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Effects of Gibberellic acid (GA_3) on reduction of rot disease and physico-chemical quality of 'Pinot Noir' grape

Pricila Santos da Silva[1*], Caroline Farias Barreto[2], Marines Batalha Moreno Kirinus[2], Andressa Vighi Schiavon[2], Marcelo Barbosa Malgarim[2], Paulo Mello-Farias[2]

[1]Departament of Biotechnology, Santa Catarina State University, Brazil
[2]Departament of Crop Science, Federal University of Pelotas, Brazil

Abstract

'Pinot Noir' grape shows sensitivity to cluster rot (*Botrytis cinerea*) because bunches are small and compact, causing economic and qualitative losses in vinery and fresh grapes. The objective of this work was to evaluate the effect of different doses of gibberellic acid (GA_3) on rot incidence of 'Pinot Noir' grapevine. The experiment was carried out for two years. The treatments were GA_3 doses of 0; 2; 4; 6 and 8 mg L^{-1} applied at the developed inflorescence (DI) on 14-year-old plants. The results showed that rot percentage in the two crops decreased from 24.75% to 20.72% with application of GA_3. The clusters length was higher when GA_3 doses of 4; 6 and 8 mg L^{-1} were applied, compared to the control and 2 mg L^{-1} of GA_3. The rachis length increased after 4; 6 and 8 mg L^{-1} of GA_3 application doses, when compared to the control and 2 mg L^{-1} of GA_3. The cluster width increased after application of GA_3 doses, compared to control. Larger rachis width was observed after application of 4, 6 and 8 mg L^{-1} GA_3, compared to the control. Bunch mass was increased with the use of GA_3 at 2 and 4 mg L^{-1} doses, compared to the control and GA_3 6 and 8 mg L^{-1} doses. Regarding the soluble solids, there were higher values in the control and 2 mg L^{-1} of GA_3. Thus, in the 'Pinot Noir' grapevine, application of GA_3 decreased clusters rotting and increased clusters and rachis lenghts.

Keywords: Gibberellin; grapevine; bunch elongation.
Abbreviations: GA_3_gibberellic acid GA_3; DI_developed inflorescence.

Introduction

The 'Pinot Noir' grape cultivar shows sensitivity to the bunch rot caused by the fungus *Botrytis cinerea* (Giovannini, 2008), because the bunches are small and compact, causing economic and qualitative losses in wine and table grapes (Ky et al., 2012). Bunches compaction hinders the grapes uniform maturation by reducing the sunlight incidence in the berries, especially in the interior part of the bunch (OIV, 2007). The grape's maturation is impaired by the climatic conditions of Southern Brazil, as a consequence of the high pluviometric volumes, which cause grapes rotting before reaching the oenological potential (Giovannini, 2008).

Gibberellic acid (GA_3) promotes seed germination, early flowering, and leaves and fruits delay senescence in plants (Shi et al., 2012). In addition, it can be used to reduce grapevine bunches, as it causes elongation in bunches (Ferrara et al., 2014) and increases berry size (Botelho, 2002), resulting from division and cell expansion (Filho et al., 2009; Rodrigues et al., 2011).

GA_3 can provide an increase in the bunch and berry size as well as decrease the crop cycle and anticipating the harvest period, when applied to the grapevine from the beginning of the inflorescence until the beginning of maturation (Botelho, 2002). The use of GA_3 in flowering of Vignoles and Chardonnay grapevines cultivars produced more elongated curls and less rot (Hed et al., 2011).

However, the application of GA_3 can promote changes in grape quality. In the case of the Bordô cultivar, GA_3 provided improvement in fruit quality for wine and grape juice production (Chiarotti et al., 2011). In the cultivar 'Thompson Seedless' application of GA increased the berry mass and diameter, bunches mass and length, soluble solids concentration and reduced bunch acidity (Abu-Zahra, 2010).

In the literature, it is observed that GA_3 improves the quality of bunch and berries. However, it was also observed that there are variations in the results which depend to several other factors, such as cultivar, rootstock, GA_3 concentration, application time and edaphoclimatic conditions (Tecchio et al., 2009). However, there is still little information about the use of GA_3 in grapevine cultivation, as well as the effect of different doses of this product for the reduction of bunch rot incidence. The objective of this research was to evaluate the effect of different doses of GA_3 on rot incidence and on physico-chemical quality of the 'Pinot Noir' grapevine shoots in the Campanha region, Rio Grande do Sul, Brazil.

Results and Discussion

Effect of application of gibberellic acid on bunch rot and yield per plant

The percentage of average bunch rot was decreased from 24.75% (control) to 20.72% during 2016 and 2017 crops (with application of GA_3) in Pinot Noir grapevine (Figure 1).

However, production per plant was not influenced by GA_3 in 'Pinot Noir' grapevines, maintaining values similar to the control in the two crop years (Figure 2). However, in 'Reçel Üzümü' grapevine, the application of GA_3 (40 mg L^{-1}) showed a production increase, when the berries were 3-5 mm in diameter (Özer et al., 2012). The results of this study, corroborate with Özer et al. (2012) that confirmed the variant effect of GA_3, emphasizing the need of specific studies for each cultivar and region of cultivation.

Effect of application of gibberellic acid on bunch length, bunch width, rachis length and rachis width

The average bunch length was higher in two studied years, with GA_3 application doses of 4 mg L^{-1} (mean 125.5 mm); 6 mg L^{-1} of GA_3 (mean 126.75) and 8 mg L^{-1} of GA_3 (mean 127 mm) were applied, compared to the control (mean 108.5 mm) and 2 mg L^{-1} of GA_3 (mean 121 mm) (Figure 3A). The average length of the clusters on 'Pinot Noir' grapevines were increased significantly in the 2016 and 2017 crop years after GA_3 application doses of 4 mg L^{-1} (mean 110 mm); 6 mg L^{-1} (mean 109.5 mm) and 8 mg L^{-1} (mean, 108.5 mm), when compared to the control (mean 94 mm) and 2 mg L^{-1} (mean 105 mm) (Figure 3B). In general, it can be observed that the cluster length presented similar behavior, increasing these variables from the dose of 4 mg L^{-1} of GA_3.

Thus, it is possible to verify the direct relationship between rot reduction and grapes clusters decompression, as can be observed in Figures 3A and 3B. It also favors the uniform fungicide penetration into the cluster (Hed et al., 2011), in addition to reducing the rainwater accumulation. The cluster length was probably increased due to the cell wall expansion, promoting the hydrogen bonds rupture between the polysaccharides and increasing the cell wall elasticity, which allows water to enter and promote cell stretching (Taiz and Zeiger, 2013).

In relation to the cluster average width, this variable increased after the use of GA_3 (mean 54.56 mm) compared to control (mean 47.5 mm) in both crop years (Figure 4A). After GA_3 application doses of 4 mg L^{-1} (mean 29.67 mm); 6 mg L^{-1} (mean 29.68 mm) and 8 mg L^{-1} (mean 30.5 mm) a larger average rachis width was observed compared to the control (mean 26 mm) (Figure 4B). In this way, the gibberellins step in cellular elongation regulation by acting on the cell wall and promoting its synthesis (Rodrigues and Leite 2004). In the 'Flame Seedless' grapevine, an increase in bunch width occurs after GA_3 applications at concentrations of 5 mg L^{-1} and 10 mg L^{-1} applied 7-10 days before flowering and 20 mg L^{-1} after flowering and before the veraison phase (Dimouska et al., 2014).

Effect of gibberellic acid on cluster, rachis and berry mass

The cluster mean mass during 2016 and 2017 was increased with the use of GA_3 doses of 2 mg L^{-1} (mean 133.92 g) and 4 mg L^{-1} (mean, 135.87 g), compared to the control (mean 124.75 g), 6 mg L^{-1} (mg 129.72 g) and 8 mg L^{-1}(127.06 g) (Figure 5A). Regarding the mean mass of rachis in both crop years, an increase after GA_3 application was observed (mean 31.25 g), when compared to the control (mean 25.12 g) (Figure 5B). The higher doses of GA_3 did not reflect the increase in the cluster mass and rachis, since from GA_3 dose of 6 mg L^{-1} began to decrease the rachis mass. The increase in cluster mass may be associated with berry fixation, since GA_3 is involved in the proteolytic enzymes synthesis, which may release tryptophan, the indoleacetic acid (IAA) precursor (Vieira et al., 2008). The IAA mode of action correlates with the fruits fixation due to suppression in formation of abscission layer (Pires and Botelho 2001). According to Ferrara et al. (2014), the cluster mass was increased from 10 to 11 mm in diameter in ‘Italy’ grapevine berries after GA_3 (10 mg L^{-1}) application.

The volume of plant cells can be increased up to 100 times without compromising the integrity of the cell wall (Taiz and Zeiger 2013). This volume expansion presents a possible connection with hormones (Cato et al., 2005). The clusters of 'Sweet Celebration' grape treated with high GA_3 concentrations of 30 and 45 mg L^{-1} applied in single or fractionated doses during the berry size of 8 mm, presented an increase of fresh and dry rachis mass (Santos et al., 2015).

No significant response was observed in berry mass, fitting any regression model after GA_3 application doses at the ID stage in 'Pinot Noir' grapevines. In the literature it is reported that to increase the berry mass, higher concentrations of GA_3 are required in more advanced phenological stages. As noted by Kukali et al. (2014) the berry mass was increased in the 'Vlosh' grapevine, when GA_3 applied at doses of 75 mg L^{-1}, 100 mg L^{-1} and 125 mg L^{-1} at the beginning of flowering and in full bloom.

Effect of application of gibberellic acid on soluble solids, titratable acidity and ratio

The average values of soluble solids in both crops showed higher values at doses of 0 (mean 13.02 °Brix) and 2 mg L^{-1} of GA_3 (mean 13.15 °Brix) in Pinot Noir grapevines (Figure 6A). Thus, the average titratable acidity was increased and the ratio decreased with GA_3 application at 4, 6 and 8 mg L^{-1} doses (Figure 6B and 6C, respectively). According to Nachtigal et al. (2005), two applications of 30, 60 and 90 mg L^{-1} of GA_3 decreased soluble solids and increased titratable acidity in 'BRS Clara' grapevine. In 'Perlette' grapevines the application of 50 mg L^{-1} of GA_3, 14 days after full bloom increased the ratio (Zahedil et al., 2013).

Materials and Methods

Location of study

The study was carried out during 2016 and 2017 in the Miolo commercial vineyard, winery located in Campanha region,

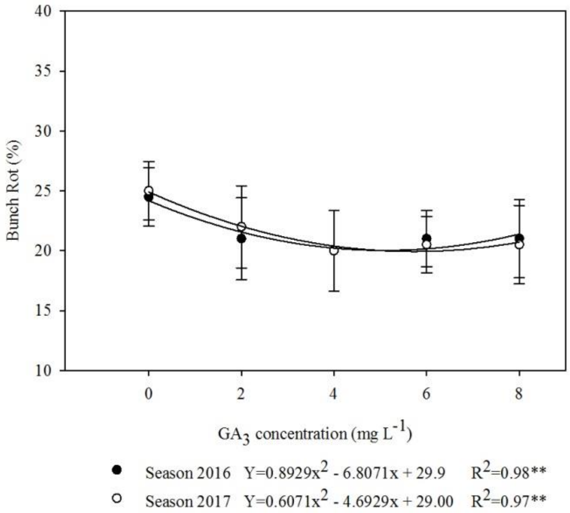

Fig 1. Effect of gibberellic acid (GA_3) on bunch rot (%) in 'Pinot Noir' grapevines. Candiota, RS, during 2016 and 2017 crops.**, significant at ($P \leq 0.01$) after analysis of variance.

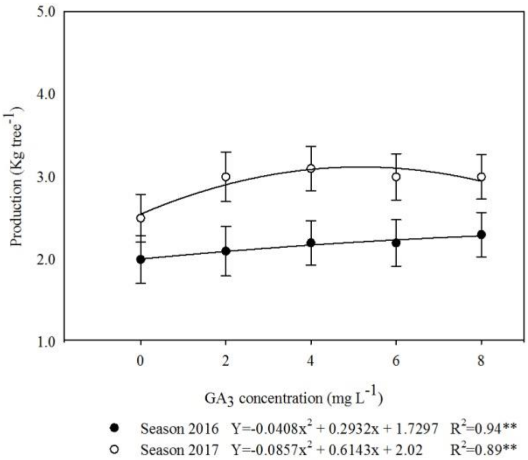

Fig 2. Effect of gibberellic acid (GA_3) application on the production per plant in 'Pinot Noir' grapevines. Candiota, RS, during 2016 and 2017 years.**, significant at ($P \leq 0.01$) after analysis of variance.

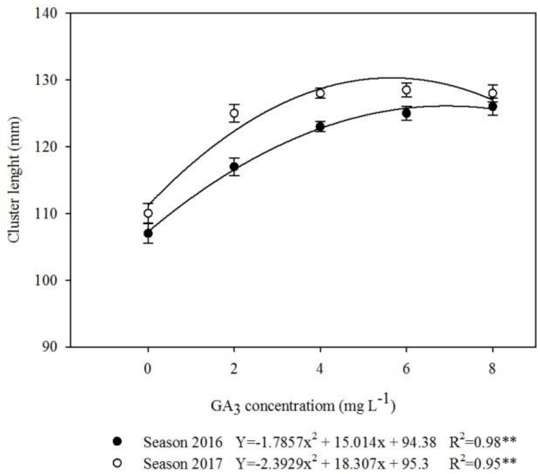

Fig 3. Effect of gibberellic acid (GA_3) application on the cluster length in 'Pinot Noir' grapevines. Candiota, RS, during 2016 and 2017 crops.**, significant at ($P \leq 0.01$), after analysis of variance.

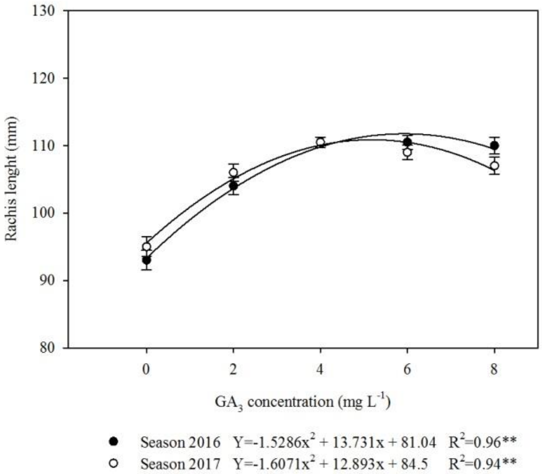

Fig 4. Effect of gibberellic acid (GA_3) application on the rachis length in 'Pinot Noir' grapevines. Candiota, RS, during 2016 and 2017 crops. **, significant at ($P \leq 0.01$), after analysis of variance.

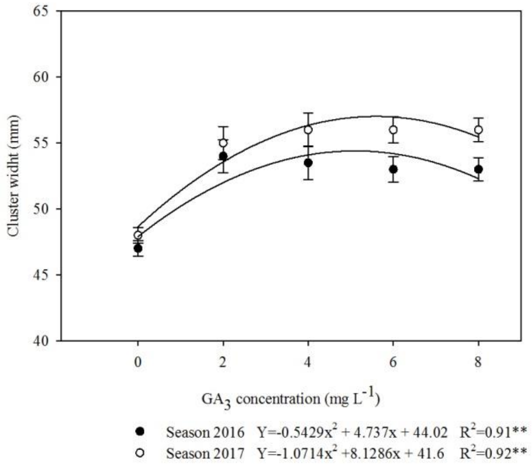

Fig 5. Effect of gibberellic acid (GA_3) application on the cluster width in 'Pinot Noir' grapevines. Candiota, RS, during 2016 and 2017 crops. **, significant at ($P = 0.01$), after analysis of variance.

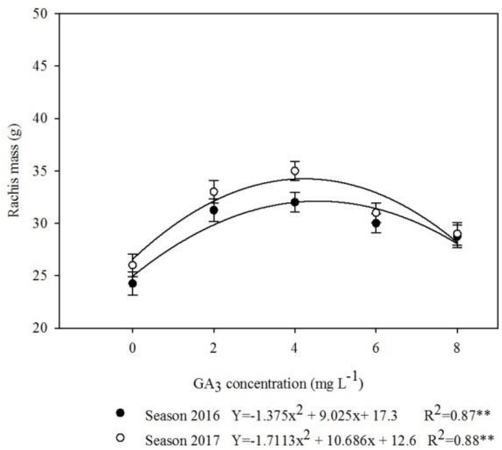

Fig 6: Effect of gibberellic acid (GA_3) application on the mass rachis in 'Pinot Noir' grapevines. Candiota, RS, during 2016 and 2017 crops. **, significant at ($P = 0.01$), after analysis of variance

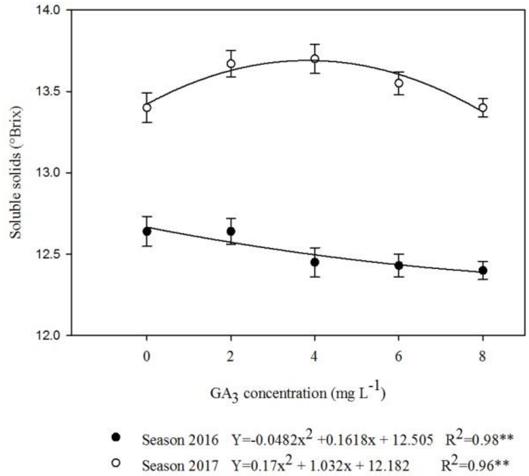

Fig 7: Effect of gibberellic acid (GA_3) application on soluble solids in 'Pinot Noir' grapevines. Candiota, RS, during 2016 and 2017 crops.**, significant at (P = 0.01), after analysis of variance.

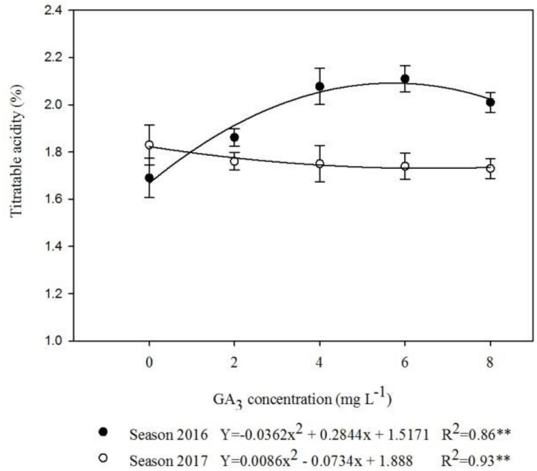

Fig 8: Effect of gibberellic acid (GA_3) application on titulable acidity in 'Pinot Noir' grapevines. Candiota, RS, during 2016 and 2017 crops. **, significant at (P = 0.01), after analysis of variance.

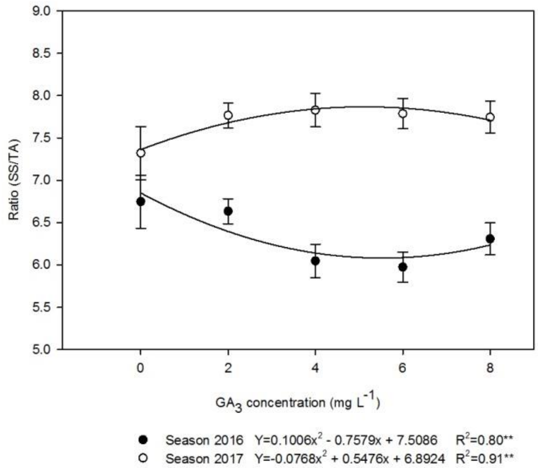

Fig 9: Effect of gibberellic acid (GA_3) application on ratio in 'Pinot Noir' grapevines. Candiota, RS, during 2016 and 2017 crops.
**, significant at (P = 0.01), after analysis of variance.

Candiota, Rio Grande do Sul (RS), Brazil (latitude 31º 33 '29 "S, longitude 53º 40' 21" W), 220 meters above the sea level. The region climate is temperate with hot and dry summer, with an average annual rainfall and temperature of 17.8°C and 1388 mm, respectively. The soil is classified as a red-yellow eutrophic (Streck et al., 2008).

Plant materials

The 'Pinot Noir' cultivar was grafted on SO4 rootstock with the clone 386. It was planted in 2001 in a sporulated cord training system (unilateral), with 1.2 in-row spacing and 3.0 m between rows. Three central plants (useful plot) were used. The central plant was evaluated and all plant bunches were sprayed with treatments. The treatments used in grapevines with gibberellic acid were 0 (control); 2; 4; 6 and 8 mg L^{-1} of GA_3 doses. The GA_3 source was the commercial product Pro-Gibb® containing 10% of active ingredient.

GA_3 applications were done using a manual sprayer in all grapevine clusters until reaching the run-off point. Solutions were suplemented with 0.025% Silwet L-77® non-ionic adhesive surfactant. Sprays were started when 50% of the bunches were at inflorescence phenological stage (ID) (Eichhorn and Lorenz, 1984). For the control treatment, water and adhesive surfactant was applied.

Grapes were harvested at maturing stage for sparkling wine production. Regarding the production per plant, the average number of bunches and the average bunches mass of the useful plot were counted. For other variables, a uniform sample including five bunches of the useful plot was collected for each treatment. After the harvest, bunches were conditioned in thermal boxes and transported to the Fruit Laboratory of the Federal University of Pelotas (UFPel), Southern of Brazil, for grape bunches quality evaluations.

Variables analyzed

Quality evaluations of grape bunches were carried out as follows: bunches rot: measured by the presence of rot in the cluster caused (%); production per plant (kg $plant^{-1}$); length and width of bunches and loops measured using a digital caliper (mm); mass of the clusters, grape rachis and mass of berries, quantified with a digital scale (g).

To define the berries soluble solids, a digital refractometer was used and the results were expressed in °Brix; titratable acidity (TA) indicated by the titration with 0.1 N NaOH solution until reaching pH equal to 8.1. The results expressed in % of tartaric acid, according to methodology described by AOAC (2005); ratio (SS/AT) determined by the relation of soluble solids and the titratable acidity.

Experimental design

The experimental design was completely randomized with four replicates containing five plants for each experimental unit. The analysis of variance was performed by the F-test ($p \leq 0.05$) and when the treatments were significant, regression analysis was performed.

Conclusion

GA_3 application in the 'Pinot Noir' grapevine is effective to reduce clusters rot and to increase the clusters and rachis length, the cluster width and the rachis mass. GA_3 doses of 4, 6; and 8 mg L^{-1} increased the rachis width and titratable acidity and reduce the ratio. The cluster mass was increased with the doses of 2, 4 and 6; mg L^{-1} of GA_3. Production per plant, soluble solids and berry mass were not influenced by GA_3.

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