03 and 8.91 cm in the following cycle. In turn, in relation to the stalk mass, there was an effect of treatments only in the second-half year cycle, where increase in mass in treatments with 18 mg.L^{-1} of GA_3 + Biostimulant A (T8), 18 mg.L^{-1} of GA_3 + Biostimulant B (T7) and 30 mg.L^{-1} of GA_3 + Biostimulant A (T12) was observed. However, changes in the size and mass of stalks and pedicels did not compromise bunch appearance.

The use of gibberellin associated or not with commercial biostimulants promoted increase in berry mass, length and diameter with variations in responses in both production cycles carried out in 2022. Treatments associated with gibberellin and biostimulants were more efficient for berry growth in the first half-year cycle than in the following cycle, demonstrating the influence of other environmental factors. In the first half-year cycle of 2022, a 34% increase in berry mass was obtained in treatment with 30 $mg.L^{-1}$ of GA_3 + Biostimulant A (T12) (Table 5), statistically differing from control. In turn, greater berry length was obtained by applying 13 $mg.L^{-1}$ (T1) and 30 $mg.L^{-1}$ of GA_3 + Biostimulant A (T12), with this treatment also promoting higher berry diameter (17.4 mm) compared to control (Table 5).

The results obtained in the second half-year cycle maintain the same trend observed in the previous cycle, with significant effects on berry mass and length, but no significant differences were observed between treatments for berry diameter. Greater berry mass was observed when 30 $mg.L^{-1}$ of GA_3 alone (T9) or associated with Biostimulants A (T12) and B (T10) were used. The values obtained are in agreement with those obtained by Botelho et al., (2003) in which 30 $mg.L^{-1}$ of GA_3 applied after flowering increased berry mass in 'Venus' grape cultivar, as well as with Ritschel et al., (2019), who recommend 30 $mg.L^{-1}$ of gibberellin for the management of 'BRS Melodia' bunches grown in the Serra Gaúcha region. Regarding berry length, the best responses were obtained in treatments 13 $mg.L^{-1}$ of GA_3 + Biostimulant B (T2), 18 $mg.L^{-1}$ of GA_3 + Biostimulant B (T6), 30 $mg.L^{-1}$ of GA_3 isolated (T9) or associated with Biostimulant A (T12). Variable berry diameter did not present significant differences between treatments, obtaining average value of 17.6 mm. However, there was a 6% increase in berry diameter in treatments with 13 $mg.L^{-1}$ of GA_3 isolated and 30 $mg.L^{-1}$ of GA_3 + Biostimulant A (Table 5).

Variable berry firmness, in turn, was not influenced by the action of growth regulators, obtaining average value of 4.83 N. No significant effect of treatments on the physicochemical variables related to grape quality was observed. Kaplan et al., (2019), when working with high gibberellic acid doses in 'Einset Seedless' grape cultivar, reported that there was no influence of GA_3 on the soluble solids content, which result is similar to that found in the present study. In the production cycle of the first half of 2022, 'BRS Melodia' grapes presented average values for soluble solids content of 18.19º Brix, titratable acidity of 0.90 $g.100mL^{-1}$ and SS/TA ratio of 19.8, observing in this cycle high acidity values in fruits, which may have been influenced by ripening in colder months (Figure 1). In the following cycle (second half of 2022), higher average values were observed for soluble solids content of 20.4º Brix, titratable acidity of 0.47 $g.100mL^{-1}$ and SS/TA ratio of 43.4 (Tabela 6). The values observed in the second half of 2022 are in agreement with those described for 'BRS Melodia' grapes grown in the Submédio São Francisco Valley, meeting the quality requirements for the marketing of table grapes (RITSCHEL et al., 2021).

Some authors observed that the use of non-purine gibberellin tends to reduce the soluble solids content, as it delays fruit ripening, reducing the accumulation of sugars (LEÃO et al., 2005; PEPPI; FIDELIBUS, 2008), which was not observed in the present study.

Based on results presented in both experiments, considering the four production cycles under study, it could be observed that there was no influence of gibberellic acid on berry growth in experiment 1. However, in experiment 2, carried out in the same experimental area, on two-year-old plants, from the 3rd pruning, gibberellic acid at doses similar to those applied in experiment 1 on young plants showed significant effects compared to control. Therefore, plant age and conditions in relation to vigor and reserve of stored carbohydrates also seem to influence the increase in berry size of plants treated with gibberellic acid.

Table 5. Means[1] and coefficients of variation for physical and physicochemical characteristics of 'BRS Melodia' grapes treated with gibberellic acid and biostimulants during the production cycle of the 1st half of 2022, Petrolina - PE.

Treatments	BM (g)	BL (cm)	BW (cm)	SM (g)	BeM (g)	BeL (mm)	BD (mm)	F (N)	SS (ºBrix)	TA ($g.100mL^{-1}$)	SS/TA
Control	216.0 b	16.7ns	8.0ns	4.0ns	3.23c	20.4c	15.8c	4.70ns	18.4ns	0.90ns	20.5ns
T1	322.0a	17.9	8.2	5.6	3.98abc	22.7ab	17.0ab	4.87	18.2	0.92	20.0
T2	292.1ab	18.2	8.4	5.8	3.98abc	22.6ab	17.1ab	4.97	18.1	0.86	21.3
T3	259.6ab	16.9	7.7	4.6	3.84abc	22.3ab	17.0ab	4.82	18.3	0.91	20.0
T4	300.1ab	18.5	7.7	5.3	4.05ab	23.3a	17.2ab	4.78	18.1	0.95	19.1
T5	235.8ab	14.7	9.1	4.3	3.77abc	22.1ab	16.3bc	4.99	18.3	1.03	17.7
T6	295.7ab	18.0	7.5	5.6	3.85abc	22.6ab	16.8abc	4.79	18.0	0.97	18.8
T7	206.4b	16.1	6.8	4.9	3.56bc	21.6bc	16.6abc	4.79	18.6	0.82	22.6
T8	291.4ab	18.1	7.4	6.0	4.3ab	22.8ab	16.9ab	4.95	18.4	0.96	19.2
T9	290.9ab	16.8	8.3	5.8	4.01abc	22.7ab	17.1ab	4.68	17.7	0.96	18.5
T10	297.3ab	17.7	7.4	4.9	3.93abc	22.5ab	17.2ab	5.02	18.1	0.95	19.6
T11	295.2ab	18.1	7.6	5.1	4.07ab	22.5ab	17.2ab	4.73	18.3	0.87	20.9
T12	291.4ab	16.7	8.2	5.1	4.35a	23.4a	17.4a	4.86	17.6	0.94	18.9
Mean	276.4	17.30	7.90	5.18	3.89	22.46	16.94	4.83	18.19	0.92	19.8
C.V(%)	15.04	9.24	17.81	18.7	8.12	2.65	2.55	5.09	3.86	10.7	12.6
p:	0.006	0.089	0.99	0.16	0.005	0.000	0.003	0.993	0.993	0.290	0.39

[1]Means followed by the same letter in the column do not differ from each other by the Tukey's test ($p < 0.05$), ns: not significant. BM: Bunch mass; BL: Bunch length; BW: Bunch width; SM: Stalk mass; BeM: Berry mass; BeL: Berry length; BD: Berry diameter; F: Firmness; SS: Soluble solids; TA: Titratable acidity; SS/TA: Soluble solids to titratable acidity ratio.

Table 6 – Means[1] and coefficients of variation for physical and physicochemical characteristics of 'BRS Melodia' grapes treated with gibberellic acid and biostimulants during the production cycle of the 2nd half of 2022, Petrolina - PE.

Treatments	BM (g)	BL (cm)	BW (cm)	SM (g)	BeM (g)	BeL (mm)	BD (mm)	SS (°Brix)	TA ($g.100mL^{-1}$)	SS/TA
Control	204.2ns	17.2ns	7.95ns	3.2b	3.73b	21.4ab	16.8ns	20.4ns	0.48ns	43.3ns
T1	270.2	19.5	9.35	4.0ab	4.21ab	22.3ab	17.9	22.5	0.45	49.6
T2	228.3	18.6	9.37	4.0ab	4.26ab	22.7a	17.7	21.4	0.48	44.4
T3	263.9	19.3	9.35	4.4ab	3.91ab	21.6ab	17.1	20.1	0.48	41.8
T4	265.5	19.0	8.87	4.3ab	4.07ab	22.5ab	17.5	19.8	0.47	41.9
T5	255.5	18.6	8.20	4.5ab	4.08ab	22.2ab	17.1	19.8	0.45	44.8
T6	254.5	19.5	9.10	4.9a	4.20ab	22.7a	17.3	20.5	0.46	44.8
T7	248.2	19.1	8.52	4.0ab	3.71b	21.1b	16.9	18.4	0.46	40.7
T8	281.7	19.5	9.57	4.5a	4.17ab	22.3ab	17.6	22.2	0.49	45.3
T9	246.6	19.1	9.20	4.2ab	4.37a	22.6a	17.7	19.4	0.48	40.4
T10	237.8	18.9	8.70	3.7ab	4.33a	22.3ab	17.8	19.3	0.46	42.0
T11	245.3	19.5	8.60	3.6ab	4.02ab	21.6ab	17.3	20.0	0.48	42.3
T12	261.8	19.0	9.04	4.7a	4.37a	22.7a	17.9	21.4	0.50	42.8
Mean:	251.0	19.03	8.91	4.17	4.11	22.2	17.6	20.4	0.47	43.4
C.V(%):	13.4	6.39	9.41	12.6	5.47	2.44	15.56	10.36	11.7	16.5
p:	0.215	0.447	0.223	0.0030	0.000	0.0006	0.3493	0.2949	0.9938	0.977

[1]Means followed by the same letter in the column do not differ from each other by the Tukey's test ($p < 0.05$), ns: not significant. BM: Bunch mass; BL: Bunch length; BW: Bunch width; SM: Stalk mass; BeM: Berry mass; BeL: Berry length; BD: Berry diameter; F: Firmness; SS: Soluble solids; TA: Titratable acidity; SS/TA: Soluble solids to titratable acidity ratio.

The berry growth curves of the 'BRS Melodia' cultivar in the second production cycle of 2021 showed similar behavior for untreated grapes (control) and those treated with the maximum gibberellic acid dose ($28mg.L^{-1}$), reaching berry diameter values around 16mm on the last date of evaluation, 98 days after pruning (Figure 2A).

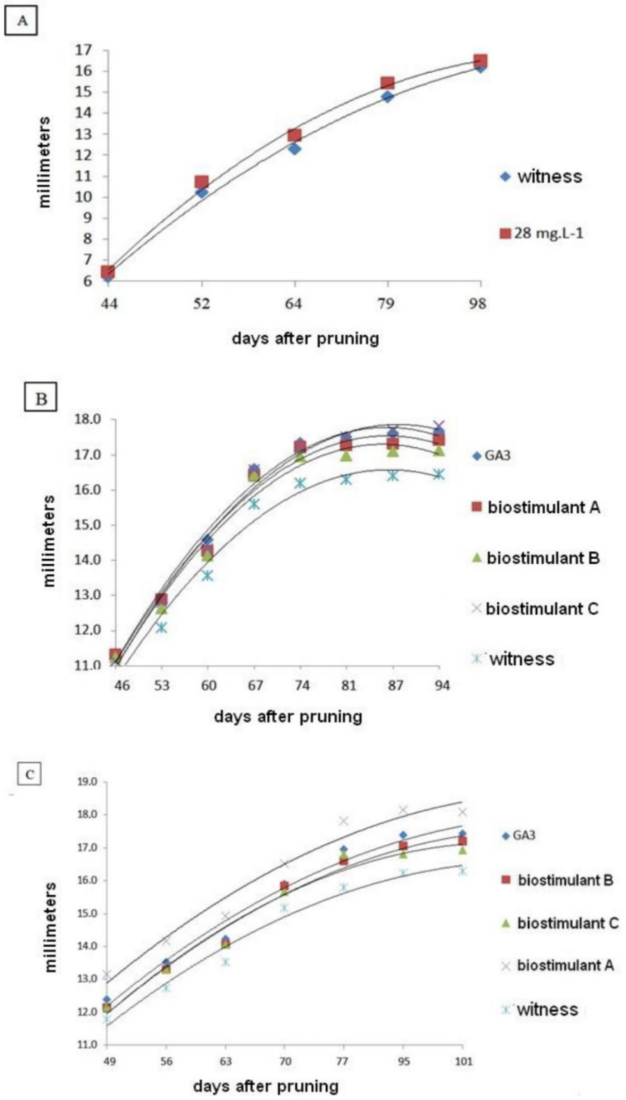

Figure 2. Berry diameter growth curve of 'BRS Melodia' cultivar treated with GA_3 and biostimulants during three production cycles. Experiment 1 (2nd production cycle of 2021): Control ($y = -0.34x^2 + 4.494x + 2.2$, $R^2 = 0.9951$); GA_3 28mg.L^{-1} ($y = -0.4364x^2 + 5.1056x + 1.88$, $R^2 = 0.9958$) (A). Experiment 2 (1st production cycle of 2022): GA_3 30 mg.L^{-1} ($y = -0.194x^2 + 2.6649x + 8.6348$, $R^2 = 0.988$); Biostimulant A ($y = -0.1855x^2 + 2.6385x + 8.4823$, $R^2 = 0.9873$); Biostimulant B ($y = -0.1867x^2 + 2.5696x + 8.7033$, $R^2 = 0.9825$); Biostimulant C ($y = -0.1905x^2 + 2.5802x + 8.5669$, $R^2 = 0.9767$); Control ($y = - 0.1707x^2 + 2.3603x + 8.4197$, $R^2 = 0.9791$). Experiment 2 (2nd production cycle of 2022): GA3 30 mg.L^{-1} ($y = -0.0957x^2 + 1.678x + 10.605$, $R^2 = 0.9765$); Biostimulant A ($y = -0.0965x^2 + 1.6897x + 11.29$, $R^2 = 0.9694$); Biostimulant B ($y = -0.1031x^2 + 1.7269x + 10.326$, $R^2 = 0.9811$); Biostimulant C ($y = -0.1168x^2 + 1.7936x + 10.272$, $R^2 = 0.9723$); Control ($y = -0.098x^2 + 1.5981x + 10.077$, $R^2 = 0.9779$).

In the first production cycle of 2022, where gibberellin and biostimulants were associated (Figure 2B), it was possible to observe that some treatments were more responsive than others. Treatment with 30mg.L^{-1} of GA_3 associated with biostimulant A showed increase in berry diameter, followed by 30mg.L^{-1} of GA_3 alone compared to control. In the second production cycle of 2022 (Figure 2C), it was observed that treatment with 30 mg.L^{-1} of GA_3 + biostimulant A again showed increase in berry diameter, reaching 18 mm at 101 days after pruning, compared to 17.4 mm for GA_3 alone, 17.2 mm for GA_3 (30 mg.L^{-1}) + Biostimulant B, and 16.9 mm for GA_3 (30 mg.L^{-1}) + Biostimulant C.

The period between 60 and 80 days after pruning is when the greatest berry growth occurs, corresponding to growth stage III, which is the phase where the embryo forms and after that, cells developed in phase I begin their elongation process, a phase that lasts on average 15 to 25 days (MÁRQUEZ et al., 2004; STAFNE et al., 2019).

Conclusion

Isolated gibberellic acid applications up to 28 mg.L^{-1} did not promote bunch elongation or increase in berry size in young 'BRS Melodia' plants in the first two production cycles;

Fractional gibberellic acid applications up to 30 mg.L^{-1} in isolation or associated with commercial biostimulants promoted increase in bunch mass, berry mass, length and berry diameter of 'BRS Melodia' grapes, whose responses were influenced by the environmental conditions of each production cycle;

Greater increase in berry mass, length and diameter was obtained by the use of gibberellic acid at dose of 30 mg.L^{-1} applied alone or associated with Biostimulant A (benzyladenine 2%);

No influence of growth regulators on the soluble solids content, titratable acidity and the SS/TA ratio of grapes was observed.

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