Fruit Composition of 'Arapaho' Blackberry Following Nitrogen Fertilization

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Abstract. An investigation was conducted over 2 years to evaluate the effect of N rate and time of application on fruit composition of 'Arapaho' thornless erect blackberry (*Rubus* L., subgenus *Eubatus*). N from ammonium nitrate was applied at 56 or 112 kg·ha⁻¹ in single applications, or at 112 kg·ha⁻¹ as a split application with 0 kg·ha⁻¹ as the control. Increasing N rates increased fruit N and pH but did not affect soluble solids concentration, titratable acidity, sugar-acid ratio, and total solids. Timing of N application had no effect on the fruit characteristics measured.

Nitrogen fertilizer is an important input in thornless blackberry production. Much research has focused on its effect on growth and yield. Where yields were increased by N and K, postharvest quality response varied. In Nelson and Martin's (1986) report, levels of N and K applied were 0, 67, and 135 kg·ha⁻¹. Soluble solids concentration (SSC) was lowest and individual berry mass was highest with N at 67 kg·ha⁻¹. Fruit pH and titratable acidity (TA) were not affected by N and K rates. However, work on N partitioning in 'Chester Thornless' blackberry demonstrated that the fruit was the strongest sink for newly acquired N fertilizer in the plant (Malik et al., 1991). In general, high levels of N have had a negative effect on quality of fruits (Montgomery, 1955; Segall et al., 1977).

'Arapaho' is a thornless erect blackberry recently released by the Univ. of Arkansas fruit breeding program. Maintaining high fruit quality in the marketplace would promote production and market expansion of this early, superior cultivar (Moore and Clark, 1993; Perkins-Veazie et al., 1993). The objective of this work was to evaluate the effect of N rate and timing of application on 'Arapaho' fruit composition.

Methods and Materials

Treatments. This study was initiated in 1994 on a 2-year-old 'Arapaho' planting at the Univ. of Arkansas Fruit Substation, Clarksville. Plants in 3-m row plots had been uniformly

fertilized the two previous seasons with N at 45 kg·ha⁻¹ using ammonium nitrate. A randomized complete block design with three replications was used for four N treatments: 1) 0 N as a control; 2) 56 kg·ha⁻¹ applied as a single spring application in late March; 3) 112 kg·ha⁻¹ applied as a single spring application in late March; and 4) 112 kg·ha⁻¹ applied in a split application, with equal portions in late March and late June (postharvest). Ammonium nitrate was the N source used and was applied in a 1-m-wide band at or near the base of the canes in 1994 and 1995.

Sample analyses. Maturity was determined subjectively, based on fruit color and ease of separation from the pedicel. At each harvest, only commercially ripe, i.e., shiny black and dull black, fruit were harvested (Perkins-Veazie et al., 1996). Samples of 20 fruit from each treatment at each harvest were stored at 3 ± 1 °C and 90% ± 5% relative humidity for 8 days and examined for mold and rot. Composition analyses were carried out on separate samples of 25 fruits from each treatment at two harvest dates each in 1994 and 1995. Samples were homogenized using a Tekmar Tissueizer (Tekmar, Cincinnati, Ohio). A 25-g portion of the resultant puree was centrifuged at 5,000 g_n for 15 min in an IEC CRU-5000 centrifuge (International Equipment Co., Needham, Mass.). The supernatant was analyzed for SSC (%), pH, and TA (%). SSC was measured using a hand-held, temperature-compensated, Atago refractometer (Tokyo, Japan). A 5-mL sample of juice was diluted with 45 mL distilled water; the initial pH was measured, and the sample was titrated to an endpoint of pH 8.2 with 0.1 N NaOH. TA was expressed as percent citric acid. The percent total solids was determined by weighing 10-g samples of puree into tared weighing dishes and freeze-drying for 48 h in a Virtis Unitop 600L freeze dryer (Virtis Co., Gardiner, N.Y.). Dried samples were reweighed to calculate total solids and were used to determine fruit N content. Fruit percent N was determined by the Univ. of

Arkansas Diagnostic Services Laboratory, Fayetteville. The freeze-dried samples were ground, and subsamples of 150 mg were weighed into aluminum foil and analyzed by combustion for percent N, using a Leco FP 228 Nitrogen Determinator (Leco, St. Joseph, Mich.). The instrument was calibrated with EDTA at 9.59% N. The low range was checked against a NIST apple standard at 2.25% N (Campbell, 1992). Samples from one harvest were analyzed from each of the three replications of the four treatments in both years.

Statistical analyses. Fruit N data were analyzed as a split plot in time (Steel and Torrie, 1980) with N treatment as the main unit factor and year as the time factor. Because fruit quality data were collected from two harvests in each year, they were also analyzed as a split plot in time, except that there were two time factors: harvest and year. Means were separated by LSD at the 5% significance level.

Results and Discussion

Dry N fertilizer surface-applied at 56 kg·ha⁻¹ and 112 kg·ha⁻¹ as single and split applications in 1994 and 1995 altered the composition of 'Arapaho' fruit with respect to N and pH (Table 1). Fruit N and pH were increased by all N applications. Average fruit N percent among treatments was higher in 1995 than in 1994 although the treatment × year interaction was not significant. Among N treatments, no significant effect was detected for SSC (means ranged from 8.8% for the full application to 9.2% in the control), sugar : acid ratio (means ranged from 8.0% to 8.7%), and total solids (means ranged from 13.7% in both full applications to 15.0% in the control). However, there was a significant N rate × harvest date interaction with respect to TA, since at the first harvest, titratable acidity was lower in the control fruits, but at the second harvest there was no treatment effect (data not shown). Neither mold nor rot was observed after 8 days storage (data not shown). Analysis of the combined data detected a profound effect of year

Table 1. Effect of rate and timing of application of N fertilizer on pH and fruit N of 'Arapaho' thornless blackberry.

Variable	Fruit	
	N (% dry mass)	pH
N - application ²		
None (Control)	1.29 b ^y	3.22 b
Half/spring	1.52 a	3.29 a
Full/spring	1.64 a	3.29 a
Full/split	1.51 a	3.29 a
Year		
1994	1.28 b	3.47 a
1995	1.70 a	3.08 b
Significance ³		
Nitrogen (N)	0.041	0.026
Year (Y)	0.020	0.004
Y × N	0.547	0.821

²Half application = 56 kg·ha⁻¹, full application = 112 kg·ha⁻¹.

³Fruit N measured from one harvest date only each year.

⁴P value for the main effect.

Mean separation within columns by LSD at P ≤ 0.05.

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on all measured characteristics, suggesting that environmental variation may have a greater influence on 'Arapaho' fruit quality than N fertilizer applied under the conditions of this study. A higher relative humidity at one harvest in 1994 due to rain the night before harvest could have contributed to the significant year response. Timing of N application did not affect fruit composition. As previously reported (Clark and Watson, 1995; Naraguma et al., 1996), yield was not influenced in 1994 and 1995 by N rate or time of application in this study, although leaf N levels were increased by all N treatments in 1994 and were significantly higher than the control for the full spring and the full split applications in 1995.

'Arapaho' fruit composition was affected by N applications, but the increase in pH was not associated with a significant difference in titratable acidity or sugar : acid ratio. Thus, no adverse N effects on fruit quality were detected. Fruit N levels capable of influencing fruit quality may not have been attained in this study, although fruit N content from the treatments were significantly higher than the control. Further, 'Arapaho' is inherently a high-quality, firm cultivar and may be tolerant to high levels of N. Current guidelines for N suggest 67.2–89.6 kg·ha⁻¹ annually for mature

'Thornless Evergreen' plants (Hart et al., 1992). However, the optimal rates and times of N application for high fruit quality are unknown. Since the higher rates of N did not adversely affect fruit quality, these data suggest that higher rates of N may be used if a corresponding increase in returns is realized. Soft-fruited blackberry cultivars may respond differently to N application than a firm-fruited cultivar such as 'Arapaho'.

Literature Cited

- Campbell, C.R. 1992. Determination of total nitrogen in plant tissue by combustion, p. 21–24. In: C.O. Plank (ed.). Plant analysis reference procedures for the Southern Region of the United States. Univ. of Georgia Southern Coop. Ser. Bul. 368.
- Clark, J.R. and P.J. Watson. 1995. Response of 'Arapaho' thornless blackberry to nitrogen fertilization, p. 41–43. In: W.E. Sabbe (ed.). Arkansas soil fertility studies 1994. Ark. Agri. Expt. Sta. Res. Ser. 443.
- Hart, J., B. Strik, and A. Sheets. 1992. Caneberries. Oregon State Univ. Ext. Ser. Fertilizer Guide 51. Ore. State Univ. Corvallis.
- Malik, H., D.D. Archbold, and C.T. Mackown. 1991. Nitrogen partitioning by 'Chester Thornless' blackberry in pot culture. HortScience 26:1492–1494.
- Montgomery, H.B.S. 1955. The effect of orchard factors on storage life of fruit. Annu. Rept. East Malling for 1954. p. 45–46.
- Moore, J.N. and J.R. Clark. 1993. 'Arapaho' erect, thornless blackberry. HortScience 28:861–862.
- Naraguma, J., J.R. Clark, and P. Watson. 1996. Response of 'Arapaho' thornless blackberry to nitrogen fertilization: Second year results. p. 34–36. In: W.E. Sabbe (ed.). Arkansas soil fertility studies 1995. Ark. Agri. Expt. Sta. Res. Ser. 450.
- Nelson, E. and L.W. Martin. 1986. The relationship of soil-applied N and K to yield and quality of 'Thornless evergreen' blackberry. HortScience 21:1153–1154.
- Perkins-Veazie, P., J.K. Collins, and J.R. Clark. 1996. Cultivar and maturity affect postharvest quality of fruit from erect blackberries. HortScience 31:258–261.
- Perkins-Veazie, P., J.R. Clark, and J.K. Collins. 1993. Changes in erect blackberry fruit after storage at different temperatures. Proc. Ark. State Hort. Soc. p. 75–77.
- Segall, R.H., A.T. Dow, and C.M. Geraldson. 1977. The effects of fertilizer components on yield, ripening and susceptibility of tomato fruit to postharvest soft rot. Proc. Fla. State Hort. Soc. 90:393–394.
- Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill, New York.