Notas Científicas

Ethephon use and application timing of abscisic acid for improving color of 'Rubi' table grape

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Abstract – The objective of this work was to evaluate the effect of ethephon and of abscisic acid (ABA) application timing on the color of 'Rubi' Table grape. Eight treatments were evaluated: control, without application; ethephon 500 mg L^{-1} applied seven days after veraison (7 DAV); and two concentrations of ABA (200 and 400 mg L^{-1}) arranged with three application timings at 7 DAV, at 15 days before harvest (DBH), and at 7 DAV + 15 DBH. ABA does not modify physical-chemical characteristics of the cluster and improves the color of grapes, especially when applied twice (7 DAV + 15 DBH) at the concentration of 400 mg L^{-1}.

Index terms: *Vitis vinifera*, ABA, anthocyanins, plant growth regulator.

Uso do etefon e épocas de aplicação do ácido abscísico para melhorar a cor da uva de mesa 'Rubi'

Resumo – O objetivo deste trabalho foi avaliar o efeito do etefon e de épocas de aplicação do ácido abscísico (ABA) na cor da uva de mesa 'Rubi'. Oito tratamentos foram avaliados: controle, sem aplicação; etefon 500 mg L^{-1}, aplicado sete dias após o início da maturação (7 DAIM); e duas concentrações de ABA (200 e 400 mg L^{-1}) arranjadas em três épocas de aplicação, aos 7 DAIM, aos 15 dias antes da colheita (DAC) e aos 7 DAIM + 15 DAC. O ABA não altera as características físico-químicas dos cachos e melhora a cor das uvas, especialmente quando aplicado duas vezes (7 DAIM + 15 DAC), à concentração de 400 mg L^{-1}.

Termos para indexação: *Vitis vinifera*, ABA, antocianinas, regulador de crescimento vegetal.

The Table grape cultivar Rubi (*Vitis vinifera* L.) was originated from a natural mutation of the cultivar Italia, selected in a commercial vineyard in 1972, in Brazil. 'Rubi' differs from 'Italia' essentially by its reddish-berry color. The clusters and the berries are large, weighing around 600 and 10 g, respectively. The flesh is crunchy with muscat flavor, and the berries have good post-harvest storage characteristics. However, the reddish-berry color is commonly deficient in vigorous grapevines with excessive fruit load. The lack of sunlight on bunches also causes deficiency in berry color (Kishino & Roberto, 2007).

The commercial value of grapes is influenced by their appearance, including color. Therefore, poor coloration of red grapes, such as 'Rubi', grown in warm regions is a frequent problem that decreases production efficiency (Peppi et al., 2006). The coloration of grapes is related to anthocyanins, which are plant pigments responsible for the majority of blue, purple, and all tones of red found in flowers, fruits, some leaves, stems, and roots. On grapes, the accumulation of anthocyanins begins at veraison and seems to be regulated, at least partially, by abscisic acid (ABA) (Ban et al., 2003; Owen et al., 2009). Various studies have suggested that the exogenous application of this regulator increases the anthocyanin content of the skins of Table grape cultivars, without changing berry maturation (Cantín et al., 2007; Peppi & Fidelibus, 2008; Peppi et al., 2008). In the past, the commercial formulation of ABA was extremely expensive. However, nowadays it has a relative low-cost, making its use feasible for grape growers (Peppi et al., 2007b).

Ethephon is also usually applied to red-colored Table grapes in order to improve berry color, but its

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effect is not consistent. Moreover, ethephon application can cause berry softening, which reduces the value of exported grapes (Peppi et al., 2007a). Therefore, it is necessary to identify other cost-effective management practices capable of enhancing berry color, without causing excessive softening.

ABA has been shown to be more effective than ethephon in coloring the berries of some Table grape cultivars, such as Crimson Seedless and Flame Seedless, grown at different conditions (Peppi et al., 2006; Cantín et al., 2007).

The objective of this work was to evaluate the effect of ethephon and of abscisic acid (ABA) application timing on the color of 'Rubi' table grape.

The trial was conducted in a 12-year-old commercial vineyard located at Marialva, in the state of Paraná, Brazil (23°30'8"S, 51°44'44"W, at 592 m altitude), during two consecutive seasons, 2010 and 2011. The cultivar Rubi was grafted onto IAC 766 rootstock and trained on an overhead trellis system covered by an 18% mesh screen.

Vines were spaced 3 m apart within rows, with 8 m between rows, and cane-pruned (eight buds on canes). A total of 2.5% hydrogenated cyanamide was applied to the terminal buds to induce bud break and uniform development. The number of canes and clusters per vine was adjusted to 40 and 70, respectively.

The experiment was carried out in a randomized complete block design, with eight treatments and four replicates; each plot consisting of five vines. The treatments were: control, without application; ethephon 500 mg L^{-1} applied seven days after veraison (7 DAV); and two concentrations of ABA (200 and 400 mg L^{-1}) arranged with three application timings at 7 DAV, at 15 days before harvest (DBH), and at 7 DAV + 15 DBH.

The commercial product used for ABA (natural enantiomer) treatments contained 100 g L^{-1} of it. BreakThru (Evonik Industries AG, Essen, Germany) non-ionic wetter/spreader surfactant (0.3 mL L^{-1}) was added to the solution, in all treatments.

Clusters were sprayed using a backpack sprayer, until runoff, at constant pressure of 40 kgf cm^{-1}, with JA1 hollow cone spray nozzles, providing complete and uniform coverage. The applied solution volume was 800 L ha^{-1}, considering the number of clusters per vine.

The usual cultivation practices for the region, as to plant nutrition, weed control, and pest and disease management were used. Giberellic acid (30 mg L^{-1}) was applied to the clusters for berry sizing.

In each season, the plots were harvested when the soluble solids content of berries reached around 14°Brix. Therefore, grape physical-chemical characteristics of all treatments were assessed by determining the mass (g) and diameter (mm) of the berries, and the mass (kg) and length (cm) of the clusters (Peppi & Fidelibus, 2008). For berry analysis, three berries were collected from each selected cluster (top, middle, and bottom), totalizing 30 berries per plot.

The overall visual appearance of the grapes, regarding color coverage, was rated from 1 to 5, in which: 1, 0 to 20% coverage; 2, 21 to 40%; 3, 41 to 60%; 4, 61 to 80%; and 5, 81 to 100%. The color intensity was rated from 1 to 3, in which: 1, low; 2, medium; and 3, high. The color type of the berries was rated from 1 to 3, in which: 1, pale; 2, pink; and 3, red. The optimum berry color of 'Rubi' corresponds to 80–100% of high-intensity red coverage.

Berry color was analyzed using a CR-10 colorimeter (Konica Minolta, Tokyo, Japan), and the following variables, from two opposite equatorial portions of each berry (n=60 per plot), were obtained: L* (luminosity), C* (saturation), and h° (hue). The color index for red grapes (Cirg) was then determined using the formula: $Cirg = [(180 - h°)/(L^* + C^*)]$ (Cantín et al., 2007).

Data were subjected to analysis of variance (F test), and means were compared by the Scott-Knott test, at 5% probability, using the Sisvar software (Ufla, Lavras, MG, Brazil).

In both seasons, treatments did not significantly differ as to berry mass and diameter, or to cluster mass and length (Table 1). The means were similar to those reported by Kishino & Roberto (2007) for 'Rubi' grape main characteristics. Similar results were obtained by Peppi et al. (2007b) for 'Crimson Seedless' grapes.

The treatment with ABA 400 mg L^{-1} applied at 7 DAV + 15 DBH provided the highest berry color coverage and the highest color intensity, in both seasons (Table 2). This treatment also provided the highest berry color type during the 2010 season (3.0). During 2011, all treatments differed from the control, except ABA 200 mg L^{-1} applied 7 DAV, showing that this treatment is not enough to improve the color of 'Rubi' berries.

Regarding the berry color analyzed at harvest (Table 3), treatments with ABA and ethephon had lower means of L*, indicating that the 'Rubi' berries subjected to these treatments had a darker coloration. During the 2011 season, the lowest means of L* were observed with ABA 400 mg L^{-1} applied 7 DAV + 15 DBH, and with ethephon. Similar results were found by Peppi et al. (2007a) with 'Red Globe' grapes, and by Peppi et al. (2008) with 'Crimson Seedless'. ABA seems to have had little effect on L* when applied once – seven DAV or 15 DBH –, independently of the concentrations tested, since these treatments resulted in berries with higher lightness. Therefore, applying ABA only at these stages seems not to be enough for

Table 1. Physical characteristics of ‘Rubi’ berries and clusters subjected to ethephon and to different application timings and concentrations of abscisic acid (ABA), during two consecutive seasons[(1)].

Treatment	Berry mass (g)		Berry diameter (mm)		Cluster mass (kg)		Cluster length (cm)	
	2010	2011	2010	2011	2010	2011	2010	2011
Control	10.9a	9.2a	24.7a	22.4a	0.7a	0.5a	20.3a	18.9a
ABA 200 mg L^{-1} (7 DAV)	11.2a	9.2a	24.6a	22.6a	0.8a	0.6a	22.1a	19.3a
ABA 400 mg L^{-1} (7 DAV)	11.6a	9.9a	24.3a	22.3a	0.8a	0.6a	21.9a	18.9a
ABA 200 mg L^{-1} (15 DBH)	12.0a	9.8a	24.9a	22.5a	0.8a	0.6a	21.9a	18.3a
ABA 400 mg L^{-1} (15 DBH)	11.8a	9.2a	24.4a	22.8a	0.8a	0.5a	21.3a	17.7a
ABA 200 mg L^{-1} (7 DAV) + 200 (15 DBH)	11.9a	9.5a	24.6a	23.5a	0.7a	0.5a	21.2a	18.0a
ABA 400 mg L^{-1} (7 DAV) + 400 (15 DBH)	11.9a	9.7a	24.4a	22.8a	0.7a	0.4a	21.1a	17.1a
Ethephon 500 mg L^{-1} (7 DAV)	12.0a	9.5a	24.6a	23.0a	0.7a	0.5a	20.9a	18.5a

[(1)]Means followed by the equal letters, in the columns, do not differ by the Scott-Knott test, at 5% probability. Application timings: 7 DAV, seven days after veraison; 15 DBH, 15 days before harvest.

Table 2. Color coverage, color intensity, and color type of ‘Rubi’ berries subjected to ethephon and to different application timings and concentrations of abscisic acid (ABA), during two consecutive season[(1)].

Treatment	Color coverage[(2)]		Color intensity[(3)]		Color type[(4)]	
	2010	2011	2010	2011	2010	2011
Control	1.5d	2.0b	1.0c	1.0d	1.0b	1.0b
ABA 200 mg L^{-1} (7 DAV)	2.8c	2.0b	1.5b	1.5c	1.8b	1.3b
ABA 400 mg L^{-1} (7 DAV)	2.8c	2.3b	1.8b	1.8c	1.8b	1.5a
ABA 200 mg L^{-1} (15 DBH)	1.5d	2.3b	1.6b	2.3b	1.5b	1.6a
ABA 400 mg L^{-1} (15 DBH)	2.0d	2.3b	1.8b	2.0b	1.8b	1.5a
ABA 200 mg L^{-1} (7 DAV) + 200 (15 DBH)	2.0d	2.5b	1.8b	2.0b	1.8b	1.5a
ABA 400 mg L^{-1} (7 DAV) + 400 (15 DBH)	4.2a	3.8a	2.0a	2.8a	3.0a	1.9a
Ethephon 500 mg L^{-1} (7 DAV)	3.5b	2.5b	1.8b	1.8c	2.0b	1.5a

[(1)]Means followed by the equal letters, in the columns, do not differ by the Scott-Knott test, at 5% probability. [(2)]Color coverage classes: 1, 0 to 20%; 2, 21 to 40%; 3, 41 to 60%; 4, 61 to 80%; and 5, 81 to 100% coverage. [(3)]Color intensity classes: 1, low; 2, medium; and 3, high. [(4)]Color type classes: 1, pale; 2, pink; and 3, red. Application timings: 7 DAV, seven days after veraison; 15 DBH, 15 days before harvest.

Table 3. Luminosity, saturation, hue angle, and color index of 'Rubi' berries subjected to ethephon and to different application timings and concentrations of abscisic acid (ABA), during two consecutive seasons[(1)].

Treatment	L*		C*		h°		Cirg	
	2010	2011	2010	2011	2010	2011	2010	2011
Control	31.4a	29.3a	6.3a	8.0a	64.9a	79.4a	3.0b	2.7c
ABA 200 mg L^{-1} (7 DAV)	27.8b	26.6b	5.9a	6.3b	63.1a	62.6b	3.9a	3.5b
ABA 400 mg L^{-1} (7 DAV)	27.7b	26.3b	5.3a	6.0b	58.7a	55.8c	4.2a	3.8b
ABA 200 mg L^{-1} (15 DBH)	28.2b	25.4b	6.3a	6.6b	67.1a	44.4c	3.9a	4.2a
ABA 400 mg L^{-1} (15 DBH)	28.6b	25.4b	6.3a	5.8b	72.8a	50.4c	3.8a	4.1a
ABA 200 mg L^{-1} (7 DAV) + 200 (15 DBH)	25.9c	26.1b	5.1a	5.6b	56.9a	60.6b	4.2a	3.7b
ABA 400 mg L^{-1} (7 DAV) + 400 (15 DBH)	25.5c	24.2c	5.1a	5.4b	57.6a	48.2c	4.0a	4.4a
Ethephon 500 mg L^{-1} (7 DAV)	27.0c	24.5c	5.6a	4.7b	64.9a	45.3c	4.0a	4.6a

[(1)]Means followed by equal letters, in the columns, do not differ by the Scott-Knott test, at 5% probability. L*, lightness; C*, saturation; h°, hue. Cirg, color index of red grapes. Cirg = (180-h°)/(L*+C*) (Cantín et al., 2007). Application timings: 7 DAV, seven days after veraison; 15 DBH, 15 days before harvest.

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'Rubi' grapes. In an experiment conducted by Peppi et al. (2006) with 'Flame Seedless', ABA and ethephon applied at veraison resulted in lower means of C*.

At harvest, all treatments influenced the Cirg. This can be explained by the fact that, when 'Rubi' grape reaches full maturity, it naturally exhibits a non-uniform color distribution over the entire surface of the berries (Maia et al., 2009).

Even though the treatment with ethephon improved color characteristics of 'Rubi' berries in this trial, it is important to emphasize that this plant growth regulator can cause the clusters to soften, reducing the commercial value of the grapes; however, this effect is not always expected (Peppi et al., 2007a).

ABA does not modify physical-chemical characteristics of the cluster and can expand the cultivation of 'Rubi' table grape to warm tropical areas by improving berry color attributes, especially when applied twice (7 DAV + 15 DBH) at the concentration of 400 mg L^{-1}.

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