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SEED DEVELOPMENT AND ABSCISIC ACID RELATED TO UNEVEN RIPENING OF 'CONCORD' GRAPES

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Uneven ripening of 'Concord' is a major problem in the Southern United States; often prohibiting production. Northwest Arkansas is the southern boundary for commercial 'Concord' production and, even in this region severe problems with juice quality can develop due to uneven fruit ripening. Uneven ripening is more severe when the grapevine is stressed by environmental or cultural factors. Daytime temperatures in Arkansas can approach 40°C during July and August and leaves can attain temperatures up to 10°C higher than ambient (4), producing an effective leaf temperature well above a photosynthetic optimum of 25 to 30°C for Vitis species (4). Cultural stress induced through increasing fruit loads (5,6), withholding irrigation during dry periods (7), or otherwise not maintaining an adequate leaf to fruit ratio increase the severity of uneven ripening.

This study investigated relationships between seed development, berry development, fruit maturation and hormonal changes in ripening and non-ripening 'Concord' berries.

MATERIALS AND METHODS

Samples were collected in 1980 and 1981 from a nonirrigated, own rooted 'Concord' vineyard established in 1957 at the Main Experiment Station, Fayetteville. Vines were trained to a single wire cordon trellis and pruned to a 30 + 10 severity. At harvest in 1980 (September 2) and during veraison in 1981 (July 28), fruit samples (three replications) were collected and sorted into three maturity categories: 1) pre-veraison green, 2) post-veraison green, and 3) ripening. Pre- and post-veraison green fruit were separated on the basis of firmness. Pre-veraison fruit showed no softening, which indicates the initial stages of fruit maturation (veraison). Post-veraison green fruit had begun to soften but had no color development. The berries were deseeded, weighed and frozen in liquid nitrogen for later analysis. The seeds were counted and classified as mature or immature based on seed coat color.

To further investigate the influence of seed number and maturity on fruit maturation, three replicate fruit samples of the three maturity categories were collected during veraison (July 28) in 1981 and subdivided into five groups based upon seed content: one-seeded berries with zero and one mature seed per berry, and two-seeded berries with zero, one, or two mature seeds per berry. All berries were deseeded, weighed and frozen in liquid nitrogen for later analysis.

RESULTS AND DISCUSSION

Environmental conditions during the summer of 1980 were severe and uneven ripening in 'Concord' vineyards were prevalent. In 1980, 45 days of the growing season between June 1 and August 31 reached or exceeded daytime temperatures of 35°C while only two days exceeded 35°C in 1981. Drought conditions also occurred in 1980 with only 4.6 cm of rainfall during July and August, compared to 27.7 cm during the same period in 1981. The 20 year (1960 to 1980) average rainfall during July and August in northwest Arkansas is 18.3 cm.

At harvest (September 2) in 1980, differences in seed number and seed maturity were evident between different maturity categories (Table 1). Normally ripening fruit contained the highest number of seeds per berry with no difference between pre-veraison and post-veraison green fruit. However, all the seeds in berries which had entered veraison were mature (brown seed coat color) as compared to 26.3% immature seeds in pre-veraison green fruit. These same trends in seed number and maturity were apparent at the time of general veraison (July 28) in 1981 (Table 1) .

Fresh weight increased with berry maturity at harvest in 1980 and at veraison in 1981 (Table 1). Soluble solids increased with berry maturity and percent acidity declined with increasing fruit maturity both years.

IAA contents were similar among the three fruit maturity categories at harvest in 1980 and at veraison in 1981 (Table 1). These results, combined with the steady IAA decline after berry shatter and the relatively low IAA levels attained before veraison (data not shown), do not indicate an involvement of IAA in uneven ripening.

Nonripening fruit had low ABA content at the time of harvest in 1980 (Table 1). Once the fruit entered veraison, ABA increased, and in the ripe maturity category, ABA levels approached 100µg/100 g fresh weight. Similar trends were evident at veraison in 1981, but fruit in the coloring category had not yet attained maximum ABA content.

At veraison in 1981, fruits were sorted on the basis of seed number and seed maturity. Berries containing only one seed were in the pre-veraison stage of development if that seed was immature (Table 2). However, if the seed was mature, then fruits were distributed through the three maturity categories. Some of the fruit (17%) containing one mature seed remained in the pre-veraison green category which suggests that the seed matures prior to the onset of the berry quality changes associated with veraison.

Of the berries containing two seeds, those with both seeds immature or those containing one mature and one immature seed were in the pre-veraison green category (Table 2). All berries containing two mature seeds had entered veraison with none remaining in the pre-veraison category. The fact that 100 % of the two-seeded berries containing one mature and one immature seed were present in the pre-veraison category suggests that both seeds must mature before the onset of veraison.

Within each fruit maturity category, two-seeded berries were larger (Table 3). One-seeded berries in the pre-veraison green category were smaller if the seed was immature. Seed number had little influence on soluble solids of fruit in post-veraison green or coloring categories. In pre-veraison green fruit, a slightly higher % soluble solids had accumulated in one-seeded berries if that seed was mature. Percent acidity was not influenced by seed number but those berries containing an immature seed were slightly more acid than berries containing all mature seeds.

IAA was not influenced by seed number or seed maturity and remained relatively constant among the fruit maturity categories (Table 3). In pre-veraison green fruit, ABA was relatively low; however, one-seeded fruit containing a mature seed had begun to increase in ABA content. These data indicate that seeds mature before ABA begins to accumulate and before the berry enters veraison. Seed number had only slight influence on ABA content of post-veraison green and coloring fruit, with two-seeded berries having somewhat higher ABA levels.

In this study, fruit ripening did not commence until ABA increased in the berry tissue. Also, ABA did not start accumulating until the seeds had matured. For two-seeded berries, ABA did not increase until both seeds matured, suggesting an association of immature seeds with suppression of ABA accumulation and delayed ripening. ABA may be the immediate initiator of the grape ripening process since increases in ABA directly precede veraison, and application of ABA to berries can initiate fruit ripening (2,3).

The physiological mechanisms triggering ABA production in grapes are not known but seem to relate to seed maturation. ABA production or accumulation in grape berries does not depend upon the presence of seeds. Seedless grape cultivars as well as seeded cultivars with chemically induced parthenocarpy show typical increases in ABA (1,3). Naturally seedless berries and those with induced parthenocarpy often mature earlier (1,3), implying that the presence of seeds may delay the onset of fruit maturation.

Since IAA contents were similar in ripening and nonripening 'Concord' berries, IAA does not appear to be directly involved in uneven ripening. However, IAA cannot be discounted based on these data nor can the possible involvement of other regulatory agents be ignored. Accumulation of IAA or any other regulatory compound in the berry flesh would not necessarily be a prerequisite for establishing senescence inhibiting activity. Direct import or export of materials between seeds and the parent vine via placental tissue is possible and could influence berry physiology with no net accumulation in the berry tissue per se. However, reports indicate that the grape seed abscises from the placental tissue when it matures (8), reducing the possibility of mature seed influence and strengthening the argument for the regulatory involvement of immature seeds in grape berry maturation.

Table 1 and 2 are in reverse order.

Table 2. Influence of seed number & seed maturity on the fruit maturity distribution of 'Concord' grapes during veraison, July 28, 1981.

Seed category		Maturity distribution within each seed category (%)		
No. seeds per berry	No. mature seeds	Pre-veraison green	Post-veraison green	Coloring
1	0	100	0	0
1	1	17	54	29
2	0	100	0	0
2	1	100	0	0
2	2	0	26	74

Table 1. Characteristics of 'Concord' grapes in different maturity stages at the time of harvest, Sept. 2, 1980 and at general veraison, July 28, 1981.

Fruit Maturity	No. Seeds Per berry	% Immature seeds	Fresh wt. (g)	Soluble solids %	Acidity %	IAA µg/100gfw	ABA µg/l00gfw
				1980			
Pre-veraison green	1.94a	26.3b	1.91c	8.7c	1.16c	2.1a	16.5c
Post-veraison Green	1.96a	0.0a	2.35b	10.5b	0.96b	2.2a	31.3b
Ripe	2.25b	0.0a	3.00a	16.7a	0.65a	2.7a	96.2a
				1981			
Pre-veraison green	1.32b	66.2b	1.70c	8.1c	2.60a	3.9a	18.3c
Post-veraison green	1.24b	0.0a	2.07b	l0.0b	2.17b	3.5a	29.1b
Coloring	1.65a	0.0a	2.54a	12.0a	1.85c	3.8a	64.0a

Table 3. Influence of seed number and seed maturity on berry size, fruit quality and hormone content of 'Concord' grapes during veraison, July 28, 1981.

Fruit Maturity	Seeds per berry	No. of immature seeds	Fresh wt. (g)	Soluble solids %	Acidity %	IAA µg/100gfw	ABA µg/l00gfw
Pre-veraison	1	0	1.67c	7.8b	2.52b	4.5a	14.8b
green	1	1	1.86b	8.8a	2.32a	3.5a	18.7a
	2	0	2.29a	7.7b	2.52b	3.6a	13.8b
	2	1	2.23a	8.1b	2.39a	4.0a	14.8b
Post-veraison	1	1	2.08b	9.7a	2.14a	3.1a	24.1b
green	2	2	2.78a	9.8a	2.12a	3.3a	26.2a
Coloring	1	1	1.94b	11.9a	1.71a	3.6a	51.5b
	2	2	2.60a	12.0a	1.75a	3.5a	61.3a

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