Cornell University Cooperative Extension
SCNYAG South Central New York Agriculture Team
FRUIT & VEGETABLE PRODUCTION
Schuyler Tompkins Cortland Chemung Tioga

Leaf and soil tests on local berry farms: Lessons from summer 2010

Molly Shaw, CCE South Central NY Agriculture Team

This past summer we sampled soils and leaves for nutrients on many of the local berry farms, and the results taught us quite a few lessons. The highlights are reviewed here.

For perennial crops like berries, the standard recommendations are to assess their fertilizer needs on a yearly basis with leaf tests, and to use soil tests periodically mainly to check the pH. Leaf tests are considered a more accurate view of what the plant has managed to take in than soil tests. The soil represents the "potential bank" of nutrients that the plant *ought* to have access to, while the leaf test tells you what it actually managed to get. We've found that having *both* the soil and leaf test side-by-side is necessary to really tease out what's going on with berry crop nutrients.

How to take a leaf test:
Leaf tests are taken during the main growing season and consist of about 50 leaves. For strawberries, sample the first full-sized leaves regrowing after renovation. For blueberries, take leaves in full sun from the middle of this year's growing shoot during or just after harvest. For raspberries, take the youngest full-sized leaves from primocanes before fruit is formed, in August. If you've used any sprays, you should wash the leaves in a dilute detergent solution, then rinse them with distilled water (use distilled so the water itself isn't adding minerals to the sample). Leaves are then sent to the lab where are dried out and ground up, and analyzed for the nutrient levels they contain. Soil tests can be taken at the same time as leaf tests, or any time the soil isn't frozen.

Reconciling soil and leaf tests
Ideally, the leaf test and the soil test would tell the same story. If the potassium level is low in leaves and also in the soil, simply follow the nutrient recommendations on one of the tests (or average them), and add more potassium in the fertilizer program. Similarly, it's a no-brainer when calcium is low in the leaf test, low in the soil test, and the soil pH is 5.6—add lime according to the soil test and you'll be good to go. **See figure 1.** The complications occur when the soil test and the leaf test seem to be telling a conflicting story.

When soil tests low for a nutrient, yet leaves test normal
There are times when the soil test levels of certain nutrients may be "medium" or even "low," but the leaf test levels of these same nutrients are normal. Normal leaf nutrient levels indicate that the plants are feeling well fed, despite the low soil levels.

First make sure that the leaf levels of the macronutrients (N, P, K, Ca, Mg) and boron are *all* adequate—that one low nutrient isn't the key holding back the rate of plant growth. ("Low" leaf levels of Mn, Cu, and Zn are not so worrisome because we don't have adequate research to determine what leaf level actually limits plant growth—keep reading below.) If leaf testing shows that the plants

Strawberries

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen	---------	Normal
Phosphorus	High	Normal
Potassium	High	Normal
Calcium	Low	Low
Magnesium	Medium	Low
Manganese	25.6	Normal
Iron	9	Normal
Copper	-----	Normal
Boron	-----	Normal
Zinc	5.7	Low
pH	5.6	-----
Organic Matter	2.4%	-----

Figure 1: When soil and leaf tests tell the same story:
In these samples, soil test showed low pH, as well as less than adequate soil Ca and Mg. Not surprisingly, leaf Ca and Mg were also low. This grower will add 1.5 tons/acre of dolomitic lime, according to the soil test.

have adequate nutrients and the plants are growing well, no need to worry. Perennials fruits, unlike vegetable crops, can store nutrients within their bodies and have permanent root systems to scavenge in the soil. Believe the leaf test and don't add fertilizer that the plant doesn't need.

If the plants aren't growing vigorously but leaf tests show that the plants are getting adequate nutrients, you should look for something besides nutrients that is holding them back—winter injury, root rots, insect infestation, etc. Cyclamen mites on strawberries have been found to be more wide spread than previously thought, and are probably taking an invisible toll on strawberries yields at many farms. Plants whose growth is slowed by non-nutrient factors can find low soil nutrient levels adequate for their slow growth rate, while if they were growing faster, perhaps these same levels would not sustain their needs. **See figure 2.**

How can you know if your plants are growing "vigorously"? Particularly on the plant vigor end of things, it's hard to tell if your plants are smaller than they ought to be until you see a comparison. I learned a tremendous amount by simply visiting many different berry farms and comparing their plant health and their past management practices. As hard as it is in the height of the season, it's well worth a few hours to check out nearby berry farms.

Strawberries

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen	---------	Normal
Phosphorus	Low	Normal
Potassium	High	Normal
Calcium	High	Normal
Magnesium	High	Normal
Manganese	16	Normal
Iron	6.8	Normal
Copper	-----	Normal
Boron	-----	Normal
Zinc	0.5	Normal
pH	6.1	-----
Organic Matter	5.3%	-----

Figure 2: When soil tests low for a nutrient, yet leaf tests are normal: Phosphorus is low in the soil, yet adequate in the leaves—no phosphorus fertilizer is needed. These berries aren't particularly vigorous—in this case I think cyclamen mites are to blame.

Blueberries

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen	---------	Normal
Phosphorus	Medium	Normal
Potassium	High	Normal
Calcium	High	Normal
Magnesium	Medium	Normal
Manganese	36	Normal
Iron	28	Low
Copper	-----	Low
Boron	-----	Normal
Zinc	1.2	Low
pH	5.2	-----
Organic Matter	5.3%	-----

Figure 3: Improper pH can make soil nutrients unavailable to plants
At 5.2, the pH is a bit too high for blueberries, inducing an iron deficiency. This grower will topdress with 200 lbs of sulfur each spring and fall until the pH comes down closer to 4.5 Adding sulfur faster than this runs the risk of burning plant roots. Two pictures illustrate the classic yellowing between the veins that you see with iron deficiency in blueberries caused not by lack of iron in the soil, but by the soil pH being too high.

When soil tests high for a nutrient, yet leaf test is low

Other times, the soil test can show adequate nutrient levels while one or more nutrients are low in the leaves. In this case, the puzzle is to determine what is preventing the plant from taking up the nutrient in the soil; adding more soil nutrient is not going to fix the problem.

1. Improper pH can make soil nutrients unavailable to plants. The classic example of this happening is when pH is too high for blueberries, leaf iron is usually low. Iron-deficient blueberries will show "interveinal chlorosis," green veins with yellowing between the veins. Blueberries are adapted to a low pH soil (about 4.5), and when pH creeps up two things happen that induce iron deficiency: 1) the higher the pH, the less soil iron is in a chemical form that the plant can use, and 2) within the plant itself, blueberries aren't very good at managing their iron supplies when calcium and nitrate are abundant as they are at higher pH's, so higher levels of Ca and NO_3

interfere with blueberries' use of iron in their leaves. In blueberries, iron deficiency (as shown by the leaf test) is caused by pH being too high, not low iron levels in the soil. The solution is to lower soil pH with sulfur. **See figure 3.**

2. Drought can interfere with plant nutrient uptake. We saw this quite a bit in 2010 with calcium and strawberries. We saw several strawberry fields where pH was fine as were soil calcium levels, but leaf calcium was low. Calcium has to be dissolved in the soil solution to move into plant roots, so when water is scarce, the plant roots can't reach the calcium present in the soil. Same deal with blossom end rot on tomatoes and peppers. In 2010 in central NY we had a dry spell in July, and many times after renovation strawberries got a little neglected on the watering end of things. We saw the same thing with potassium—lack of water was limiting its uptake. The solution is to water after renovation! **See figure 4.**

3. Low boron. Boron is important for plant growing tips, including roots. When it's limiting, roots don't grow adequately and the plant can't reach the other nutrients that are present in the soil. In these cases, you can see adequate soil levels of a nutrient while the leaves still test hungry. Strawberries seem particularly sensitive to low boron, and many of the strawberry fields showed low boron in the leaf tests as well as the soil tests. In these fields, applying boron according to the leaf test will probably fix the other nutrient deficiencies.

Strawberries

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen	---------	Normal
Phosphorus	High	Normal
Potassium	High	Low
Calcium	High	Low
Magnesium	High	Normal
Manganese	11.0	Normal
Iron	5.5	Normal
Copper	-----	Low
Boron	0.9	Low
Zinc	0.9	Low
pH	6.2	
Organic Matter	3.9%	

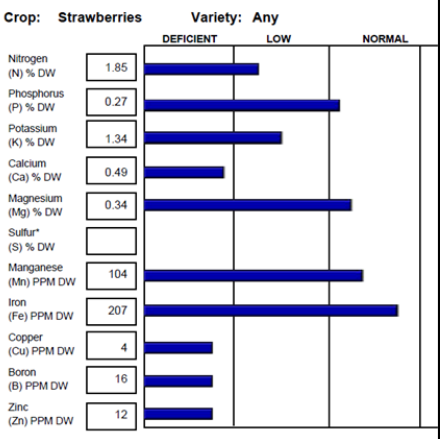

Figure 4: Drought can interfere with plant nutrient uptake
Calcium and Potassium are low in the leaf test although soil levels are fine and pH is good. Low P and K are probably due to drought, though in this case boron is also low, and this could be limiting root growth. This grower will fall fertilize with boron (5 lbs/A solubor) according to the leaf test recommendations. In addition, this farm had been using 15-15-15 to fertilize strawberries, but since soil levels of P and K are high, they can switch to an all-nitrogen fertilizer like urea and save money.

Raspberries

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen	---------	Normal
Phosphorus	Medium	Normal
Potassium	High	Low
Calcium	High	Normal
Magnesium	High	Normal
Manganese	27.4	Normal
Iron	2.4	Normal
Copper	-----	Normal
Boron	-----	Normal
Zinc	1.0	Normal
pH	6.2	
Organic Matter	4.9%	

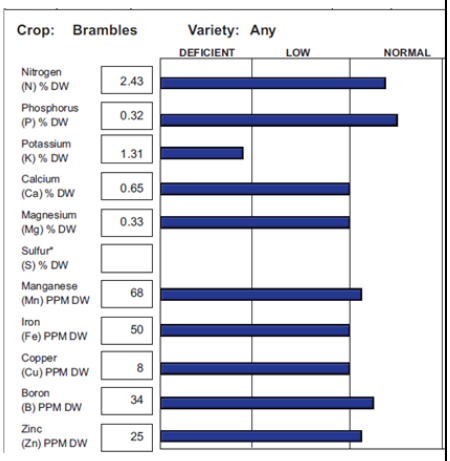

Figure 5: Plants are fruiting and sucking K from plant leaves
Almost all the raspberry leaf samples we took in 2010 had low K in leaves, while soil levels were fine. Leaf samples are supposed to be taken before fruiting, but raspberry fruiting happened earlier than we expected in 2010 because of the warm summer. Developing fruit was pulling K from the leaves at the time of sampling, resulting in low K in the leaves. There is no need to fertilize with K when soil levels are high.

Plants are fruiting. 2010 was a warm year, and raspberry season was advanced. We planned to sample fall-bearing raspberries in mid-August before fruit set, but this year fruiting came early, so we ended up sampling individual primocanes that didn't yet have any berries while other canes on the same plant were beginning to develop fruit. Berries have high K levels, so we see lower K levels in leaves as they feed developing fruit. By sampling a little late, when resources were being put to fruit, we got low K levels in leaves while we had adequate K in the soil. **See figure 5.**

What about micronutrients?
Many of our leaf tests show low zinc and low copper. Soil tests report a number for Cu and Zn, but don't give an interpretation about whether that level is high, medium or low. Marvin Pritts, Cornell Berry specialist, says that research hasn't been done on berries to definitively determine what levels of Cu and Zn limit yield. That would take a study where micronutrient levels were varied and yield responses measured. The "adequate" levels have been determined by sampling extremely healthy plants, noting their micronutrient levels, and assuming that levels lower that those measured were "low". Leaf tests tend to recommend micronutrient applications to bring up levels of zinc and copper, but Marvin suspects that it's not worth the fertilizer investment in most cases. We saw plenty of berry fields in our survey whose leaf tests reported "low" levels of Zn and Cu but which were performing admirably, so at this time we recommend not worrying about reportedly low Zn and Cu levels.

It's worth it to soil and leaf test
Each farm's unique soil/leaf tests provide a different puzzle with different questions to answer. The observations above applied to several farms, and there were other scenarios besides these. Of the 14 local berry farms that did soil/leaf tests this summer, changes is fertilization practices were recommended for 12 of them. A soil test costs about $16, leaf test $24—$40 well spent considering the value of your berry crop!

Many thanks to the NY Berry Growers' Association for partially funding this project.