Title of Project: Determining optimum date for foliar sampling of primocane fruiting blackberry in the Mid-South

Final Report

Grant Code SRSFC Project # 2012-08

Research Proposal

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Objective:
The objective of this project is to begin progress toward the development of fertilizer recommendations for primocane-fruiting blackberry. To this end we propose to:

- Determine the sampling date with the least variation of elemental concentrations in the leaves of primocane-fruiting blackberries in North Carolina and Arkansas.

Justification:
The Northern hemisphere is the most important part of the world where blackberries are grown, and the amount and types of cultivars are diverse. Various kinds of blackberries with special characteristics have been developed by researchers and special programs in the U.S. During the last decade, the University of Arkansas has developed a new type of blackberry genotype: the primocane fruiting (PF) blackberry. This genotype has the potential to extend the fresh market season annually, which makes PF blackberries an attractive crop. However, there are some important plant nutritional parameters that need to be researched in order to optimize yield and financial returns. There is information on the optimum rate and time of application of nitrogen (N) fertilization for floricane-fruiting blackberries and raspberries, but nothing specific for PF blackberries. It is important to know the optimum stage of development for collecting foliar sample of

blackberry leaves in order to make the necessary recommendations to improve the yield and fruit quality.

Methodology:
Foliar samples were collected from several locations in Arkansas and North Carolina (Table 1). The foliar sampling protocol was similar to that used for FF blackberry in Clark et al. (1988). Leaves were collected from the fifth node from the apical bud. Ouachita, a floricane-fruiting cultivar for added for comparison.
In year 1, leaves were sampled on five dates throughout the season in each location for each genotype, in April, May, June, July, and August. For Year 2 in Fayetteville, only three foliar collections were made due to excessive heat in July that severely damaged the primocanes.

In Arkansas, plants were managed according to several cultural practices. In Fayetteville, Arkansas, three plantings of Prime-Ark 45 were sampled. One planting was located under a high tunnel where the canes are mown to ground level in May. The second planning is also under high tunnel conditions, but the canes are not mown. The third planning was mown and tipped. Mowing in combination with high tunnels is recommended in Arkansas to delay harvest until optimum fall temperatures for fruit development (four replications). In Clarksville, Arkansas, samples were collected from Prime-Ark® 45 and Ouachita (for the comparing between cultivars and between FF and PF types) (three replications). All three genotypes were in field conditions (not under any covering) and were not mown in the spring. In North Carolina, Prime-Ark® 45 samples were collected from three locations, Owl's Den Farm and Toluca Blackberry Farm, and Faith Farms (four replications) (Table 1). All samples were sent to the soil testing research laboratory of the University of Arkansas for nutrient analysis (N, P, K, Ca, Mg, S, Na, Fe, Mn, Zn, Cu and B).

State	Location	Treatment and cultivar
Arkansas	Fayetteville	Prime-Ark® 45, high tunnel, mown in May
		Prime-Ark® 45, high tunnel, not mown
		Prime-Ark® 45, high tunnel, mown, tipped
	Clarksville	Prime-Ark® 45, field, not mown
		Prime-Jan®, field, not mown
		Ouachita, field, not mown
North Carolina	Owl's Den Farm	Prime-Ark® 45
	Toluca Blackberry Farm	Prime-Ark® 45
	Location 3	Prime-Ark® 45

Results:
Results from 2011 season indicate all elements were within the sufficiency ranges indicated for floricane fruiting blackberries. In 2012, N and P were below sufficiency rages for Fayetteville, but all elements were within sufficiency ranges for Clarksville and North Carolina.

Fayetteville 2011

Sampling date affected N, P, K, Ca, Mg, S, Na, Fe, and B foliar concentrations of 'Prime-Ark® 45' blackberries, showing significantly different concentrations for the sampling period (Table 2).

Table 2. Mean nutrient concentrations of macro and micronutrients in one-year-old 'Prime-Ark® 45' blackberry leaves collected in Fayetteville, Ark. under high tunnel conditions, and sampled from June to August 2011.

	Sampling Date					
Element	14-Jun	29-Jun	11-Jul	25-Jul	4 Aug.	26 Aug.
			%			
N	2.88c[z]	2.88 c	2.67 b	2.66 b	2.43 a	2.31 a
P	0.22 b	0.24 c	0.19 a	0.21 b	0.19 a	0.19 a
K	1.99 c	1.91 c	1.78 b	1.73 b	1.55 a	1.57 a
Ca	0.47 b	0.44 b	0.47bc	0.52 dc	0.21 a	0.56 d
Mg	0.29 b	0.32 d	0.30bc	0.30bc	0.27 a	0.36 e
S	0.20 d	0.22 e	0.18 b	0.20 d	0.17 ab	0.18 b
			$mg.kg^{-1}$			
Na	14.88 b	9.95 ab	9.12 ab	14.78 ab	87.19 c	2.73 a
Fe	55.39 a	89.29 b	51.44 a	66.13 a	55.88 a	72.54 ab
B	28.14 a	30.53 b	31.82 b	34.07 c	39.09 d	38.56 d

[z]Means separated by LSD, *P*= 0.05. Each value is a mean of 16 sample concentrations.
Means within elements with the same letter are statistically similar.

In 2012, there was no significant treatment (pruning) effect. For N, Ca, S, B, Cu, and Fe (Table 3). There were significantly due to sampling date. There were significant interactions between pruning treatment and collection date for P, K, and Mg. These results from Fayetteville may not be very reliable and may indicate an effect of the high temperatures the plants were experiencing.

Table 3. Mean nutrient concentrations of macro and micronutrients in two-year-old 'Prime-Ark® 45' blackberry leaves collected in Fayetteville, Ark. under high tunnel conditions, and sampled from June to July 2012.

	Sampling Date		
Element	6-June	12-Jul	26-Jul
	%		
N	2.22a	1.96b	1.86b
Ca	0.89b	0.90b	1.34a
S	0.15a	0.13b	0.12b
	$mg.kg^{-1}$		
B	40.43b	39.46c	54.11a
Cu	6.62a	6.31c	6.45b

Fe	48.16b	37.43c	54.61a
Mn	287.1b	277.0c	443.4a
Zn	21.86c	23.22b	28.45a

[z]Means separated by LSD, *P*= 0.05. Each value is a mean of 16 sample concentrations.
Means within elements with the same letter are statistically similar.

Clarksville:
In 2011, sampling date had a significant effect on Mg, Fe, Mn, Zn, and B (Table 4). There were significant interactions for the other elements (N, P, K, Ca, S, and Cu), between cultivar and sampling date.

Table 4. Nutrient concentrations of macro and micronutrients in leaves cultivars collected in Clarksville, Ark., sampled from May to July 2011.

Element	Sampling Date					
	19-May	3-Jun	20-Jun	30-Jun	12-Jul	28-Jul
			%			
Mg	0.23a[z]	0.30 b	0.31 b	0.32 b	0.29 b	0.32 b
			$mg{\cdot}kg^{-1}$			
Fe	31.44[NS]	51.14[NS]	66.62[NS]	55.56[NS]	69.14[NS]	73.07[NS]
Mn	132.98 a	118.46 a	122.87 a	148.86 ab	188.04 b	250.28 c
Zn	30.68 c	29.51c	32.52 d	29.45bc	26.61 b	22.24 a
B	17.00 a	17.19 a	15.36 a	18.15 ab	19.62 b	26.12 c

[z]Means separated by LSD, *P*= 0.05. Each value is a mean of 16 sample concentrations.
Means within elements with the same letter are statistically similar.

In 2012, sampling date had a significant effect on P, S, B, Fe, Mn, and Zn (Table 5). There were significant interactions between cultivar and sampling date for (N, K, Mg, Ca, and Cu).

Table 5. Nutrient concentrations of macro and micronutrients in leaves of two blackberry cultivars collected in Clarksville, Ark., sampled from May to July 2012.

	Sampling Date					
Element	5-May	17-May	14-June	25-June	7-July	26-July
	%					
P	0.21a	0.18b	0.21a	0.16b	0.14bc	0.12d
S	0.21a	0.19b	0.18b	0.15c	0.14c	0.14c
	$mg.kg^{-1}$					
B	17.1c	14.0d	15.5c	13.6d	22.6b	24.6a
Fe	48.33b	46.83c	48.17b	41.33d	56.47a	49.62b
Mn	210c	170.33d	139.67e	166.83d	387.83a	284.5b
Zn	31.73b	28.43bc	33.28a	28.80bc	30.80b	33.88a

[z]Means separated by LSD, *P*= 0.05. Each value is a mean of 16 sample concentrations.
Means within elements with the same letter are statistically similar.

North Carolina

In 2011, there were significant differences for P, K, Ca, Mg, Na, Fe, and B foliar concentrations of 'Prime-Ark® 45' across the six sampling dates. However, there were no significant differences in sampling dates for N, S, Mn, Zn, and Cu foliar concentrations (Table 6).

Table 6. Mean nutrient concentrations of macro and micro nutrients in 'Prime-Ark 45®' blackberry leaves collected in North Carolina from May to August 2011.

Element	Sampling Date						
	20-May	4-Jun	22-Jun	5-Jul	22-Jul	4 Aug.	22 Aug.
				%			
N	3.26[NS]	2.91[NS]	2.63[NS]	2.51[NS]	2.36[NS]	2.50[NS]	2.48[NS]
P	0.29 b	0.28 b	0.23ba	0.19 a	0.18 a	0.18 a	0.17 a
K	1.91 c	1.97 c	1.59 b	1.65 b	1.40ba	1.37a	1.22 a
Ca	0.44 a	0.38 a	0.48 ab	0.62bc	0.75 c	0.67 c	0.66 c
Mg	0.31 a	0.34 ab	0.37 b	0.40 c	0.41 c	0.44 d	0.41 c
S	0.22[NS]	0.22[NS]	0.19[NS]	0.17[NS]	0.15[NS]	0.17[NS]	0.16[NS]
Na	16.82a	12.50 a	6.05 a	17.51 a	25.37 a	114.42 b	119.92 b
			$mg \cdot kg^{-1}$				
Fe	37.71 a	63.08 b	62.79 b	55.08 b	63.81 b	68.58 b	63.92 b
Mn	221.04 [NS]	169.81 [NS]	190.28 [NS]	239.79 [NS]	339.20 [NS]	355.67 [NS]	392.92 [NS]
Zn	35.30 [NS]	37.67 [NS]	31.82 [NS]	29.39 [NS]	29.87 [NS]	28.54 [NS]	28.58
Cu	9.38 [NS]	11.45 [NS]	9.73 [NS]	9.35 [NS]	9.20 [NS]	8.83 [NS]	8.02 [NS]
B	33.14 a	39.58 ab	36.38 ab	41.61bc	47.90 c	60.08 d	58.80 d

[z] means separated by LSD, $P<0.05$. Each value is a mean of 12 sample concentrations.
Means within elements with the same letter are statistically similar.
[NS]Nonsignificant

For the 2012 season, sampling date was significant for all elements (Table 7). However, there were significant interactions between location and sampling dates for all of the elements.

Table 7. Mean nutrient concentrations of macro and micro nutrients in 'Prime-Ark 45®' blackberry leaves collected in North Carolina from May to July 2012.

Element	Sampling Date				
	5-May	14-Jun	25-Jun	9-Jul	26-Jul
				%	
N	3.63a	2.95b	2.99b	2.69c	2.64c
P	0.33a	0.23b	0.200c	0.19c	0.19c
K	1.73a	1.61b	1.47c	1.52c	1.38d
Ca	0.40e	0.46d	0.51c	0.56b	0.56b

Mg	0.37ab	0.37ab	0.36b	0.38a	0.39a
S	0.26a	0.22b	0.19c	0.18c	0.18c
			$mg \cdot kg^{-1}$		
Fe	114.58a	62.73b	63.82b	55.53b	55.23b
Mn	381.00a	328.83b	315.92b	341.25b	412.46a
Zn	40.54a	33.76b	32.05b	29.44c	28.16c
Cu	11.86a	9.56b	9.8b	8.35d	8.99c
B	31.01d	38.59c	41.68b	48.87a	48.80a

[z] means separated by LSD, $P<0.05$. Each value is a mean of 12 sample concentrations. Means within elements with the same letter are statistically similar.

Conclusions:

Although there were significant interactions, according to our objective, it was assumed that a detailed analysis of interactions were not relevant in this case. The central purpose of this study was to identify the periods of stability of elemental nutrient content, if any. Based on the LSD comparison and the statistical similarities, there seems to be a period of relative stability of nutrient concentration means between 11 July and 25 July sampling periods (approximately) in 2011. These dates coincide with 10 to 20 percent bloom. For Fayetteville and Clarksville in 2012, the results are not conclusive. This may be due to the excessive heat experienced in late June. For North Carolina in 2011, we conducted an analysis of the mean of logarithm (log) variances to identify periods with minimum variance. Results indicated the period of minimum variance among samples taken at the same date was found between the 5 July and 22 July sampling dates, approximately, for all of the macro- and micro-elements tested. Phenologically, these plants were between 10 to 50% bloom.

Impact Statement:

This project was part of a M.S. student thesis. Although defended, the thesis has not been published, but should be completed by May 2014. Although Year 2 data was not conclusive for Fayetteville and Clarksville, the results from North Carolina indicate that we can recommend to foliar sample during the early to mid-July.

Citation(s) for any publications arising from the project:
None at this time