Lessons Learned Through the NE SARE Berry Soil and Nutrient Management Project: Soil and Plant Tissue Nutrient Survey

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Commercial berry growers in the Northeast have traditionally made fertilizer applications based on generalized tables and with nitrogen recommendations that vary based on crop age. This practice continues today, some 20 years or more after commercial berry growers have available to them tools (e.g. leaf analysis) to develop crop specific guidelines for individual fields and farms. New soil health testing methods are now available that also include consideration of biological and physical properties of soil, but adoption has been slow.

> **"An analysis-based approach to berry crop nutrition provides increased yields along with better fruit quality and plant health, at the same time reducing grower costs and environmental impacts."**

Previous research has demonstrated that an analysis-based approach to berry crop nutrition provides increased yields along with better fruit quality and plant health, and a reduced environmental impact. Use of soil health management practices (i.e. cover cropping) reduces weed, nematode and soil-borne disease pressure, and improves soil tilth, organic matter and nutrient content. Rising costs of products and concerns about environmental impacts of fertilizers make a whole-farm approach to berry crop nutrient and soil management highly desirable.

Moreover, commercial berry growers, and the ag educators who assist them, frequently struggle with identification and management of berry crop soil and nutrient issues. No single comprehensive resource on this topic is currently available for either growers or educators.

Project Overview

A 2-year project supported by the Northeast Sustainable Agriculture Research and Education Professional Development Program was designed to provide in-depth berry crop nutrition and soil management training and resources for ag educators and the commercial berry growers they serve. Year one of the project (2012) focused on helping ag educators build berry crop nutrient and soil management expertise through 1) presenting a series of 12 in-depth webinars and case study learning modules on the subject and 2) developing resources to be used by educators in grower training. Year 2 of the project (2013) focused on assisting ag educators by 3) developing and implementing grower training programs and 4) carrying out one-on-one consultations with participating growers. Year 2 also involved educators in monitoring adoption and success of analysis-based berry crop nutrient and soil health management by working with growers participating in on-farm demonstration trials.

Materials and Methods

Forty commercial berry growers from New York, Connecticut and Maine who participated in berry soil and nutrient management training opportunities provided by the project were recruited to take part in on-farm berry soil and nutrient management demonstration trials. In exchange the growers received complementary soil, soil health, and leaf testing. Educators provided assistance and training in sample collection, preparation and shipping of samples, and interpretation of results.

Soil, soil health, and leaf analysis test result data sets were compiled and analyzed as a whole and then again on a crop by crop basis. Results were available for 35 of the 40 participating commercial berry growers located in NY (25), CT (5), and ME (5). This paper discusses the results of the soil and plant tissue chemical properties from the sampled soil and leaves.

Results were compared to known standards to determine if values were within range. Target pHs for the 4 major berry crops reported in this study were: blueberries pH 4.2 to 4.8, strawberries and raspberries pH 6.0 to 6.5, and cranberries pH 4.0 to 5.5. Recommended organic matter content for berry crops was 3% or greater. Aluminum levels above 300 ppm were considered toxic to plants.

Results and Discussion

Soil test results: all samples Less than half (46%) of the 35 samples tested had soil pH values within the desired range, indicating even if various soil nutrients were sufficiently present in soil they may not necessarily be readily available to the plant.

It might be expected that blueberries would, in large part, be responsible for the high percent of samples out-of-range, given their lower pH requirement. This was not the case however. On a crop-by-crop basis, strawberry and raspberry pH was in range for only 25% of samples (8 samples each). Sample pH ranged from 5.3 to 6.8 for strawberries and 4.8 to 7.2 for raspberries. For blueberries, 33% were within the desired pH range. Blueberry pH ranged from 3.2 to 6.2. Cranberries had 100% of samples (5) within the desired pH range, with the pHs ranging from 4.9 to 5.5.

A soil organic matter content of 3% or higher is preferred for commercial berry crop production. OM values for the 35 berry samples in the study (NY, CT, and ME) ranged from 1.3% to 6.4%. About two thirds of the samples had an OM content of 3% or above. Strawberry and cranberry samples had the most frequent low OM scores.

Soil test results: NY samples Thirty-six percent of the 25

NY soil samples had a pH within the desired range; 68% had an OM within the desired range (Table 1a). Only one NY soil sample had all 7 of the measured soil nutrients and/or variables fall within the optimum range. One sample had only one value fall within the optimal range. The average was 3 of the 7.

Mg and Al had the highest proportion of samples falling into the optimum range; in the case of Mg however, almost an equal proportion of samples were either very low or low, and high or very high. P, K, and Ca fell into high or very high ranges for the majority of samples (16, 10, and 14, respectively). Ca had the highest number of samples in the very low or low range (9).

Soil test results: NY blueberries Only 4 of the 11 total blueberry samples had a pH within optimal range (Table 1b); pH levels for the samples varied from 3.2 to 6.2. Six of the samples had Ca levels in the high or very high range corresponding to the 6 pH values falling in the high or very high range. One blueberry soil pH level fell in the very low range (3.2).

Organic matter levels were much better than pH levels with the bulk of samples at or above the recommended 3%; OM values for blueberry samples ranged from 1.6% to 6.4%.

As previously noted, Al levels above 300 ppm are toxic to plants; blueberries are particularly susceptible to aluminum toxicity because aluminum becomes more available in soil as pH is lowered. Two of the 11 blueberry samples had soil aluminum levels above the suggested 300 ppm range.

The majority of P and K levels for the blueberry fell in the high or very high range; one P level was in the optimum range; one K level fell in the low or very low range.

Soil test results: NY raspberries Five of the seven of the raspberry sample pH levels were outside desired levels; pH values ranged from 4.8 to 7.2. Organic matter content for raspberry soils was relatively good with only one sample falling in the low or very low category.

As with blueberries, the majority of raspberry samples fell in the high or very high range for K with only 1 sample being optimal; no samples were low. P, Ca, and Mg levels were somewhat evenly divided between the 3 nutrient ranges.

Soil test results: NY strawberries The seven strawberry soil pH levels were, for the most part, evenly divided between the categories; 2 samples fell within the optimal range. Organic matter content for strawberries was about evenly divided between optimal and low or very low.

P and K levels again fell into the high or very high range for

Table 1a. Summary of soil test results for 25 commercial berry growers in NY; values indicate number of samples within each of the three ranges.

	Soil nutrient						
Nutrient Range	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Soil pH	Aluminum (Al)	Organic Matter (OM)
very low or low	3	2	9	7	7	0	8
optimum	6	3	2	13	9	23	17
high or very high	16	10	14	5	9	2	0

Table 1b. Summary of soil test results for 11 commercial blueberry growers in NY.

	Soil nutrient						
Nutrient Range	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Soil pH	Aluminum (Al)	Organic Matter (OM)
very low or low	0	2	0	4	1	0	3
optimum	1	0	6	6	4	9	8
high or very high	10	9	5	1	6	2	0

Table 1c. Summary of soil test results for 7 commercial raspberry growers in NY.

	Soil nutrient						
Nutrient Range	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Soil pH	Aluminum (Al)	Organic Matter (OM)
very low or low	2	0	4	1	4	0	1
optimum	2	1	1	3	2	7	6
high or very high	3	6	2	3	1	0	0

Table 1d. Summary of soil test results for seven commercial strawberry berry growers in NY.

	Soil nutrient						
Nutrient Range	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Soil pH	Aluminum (Al)	Organic Matter (OM)
very low or low	1	0	5	2	2	0	4
optimum	2	2	1	4	3	7	3
high or very high	4	5	1	1	2	0	0

Table 2. Summary of leaf analysis test results for 14 commercial berry growers in NY, CT and ME.

Nutrient Range	pH	Nitrogen (N)	Potas-sium (K)	Phospho-rus (P)	Calcium (Ca)	Magnesium (Mg)	Manganese (Mn)	Iron (Fe)	Copper (Cu)	Boron (Bo)	Zinc (Zn)
Low or Deficient	0	1	4	4	4	5	2	7	9	3	8
In range	14	9	9	6	6	9	10	6	2	11	5
High or Excessive	0	4	1	4	4	0	2	1	3	0	1

the majority of strawberry samples; one sample was low or very low for P. A large proportion of Ca levels fell into the low or very low range; a similar proportion fell into the optimal range with Mg.

Leaf test results: all samples As previously noted in the soil analysis test results above, only 40% of the leaf samples submitted had corresponding soil pH values within the desired range, one of the necessary criteria for getting representative leaf analysis test results. Those tests with pH values more than one half point higher or lower than the desired range return leaf analysis values that are most often non-representative for those samples across the gamut of nutrients tested.

Results for those leaf samples with pH falling within the desired range or less than one half point away from desired range are summarized in Table 2.

Leaf nitrogen levels were 64% within range for the 14 leaf samples with 3% low or deficient and 29% as high or excessive. The range in potassium level was within the same percentage as nitrogen, as well as magnesium. Phosphorus, calcium, and iron leaf levels were 43% within range; zinc slightly lower at 36% and manganese and boron slightly higher at 71% and 79%, respectively. Numbers of low or deficient samples and high or excessive sample values were evenly distributed for P, Ca, and Mn. K, Mg, Fe, Cu and B low to deficient samples outnumbered high to excessive samples for the same nutrients anywhere from 3 to 1 to 8 to 1.

No crop-by-crop comparisons were made for leaf analysis results as the final data set for each crop after reduction to only samples in the correct pH range was very small (strawberry 3, blueberry 4, raspberry 2, and cranberry 5, respectively).

Conclusions

Growers may assume that their soil pH is within the desired range, but clearly this was not the case for the majority of farms in this study. Growers also apply P and K fertilizers routinely in their crops, but most of the soils in this study were already high in both P and K. The leaf analyses also indicated sufficient P and K in most cases. The most significant problems with the leaf analysis were low levels of micronutrients, and this is likely a reflection of improper pH.

Our standard recommendation is to conduct a soil test before planting and then every 2- 3 years after that. Prior to planting, the soil pH should be adjusted to within the appropriate range. Regular monitoring of leaf nutrients (every two years) will help keep nutrient values in range and prevent deficiency symptoms from occurring.

Nitrogen levels were adequate in most cases, but excessive in about 1/3 of samples. This suggests that some growers may be over-fertilizing as well. Soil tests do not measure plant-available nitrogen, so leaf analysis is required to determine plant status. More frequent use of leaf analysis to determine nitrogen status could allow growers to use less fertilizer, which would more than pay for the cost of the analysis.

If these farms are representative of those throughout the Northeast, then these data suggest that growers need to pay more attention to basics. Ensuring that soil pH falls within the correct range, and not assuming that P and K are required each year, are two of these basics. Our experience suggests that boron levels may be more critical to ensure adequate P and K in the plant. When B is low, the plant may not have the capacity to take up adequate amounts of P or K.

Soil nutrient levels interact with the physical and biological properties of soil. As one might expect, these varied considerably among the farms as well. A future article will discuss the biological component of the soil and what can be done to enhance overall soil health.

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