2023 SRSFC Research Report
Title: Multistate Evaluation of Nitrogen Fertilizer Rate Impacts on Blackberry and Survey of Blackberry Crop Nutrient Status in the Southeast

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Public Abstract:
Regionwide leaf tissue sampling of blackberry floricane and primocane leaves at major phenological stages was conducted across the Southeast in 2022 and 2023. Results will be utilized to verify current leaf tissue recommendations. In addition nitrogen fertilization rate trials in Arkansas are underway to verify nitrogen rate recommendations. Final results are expected in 2024.

Introduction:
Blackberry fertility management recommendations in the Southeast have primarily been based on data developed for Western type blackberries (Strik, 2017), from tissue sampling of productive blackberry plantings to determine baseline nutrient status (Cleveland, 2009) or from data on cultivars that are less widely grown (Naraguma, 1994). Updated fertility recommendations are needed as blackberry acreage has doubled across the Southeast in the last 15 years (Fernandez, 2021). Current recommendations for blackberry growers are to apply 60-80 lbs. of Nitrogen $acre^{-1}$ each year. Nitrogen rate trials to determine how different levels of fertility actually impact yield, fruit quality, and plant growth have not been conducted in recent memory in the Southeast. This is a concern as recent research has demonstrated that high nitrogen rates during harvest can negatively impact blackberry fruit quality and result in increases in the occurrence of red cell regression (Edgley, Close and Measham, 2018). Further excessive nitrogen applications can result in increased internode lengths associated with reduced yield (Strik, 2017). How nitrogen rates impact blackberry yield, fruit quality, leaf tissue N content, cane characteristics and pruning labor in the southeastern environment are key questions that need answers to continue the advancement of the industry. Regionwide differences in cultural practices (weed control, fertility application method) and soil types should be taken into consideration for their impacts on nutrient management and necessitate a region wide approach.

Currently growers are able to monitor plant tissue nutrient status in the late season with plant tissue nutrient sampling of the primocanes after harvest. This sampling time was chosen due to nutrient stability in the plant during that time period and sufficiency ranges are based off of samples pulled from ‘productive’ plantings and previously not been correlated to fertility rate response trials. Further, the timing of this testing limits growers to making fertility changes late in the season with the goal of impacting yield the following year. Growers want to be able to more quickly respond to nutrient deficiencies in real-time, similar to the petiole testing program available in many states for strawberries in the spring. Leaf sampling recommendations must be coordinated with trials evaluating fertility rates in order to optimize fertility management. Thus, we propose a multi-state approach to addressing two key issues for fertility management of blackberries in the southeast: updating recommended nitrogen fertility rates and updating leaf tissue nutrient sampling sufficiency ranges.

Materials and Methods:

Nitrogen Fertility Rate Trial in Arkansas (Objective 1)

A planting of standard T-trellised floricane-bearing variety 'Ouachita' was planted in June 2021 by Dr. Amanda McWhirt for this trial at the University of Arkansas Fruit Research Station (UA FRS). The trial is laid out as a completely randomized design (CRD) of three rows of plants with rows spaced 12' apart on center and plants spaced 2.5' apart in the row. The trial is planted into landscape fabric with drip irrigation on top of the fabric. Soil samples were collected prior to planting and soils were amended according to standard recommendations. Treatments will include nitrogen rates of (0, 30, 60, 90, 120, and 150 lb N/acre) applied using ammonium-nitrate in 2022 (year 2) and 2023 (year 3), with 4 replications. Each plot was 3' x 15' ft. (5 plants), with approximately a width of 3 ft. covered by landscape fabric under each row and fescue ground cover maintained in the area between rows. Treatments were drip applied weekly from April to August.

In the spring of 2022 and 2023 bi-weekly plant tissue nutrient sampling of primocane and floricane leaves from April through late August by pulling most recently mature leaves (5^{th} leaf from the growing tip). Air dried tissue samples will be sent to UA Soil Testing Laboratory for total nutrient analysis (Hardy et al., 2014).

Fruit was harvested twice per week at the shiny-black stage of ripeness. Fruit was sorted and weighed for cull and marketable fruit weights into 240g clamshells. Average berry weight was calculated. Cull fruit was assessed for % incidence of white drupe.

Data analysis

Data were analyzed in SAS (SAS Institute Inc, Cary, NC) using Proc Glimmix and response variables means separation was performed using Tukey's HSD for post-hoc analysis. Treatment effects, sampling date, and their interaction were assessed for 10 sampling dates for the petiole NO3-N data. At the time of writing this report only two sampling dates for leaf total N concentration had been received and as such no sampling date effect was analyzed. The figure presented was created via JMP Pro 16 (SAS Institute Inc, Cary, NC).

Southeastern Blackberry Nutrient Status Survey (Arkansas, Alabama, Georgia, Mississippi, North Carolina, Tennessee, and Virginia) (Objective 2)

Experimental plots were established in research stations and/or blackberry farms in Alabama, Georgia, Mississippi, Tennessee and Virginia as part of a replicated study to examine the leaf tissue nutrient content of primocanes and floricanes of major cultivars across the region.

During the experiment establishment stage, soil samples was collected at each location to estimate soil pH, Ca, Mg. The soil samples was collected 8 inches deep. To determine the nutrient movement, soil samples was split for analysis in two categories: collected from 0-4 inches depth and from 4-8 inches depth. Fertilizer was applied according to the

current recommendations for commercial blackberry production at total 60 to 80 lb. nitrogen/acre, split after harvest and also again in springtime (March to May) and then again in July-August at locations under the PIs control. At on-farm locations fertility applications was recorded. Both floricane and primocane tissue was sampled at five phenological stages (bloom, primocane emergence (6'' of growth), green fruit, peak harvest, post-harvest) from most recently mature leaves (MRML), usually 4-6 leaves back from the growing tip. From each cultivar at each sampling period 50 full leave (5 leaflets) were collected and the petiole was removed and discarded. Samples were sent for analysis to the UA tissue sampling lab.

Data analysis
Average primocane and floricane leaf tissue nutrient concentration at five phenological stages for blackberry was calculated and compared to established macro- and micronutrient foliar tissue nutrient ranges established for primocane leaves samples at post-harvest. After two years of sampling recommended ranges for sampling blackberry leaf tissue nutrient concentrations at other phenological stages may be developed.

Outreach (Objective 3)
Disseminate results to growers and develop updated blackberry leaf tissue nutrient recommendations.

Results and Discussion:

Objective 1
Nitrogen fertilization rate did not impact ($p > 0.05$) marketable yield, percent cull, total yield, average berry weight, or white drupe occurrence for one-year old 'Ouachita' blackberry during our trial in 2022 (Table 1). Very similar results were observed in 2023, but final analysis is still ongoing. A lack of a response of in-season N application on floricane yield and fruit quality has been noted (Strik, 2017b), because floricane fruiting laterals and cane growth are determined in the previous season during primocane growth. In our trial in 2021 a uniform N rate was applied to all primocanes which likely resulted in uniform floricane yields during the 2022 harvest season. At the time of writing this report only two sampling dates for leaf total N concentration had been received and as such this data is withheld.

Objective 2
A total of 314 samples were collected during the 2022 season and similar sample numbers were collected in 2023 (Table 2). Additional samples were collected in TN and are still being processed by the analysis lab. Results was updated once they are received.

Floricane and primocane leaf tissue nutrient concentration averaged across all locations and samples are reported in Table 3. General trends and cultivar differences are still being investigated, however noticeable declines in leaf tissue nitrogen and potassium were observed from bloom (spring) to post-harvest (late summer) for both floricanes and primocanes. At all dates leaf tissue N, P and K concentration (%) where numerically higher in primocanes than in floricanes, whereas leaf tissue Ca (%) and B (mg/kg)

generally tended to be higher in floricanes than primocanes. Most locations experienced bloom prior to primocane emergence, so only 4 sampling dates on primocanes were feasible.

At the current recommended leaf tissue sampling period is to sample primocane leaves at post-harvest. At this sampling period for primocane leaves, on average most of our samples fell within the established standard ranges. However, leaf tissue nutrient concentration averages for P, K and Fe were lower than recommended ranges, and Mn were above the established recommended ranges.

The findings from the tissue analysis will be used to adjust blackberry nutrient demand during plant growth and development stages and the outcome of these adjustments will be compared to results from NC and AR where rate trials are conducted.
Results from both trials will combined to update recommendations to southeastern blackberry growers regarding nitrogen fertility management and to update plant tissue nutrient recommendations for new cultivars. Effort to develop in season sampling recommendations will be made if results indicate a potential for its use.

Objective 3
Findings from this study will be presented at the Southeast Regional Fruit and Vegetable Conference in Jan, at the Arkansas Blackberry Growers Association conference, the Southern Region American Society of Horticulture Science Conference and at the North American Raspberry and Blackberry Association Annual Conference in Feb 2023.

References:

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Table 1. Effect of nitrogen (N) fertilization rate (lb N/acre) on marketable cull and total yield, berry weight, and white drupe occurrence on 'Ouachita' blackberry in Clarksville, Arkansas during 2022

N Rate	Marketable Yield†	Cull	Total Yield	Average Berry Weight	White Drupe
(lb N/acre)	**kg per plot**	**%**	**kg per plot**	**g**	**%**
0	33.31	31.69	44.78	5.94	12.5
30	36.02	31.62	49.54	6.21	15.3
60	32.76	33.08	46.21	6.18	16.0
90	34.44	34.11	48.50	6.29	15.7
120	32.89	33.71	45.53	6.21	13.5
150	36.35	28.66	48.22	6.25	15.7
p-value	*0.5157*	*0.0806*	*0.3709*	*0.5846*	*0.8139*

† Means followed by the same letter within the same column are not significantly different at p = 0.05, as determined by Tukey HSD post-hoc analysis.

Table 2. Overview of site locations and blackberry plants sampled for regional floricane and primocane leaf tissue nutrient concentration survey in 2022.

State	Cultivar	Replicate samples	Age (years)	Cultural Practices
Arkansas	Ouachita	4	2	landscape fabric
	PA Traveler	3	2	landscape fabric
Alabama	Natchez	2	8	bare ground
	Osage	2	7	bare ground
	Ouachita	2	8	bare ground
	Prime Ark-45	2	7	bare ground
	Prime Ark-Freedom	2	7	bare ground
Georgia	Osage	1	4	white plastic
	Ouachita	2	8	white plastic
	Ouachita	2	8	white plastic
Mississippi	Chickasaw	5	8	pine bark mulch
	Kiowa	5	8	pine bark mulch
	Sweetie Pie	5	8	pine bark mulch
North Carolina	Ouachita	1	7	bare ground
Virginia	Chester	1	.	
	Natchez	1	5	
	Ouachita	1	8	white plastic fabric
	Ponca	1	2	
	Prime Ark Freedom	1	8	white plastic fabric
	Prime Ark Traveler	1	8	white plastic fabric
	Von	1	5	

Table 3. Southeastern blackberry primocane and floricane leaf tissue nutrient concentration at five phenological stages in 2022.

	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B
	----------%----------						----------mg/kg----------				
	Floricane										
Bloom†	3.23	0.33	1.27	0.64	0.35	0.21	67.4	643.8	46.0	38.3	32.4
Primocanes six inches	2.96	0.24	1.27	0.68	0.33	0.17	56.0	604.6	37.2	9.7	36.0
Small Green Fruit	2.92	0.21	1.28	0.76	0.34	0.16	54.8	541.3	34.1	12.5	38.9
Harvest	2.03	0.17	1.17	0.98	0.34	0.14	62.8	484.1	27.3	7.8	46.4
Post-harvest	1.68	0.16	1.08	1.14	0.35	0.13	65.8	596.1	27.0	7.5	53.8
	Primocane										
Bloom	.	.	.	.	.	.	.	.	.	.	.
Primocanes six' inches	3.41	0.33	1.41	0.45	0.36	0.20	51.3	268.2	39.7	9.8	21.1
Small Green Fruit	3.26	0.29	1.35	0.45	0.38	0.18	49.3	243.5	38.1	9.6	22.3
Harvest	2.33	0.22	1.37	0.55	0.38	0.16	44.9	243.7	32.1	8.4	28.3
Post-harvest	**2.01**‡	**0.20**	**1.27**	**0.65**	**0.43**	**0.16**	**44.1**	**304.2**	**32.6**	**9.2**	**34.0**

† Samples collected from most recently mature leaves on both floricane and primocane leaves at each physiological stage. Samples collected in Arkansas, Alabama, Georgia, Mississippi, North Carolina, and Virginia. Samples from Tennessee were still being processed at the time of this report. Most locations experienced bloom prior to primocane emergence, so only 4 sampling dates on primocanes were feasible.

‡ Established macro- and micronutrient foliar tissue nutrient ranges have been established (Southeast Caneberry Production Guide, 2016) for primocane leaves samples at post-harvest. The averages reported here fall within (black), below (red), or above (blue) these recommended ranges