Chapter 6 Interpreting Foliar Analysis Results - *Dr. Marvin Pritts, Cornell University*

Let's review

When to sample leaves? The best time varies slightly for each crop but in general late July to early August when nutrient levels in leaves are relatively stable is the best time for sampling (*Figures 20a, b*). Seasonal levels of boron and zinc, for example, start out relatively high in the spring, drop over the course of the season, then stabilize later in the season when fruit is no longer present.

Figures 20a. *Seasonal concentration of leaf boron, and 20b, leaf zinc. (From:* May, G. M., M. P. Pritts and M. J. Kelly. 1994. Seasonal patterns of growth and tissue nutrient content in strawberries. Jour. Plant Nutrition 17:149-1162.)

Strawberry leaves for analysis should be collected from the first regrowth after renovation, selecting the youngest full-sized leaves (July). Blueberry leaf samples should be collected just before or during harvest, choosing leaves from middle of this year's shoots, full sun (July-Aug). For either summer or fall raspberries collect leaves from the primocanes selecting the youngest full-sized leaves (early Aug).

Standard foliar nutrient ranges

There are standard foliar nutrient ranges for all the berry crops; these are generally accepted across the board regardless of location, climates, soils, etc. which make them easier to interpret (*Table 19a*). Note N, P, K, Ca, and Mg values in the table are percentages; B, Mn, Fe, Cu, and Zn values are listed in parts per million (ppm).

Table 19a. *Standard foliar nutrient ranges for strawberries, raspberries and blueberries*

	Strawberries		Raspberries		Blueberries	
Foliar Nutrient	**Critical Value**	**Normal Range**	**Critical Value**	**Normal Range**	**Critical Value**	**Normal Range**
Nitrogen (N)	1.9 %	2.0 - 2.8 %	1.9 %	2.0 - 2.8%	1.7 %	1.7 - 2.1%
Phosphorus (P)	0.2	0.25 - 0.4	0.2	0.25 - 0.4	0.08	0.1 - 0.4
Potassium (K)	1.3	1.5 - 2.5	1.3	1.5 - 2.5	0.35	0.4 - 0.65
Calcium (Ca)	0.5	0.7 -1.7	0.5	0.6 - 2.0	0.13	0.3 - 0.8
Magnesium (Mg)	0.25	0.3 - 0.5	0.25	0.6 - 0.9	0.1	0.15 - 0.3
Boron (B)	23 ppm	30 -70 ppm	23 ppm	30 - 70 ppm	20 ppm	30 - 70 ppm
Manganese (Mn)	35	50 - 200	35	50 - 200	25	50 - 350
Iron (Fe)	40	60 - 250	40	60 - 250	60	60 - 200
Copper (Cu)	3	6 - 20	3	6 - 20	5	5 - 20
Zinc (Zn)	10	20 - 50	10	20 - 50	8	8 - 30

Notice when comparing strawberries and raspberries, both rosaceous plants, the accepted values are relatively the same for both; there's very little different between the two. They grow in similar ways, accumulating nutrients to similar amounts, and these are indicative of healthy plants that are growing normally.

Critical values for blueberries however, are usually quite a bit lower than they are for strawberries and raspberries (Table 19b). One of the things to keep in mind when using a soil and/or leaf testing lab that is not familiar with blueberries, is that they will often use a standard appropriate for strawberries and raspberries (and truthfully for many other crops with similar ranges, such as alfalfa) on which to base their recommendations. They need to be adjusted down quite a bit for blueberries. Blueberries have a lower nutrient requirement than other crops, they grow more slowly, they don't require much nutrient, and critical levels in leaves are much lower in most cases. Keep that in mind if you get nutrient recommendations that don't seem right, it may be that the lab is using the wrong standard, one that has not been adjusted for blueberries.

Table 19b. *Standard foliar nutrient ranges for strawberries and raspberries vs. blueberries*

	Strawberries		Raspberries		Blueberries	
Foliar Nutrient	**Critical Value**	**Normal Range**	**Critical Value**	**Normal Range**	**Critical Value**	**Normal Range**
Nitrogen (N)	1.9 %	2.0 - 2.8 %	1.9 %	2.0 - 2.8%	1.7 %	1.7 - 2.1%
Phosphorus (P)	0.2	0.25 - 0.4	0.2	0.25 - 0.4	0.08	0.1 - 0.4
Potassium (K)	1.3	1.5 - 2.5	1.3	1.5 - 2.5	0.35	0.4 - 0.65
Calcium (Ca)	0.5	0.7 -1.7	0.5	0.6 - 2.0	0.13	0.3 - 0.8
Magnesium (Mg)	0.25	0.3 - 0.5	0.25	0.6 - 0.9	0.1	0.15 - 0.3
Boron (B)	23 ppm	30 -70 ppm	23 ppm	30 - 70 ppm	20 ppm	30 - 70 ppm
Manganese (Mn)	35	50 - 200	35	50 - 200	25	50 - 350
Iron (Fe)	40	60 - 250	40	60 - 250	60	60 - 200
Copper (Cu)	3	6 - 20	3	6 - 20	5	5 - 20
Zinc (Zn)	10	20 - 50	10	20 - 50	8	8 - 30

There is one exception for blueberries - manganese (Table 19c). It won't have much impact on your interpretation except you might see high manganese values in blueberries occasionally. For other crops this might signal a toxicity problem, but not blueberries. Blueberries have evolved a tolerance to high Mn levels. At low pH levels, manganese levels tend to be higher. The other thing is blueberries have evolved in flooded soils. These soils have less oxygen. Oxygen diffuses 1,000 – 10,000 times more rapidly in aerated vs. waterlogged soils. When oxygen isn't available as an electron acceptor for respiration (as it normally would be without flooding), other elements are used instead. The next thing an electron goes to after oxygen is manganese. Mn++++ (IV), the form typically found in soil, then converts to Mn++(II) form, the biologically active form. Mn++ is rapidly taken up by the plant. Blueberries take this form and isolate it in vacuoles so that does not become toxic. This is not a problem unless levels become extremely high in the plant.

Table 19c. *Manganese nutrient ranges for strawberries and raspberries vs. blueberries*

	Strawberries		Raspberries		Blueberries	
Foliar Nutrient	**Critical Value**	**Normal Range**	**Critical Value**	**Normal Range**	**Critical Value**	**Normal Range**
Nitrogen (N)	1.9 %	2.0 - 2.8 %	1.9 %	2.0 - 2.8%	1.7 %	1.7 - 2.1%
Phosphorus (P)	0.2	0.25 - 0.4	0.2	0.25 - 0.4	0.08	0.1 - 0.4
Potassium (K)	1.3	1.5 - 2.5	1.3	1.5 - 2.5	0.35	0.4 - 0.65
Calcium (Ca)	0.5	0.7 -1.7	0.5	0.6 - 2.0	0.13	0.3 - 0.8
Magnesium (Mg)	0.25	0.3 - 0.5	0.25	0.6 - 0.9	0.1	0.15 - 0.3
Boron (B)	23 ppm	30 -70 ppm	23 ppm	30 - 70 ppm	20 ppm	30 - 70 ppm
Manganese (Mn)	35	50 - 200	35	50 - 200	25	50 - 350
Iron (Fe)	40	60 - 250	40	60 - 250	60	60 - 200
Copper (Cu)	3	6 - 20	3	6 - 20	5	5 - 20
Zinc (Zn)	10	20 - 50	10	20 - 50	8	8 - 30

Deficient or not deficient?

Foliar analysis will give you values for nutrients that are not commonly reported in soil tests such as Manganese, Iron, Copper and Zinc. The probability of any one (or more) nutrients being deficient varies across nutrients (Table 20).

Table 20. *Probability of a nutrient deficiency occurring in leaves*

Nutrient	Probability of being deficient
Nitrogen (N)	Low – often in excess
Phosphorus (P)	Low
Potassium (K)	Medium – lighter soils
Calcium (Ca)	Low – except on acid soils
Magnesium (Mg)	Medium – higher for blueberries
Manganese (Mn)	Medium
Iron (Fe)	Low – higher for blueberries
Boron (B)	Medium High (Atlantic coastal plain)
Zinc (Zn)	Medium (high P soils)
Copper (Cu)	Low (high OM soils)

Nitrogen is in leaves is rarely reported as low. Most growers fertilize fairly well with nitrogen. In fact it is often reported above the critical values as growers tend to put on more than they really need. In this instance leaf analysis values will be reported as high (to excessive).

Phosphorus. The same is true for P as for N; reported leaf levels rarely come back as low. Phosphorus levels are generally relatively high due to nature of soils in NE region, the past presence of dairy farms on production fields and/or use of manure to fertilize fields in the past.

Potassium is sometimes low on lighter soils.

Calcium is sometimes low, but a calcium deficiency occurs infrequently, especially if pH is in the appropriate range.

Magnesium sometimes shows up as deficient, particularly in blueberry fields.

Manganese shows up as deficient somewhat frequently, particularly in fields that were once wet and have been drained.

Iron in leaves is sometimes low. Iron is a very common element in soils. If iron is reported to be deficient in leaves it is most likely a problem with pH, not a soil deficit. In that instance, pH adjustment often solves the deficiency problem without the need for supplemental application of iron. A chelated iron product is sometimes applied to *foliage* as a temporary measure until soil pH has time to moderate. This is especially true in the case of blueberries.

Boron is an element frequently low in NE region soils. Atlantic coastal plains soils characteristically tend to be very low in boron; parts of Ontario and Canada are also deficient. Boron is the element most commonly found to be reported deficient in leaf analyses.

Zinc. If phosphorus levels are high, then zinc is sometimes low.

Copper – Frequently deficient in soils with high organic matter.

Aluminum (Al). Aluminum levels are routinely determined as part of a standard leaf analysis but are not reported unless specifically requested. Aluminum levels tend to be very sporadic in soils. High aluminum soils with low pH may result in aluminum toxicity; if pH is in the normal range, no evidence of toxicity is apparent. Thus Al toxicity is sometimes seen in blueberries on low pH high Al soils. Raspberries or other crops grown on the same high Al soil at higher pH show no evidence of toxicity…

Foliar test interpretation

Foliar tests are useful for adjusting your fertility program only when plants are healthy and pH is within range. A foliar test doesn't really provide insights if plants are diseased or plants aren't growing well. It's a really good way to fine tune a fertility program but not really meant to be used it as a sole guide for wholesale adjustments.

Leaf analysis interpretation checklist

1. Ensure that the soil pH is within the correct range; if yes, proceed. ***If no, STOP!***
2. Are there any other limiting factors? Assess the status of the planting to determine if something other than nutrients could be limiting growth (disease, drought).
3. Check the status of boron. Low boron may result in deficits in other nutrients…
4. Look for specific nutrients that might be deficient.
5. Check for interactions/imbalances that can exacerbate low nutrient levels.
6. Derive recommendations.

Possible Scenarios

There are three possible scenarios that are seen when examining corresponding soil and leaf tests. They include:

- Leaf test and soil test tell the same story
- Soil test is low for a nutrient, yet leaf test is normal
- Soil test is high for a nutrient, yet leaf test is low

Interpreting Leaf Test Results – Test Your Skills

Eighteen examples follow illustrating the 3 scenarios that may occur. These are taken from paired sets of actual soil and leaf analysis test results and are summarized here for ease of review.

Things to think about when reviewing soil and leaf test results:

- ✓ Optimal pH ranges for each crop:
  - Strawberries and raspberries: 6.2 – 6.5
  - Blueberries: 4.2 – 4.8
- ✓ Desired organic matter content: greater than 2%
- ✓ Optimal soil Boron level: 1.0 lb/A or above
- ✓ Standard foliar nutrient ranges for strawberries, raspberries, and blueberries. Remember N, P, K, Ca, and Mg values in the table are percentages; B, Mn, Fe, Cu, and Zn values are listed in parts per million (ppm).
- ✓ Plants compromised by disease do not grow very much. Unhealthy plants often have normal to high soil and leaf nutrient levels; you need to look at plant health as well as test results to determine what is else is happening…
- ✓ Do your soil test recommendations change once you have data on foliar analysis?

Example# 1: Strawberries, Castile soil, Good growth and yield

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	Medium	Normal
Potassium (K)	High	Normal
Calcium (Ca)	High	Normal
Magnesium (Mg)	High	Normal
Manganese (Mn)		Normal
Iron (Fe)		Normal
Copper (Cu)		Normal
Boron (B)	2.0	Normal
Zinc (Zn)		Normal
pH	6.2	-----
Organic Matter	5.3%	-----

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

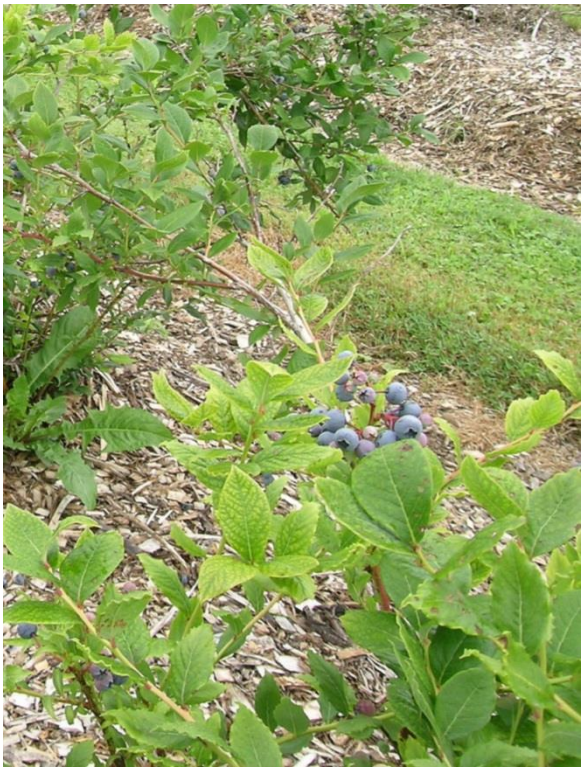
Your Recommendation(s):_____

_____

Checklist: Soil test results look good; pH is in range, organic matter is good, nutrient levels for soil and leaf tests are normal. **Recommendation:** You're doing the right thing; keep up the good work.

Example# 2: Blueberries, Volusia soil

Nutrient	Leaf (%, ppm)
Nitrogen (N)	Normal
Phosphorus (P)	Normal
Potassium (K)	Normal
Calcium (Ca)	High
Magnesium (Mg)	Normal
Manganese (Mn)	Low
Iron (Fe)	Low
Copper (Cu)	Low
Boron (B)	Normal
Zinc (Zn)	Low
pH	-----
Organic Matter	-----



Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: Let's start with leaf analysis - Normal N, P, K, Mg, and B levels. High Ca levels; low Mn, Fe, Cu, Zinc.
Recommendation: Check soil pH.

Example#3: Blueberries, Volusia soil

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	Medium	Normal
Potassium (K)	High	Normal
Calcium (Ca)	High	High
Magnesium (Mg)	High	Normal
Manganese (Mn)		Low
Iron (Fe)		Low
Copper (Cu)		Low
Boron (B)	Medium	Normal
Zinc (Zn)		Low
pH	5.8	-----
Organic Matter	5.3%	-----

High pH means low iron availability. Note iron deficiency symptoms.

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: Soil analysis shows that the pH is high at 5.8; the desired range for blueberries is 4.2 to 4.5.
Recommendation: When the last four leaf micronutrients (Fe, Cu, B, Zn) in particular are low together most often it's not an indication that they are low in soil BUT that pH is not where it should be…Adjust pH; no need to amend with micronutrients at this point; once pH has been moderated the levels should return to normal without adjustment.

Example# 4: Strawberries, Tioga (river bottom) soil

Nutrient	Leaf (%, ppm)
Nitrogen (N)	Normal
Phosphorus (P)	Normal
Potassium (K)	Medium
Calcium (Ca)	Low
Magnesium (Mg)	Low
Manganese (Mn)	Normal
Iron (Fe)	Normal
Copper (Cu)	Normal
Boron (B)	Normal
Zinc (Zn)	Medium
pH	-----
Organic Matter	-----

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: Leaf analysis - Normal N, P, K, Mn, Fe, Cu, Zn and B levels. Low Mg and Ca levels. **Recommendation:**
Add Mg and Ca.

Example# 5: Strawberries, Tioga (river bottom) soil

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	High	Normal
Potassium (K)	High	Medium
Calcium (Ca)	Low	Low
Magnesium (Mg)	Medium	Low
Manganese (Mn)		Normal
Iron (Fe)		Normal
Copper (Cu)		Normal
Boron (B)	Medium	Normal
Zinc (Zn)		Medium
pH	5.6	-----
Organic Matter	2.4%	-----

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: Soil analysis indicates Ca is low, Mg is medium, all other nutrients within normal range; pH is low at 5.6; the desired range for strawberries is 6.2 to 6.5. Leaf analysis also indicates Ca is low, along with Mg.
Recommendation: Adjust pH using high magnesium lime to adjust pH and provide Ca and Mg.

Example# 6: Blueberries, Volusia soil

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Low
Phosphorus (P)	Medium	Normal
Potassium (K)	High	Normal
Calcium (Ca)	High	Normal
Magnesium (Mg)	Medium	Normal
Manganese (Mn)		Normal
Iron (Fe)		Low
Copper (Cu)		Low
Boron (B)	Medium	Normal
Zinc (Zn)		Low
pH	5.2	-----
Organic Matter	5.3%	-----

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

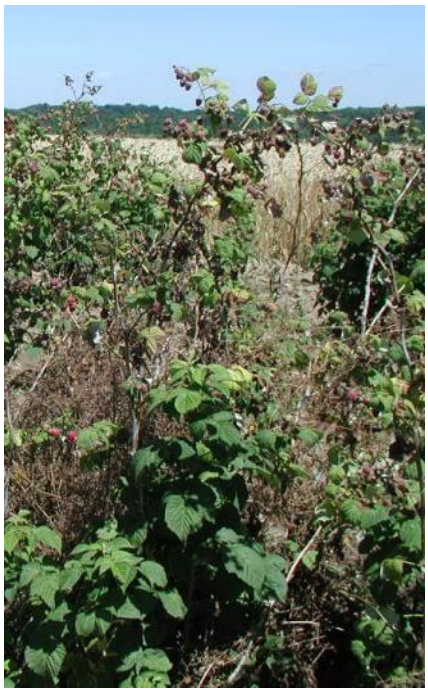
Your Recommendation(s):_____

_____

Checklist: pH is slightly high at 5.2; organic matter is good; soil nutrient levels all OK. Leaf analysis shows low N, Fe, Cu, Zn. Other leaf nutrient levels are normal. What may be causing nitrogen deficiency? Most likely the weed competition (*photo right*) vs. grower not fertilizing with N fertilizer…**Recommendation:** Manage weeds better; keep N fertilization program the same for now. Adjust pH slightly using sulfur; micronutrients should balance out when pH is in desired range.

Example# 7: Raspberries, Conesus soil, poor growth

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	Low	Normal
Potassium (K)	Low	Normal
Calcium (Ca)	Medium	Normal
Magnesium (Mg)	Medium	Normal
Manganese (Mn)		Normal
Iron (Fe)		Normal
Copper (Cu)		Normal
Boron (B)		Normal
Zinc (Zn)		Normal
pH	6.2	-----
Organic Matter	5.9%	-----



Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: A few soil things are low here (P and K); Ca, Mg are medium, pH is OK, organic matter is good. Leaf levels are all normal but plants are not growing well. **Recommendation:** The problem probably isn't nutritional as both soil and leaf nutrient levels are good. Look for another factor affecting growth.

Example# 8: Strawberries, Bath soil, plants not healthy

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	High	Normal
Potassium (K)	High	Normal
Calcium (Ca)	High	Normal
Magnesium (Mg)		Normal
Manganese (Mn)		Normal
Iron (Fe)		Normal
Copper (Cu)		Normal
Boron (B)	1.0	Normal
Zinc (Zn)		Normal
pH	6.4	-----
Organic Matter	3.8%	-----

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: pH and organic matter good, soil and leaf nutrient levels all OK but plants not healthy. What's happening here? **Recommendation:** The problem probably isn't nutritional. Look for another factor affecting growth such as black root rot, strawberry root weevil etc.

Example# 9: Strawberries, Castile soil (soil test only)

Nutrient	Soil (lb/A)
Nitrogen (N)	---------
Phosphorus (P)	Medium
Potassium (K)	Medium
Calcium (Ca)	High
Magnesium (Mg)	High
Manganese (Mn)	
Iron (Fe)	
Copper (Cu)	
Boron (B)	0.9
Zinc (Zn)	
pH	5.8
Organic Matter	4.4%

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____

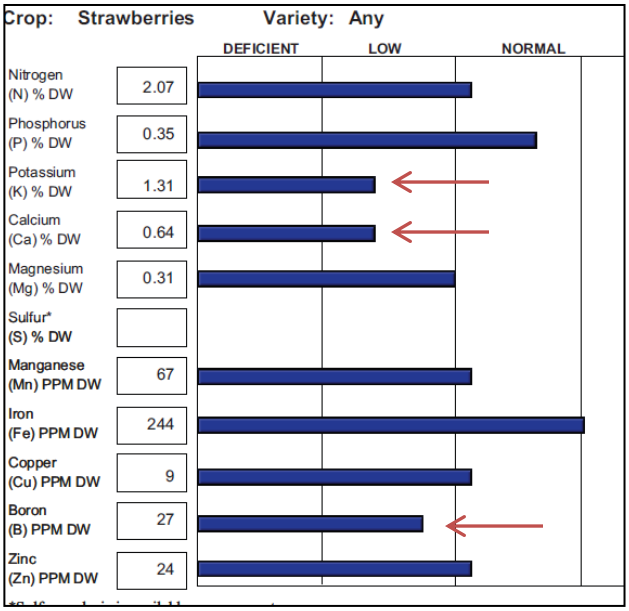
Your Recommendation(s):_____

_____

Checklist: pH is low; optimal range for strawberries 6.2 to 6.5, organic matter OK, nutrient levels OK except Boron. **Recommendation:** Raise pH; add boron.

Example# 10: Strawberries, Castile soil (with foliar analysis)

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	Medium	Normal
Potassium (K)	Medium	Low
Calcium (Ca)	High	Low
Magnesium (Mg)	High	Normal
Manganese (Mn)		Normal
Iron (Fe)		High
Copper (Cu)		Normal
Boron (B)	0.9	Low
Zinc (Zn)		Normal
pH	5.8	---------
Organic Matter	4.4%	---------



Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients*: (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: Leaf analysis shows K and Ca are low; Boron is low. **Recommendation:** Raise pH (and Ca level at the same time) using 2 T/A lime (per soil test recommendation), add 90 lbs K/A and 4 lbs Solubor (per leaf test recommendations).

Example# 11: Strawberries planted 2010, well-drained soil, dry year (soil test only)

Nutrient	Soil (lb/A)
Nitrogen (N)	---------
Phosphorus (P)	High
Potassium (K)	High
Calcium (Ca)	High
Magnesium (Mg)	High
Manganese (Mn)	
Iron (Fe)	
Copper (Cu)	
Boron (B)	0.7
Zinc (Zn)	
pH	6.2
Organic Matter	3.9%

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____

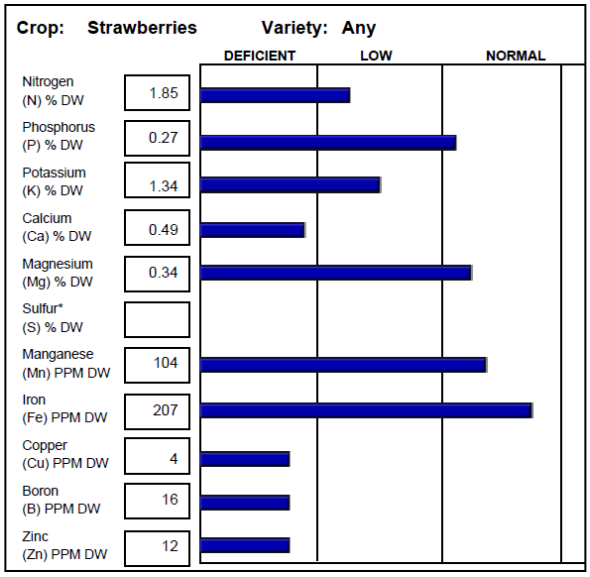
Your Recommendation(s):_____

_____

Checklist: pH and Organic matter OK; P, K, Ca, Mg high; Boron low, desired range 1.0 lb/A or higher.
Recommendation: Raise Boron level.

Example# 12: Strawberries planted 2010, well-drained soil, dry year

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Low
Phosphorus (P)	High	Normal
Potassium (K)	High	Low
Calcium (Ca)	High	Low
Magnesium (Mg)	High	Normal
Manganese (Mn)		Normal
Iron (Fe)		Normal
Copper (Cu)		Low
Boron (B)	0.7	Low
Zinc (Zn)		Low
pH	6.2	---------
Organic Matter	3.9%	---------



Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: N, P, Ca high for soil analysis but low for leaf analysis; Cu, B, Zn also low for leaf analysis.
Recommendation: Drought likely limiting uptake of Ca and K. Irrigate. Don't need complete fertilizer as soil levels of P and K are fine. Fall fertilize with urea (30 lbs actual N/A, ~60 lbs urea) and boron (5 lbs/A solubor).

Example#13: Summer Raspberries Conesus soil, very heavy crop load

Nutrient	Soil (lb/A)
Nitrogen (N)	---------
Phosphorus (P)	Medium
Potassium (K)	High
Calcium (Ca)	High
Magnesium (Mg)	High
Manganese (Mn)	
Iron (Fe)	
Copper (Cu)	
Boron (B)	1.2
Zinc (Zn)	
pH	6.2
Organic Matter	4.9%

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____

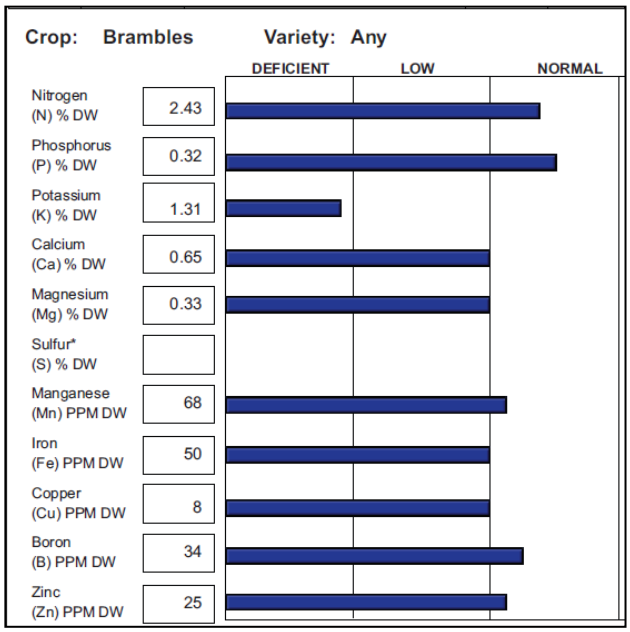
Your Recommendation(s):_____

_____

Checklist: pH and Organic matter fine; soil nutrient levels also good. **Recommendation:** Nothing needed; keep up the good work…

Example# 14: Raspberries Conesus soil, heavy crop load

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	Medium	Normal
Potassium (K)	High	Low
Calcium (Ca)	High	Normal
Magnesium (Mg)	High	Normal
Manganese (Mn)		Normal
Iron (Fe)		Normal
Copper (Cu)		Normal
Boron (B)	1.2	Normal
Zinc (Zn)		Normal
pH	6.2	---------
Organic Matter	4.9%	---------



Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: Everything good except potassium (K) is low. Why? Soil levels are high… **Recommendation:** Fruiting takes a lot of K; just need to allow time for plants to replenish from soil irrigate to maintain soil moisture so this can happen.

Example# 15: Strawberries, poor growth

Nutrient	Soil (lb/A)
Nitrogen (N)	---------
Phosphorus (P)	High
Potassium (K)	High
Calcium (Ca)	High
Magnesium (Mg)	Medium
Manganese (Mn)	
Iron (Fe)	
Copper (Cu)	
Boron (B)	2.0
Zinc (Zn)	
pH	6.5
Organic Matter	3.4%

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: pH and Organic matter OK; other nutrient levels OK, Boron OK. **Recommendation:** Look for another cause of poor growth such as a disease or drought.

Example# 16: Strawberries, poor growth

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	Very High	High
Potassium (K)	High	High
Calcium (Ca)	High	High
Magnesium (Mg)	Medium	Low
Manganese (Mn)		Normal
Iron (Fe)		Low
Copper (Cu)		Low
Boron (B)	2.0	Normal
Zinc (Zn)		Low
pH	6.5	---------
Organic Matter	3.4%	---------

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: pH and organic matter OK. Mg medium for soil analysis but low for leaf analysis; Fe, Cu, Zn also low for leaf analysis. **Recommendation:** Sometimes soil nutrient can be too high; P is high (too much manure or P fertilizer. P interacts with many micronutrients, forming precipitants and tying them up. Likely this is what's happening here. High Ca can also interfere with iron; this is particularly true for blueberries; not uptake, but the fact it becomes the inactive form and becomes unavailable. If soil P is exceptionally high, you may want to select another site before planting berries.

Example# 17: Blueberries, poor growth, no disease

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	Medium	Medium
Potassium (K)	High	High
Calcium (Ca)	High	High
Magnesium (Mg)	Medium	Low
Manganese (Mn)		High
Iron (Fe)		Low
Copper (Cu)		Low
Boron (B)	Medium	Normal
Zinc (Zn)		High
pH	4.5	-----
Organic Matter	3.4%	-----

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

_____

Checklist: pH and organic matter are good; Mg low; leaves showing typical deficiency symptoms. Why?
Recommendation: Ca, P, Zn, and Mn to some extent compete for binding sites with Mg. High levels of these nutrients are likely suppressing Mg. Apply 100 lb/A Mg.

Example# 18: Blueberries, very poor growth, no disease

Nutrient	Soil (lb/A)	Leaf (%, ppm)
Nitrogen (N)	---------	Normal
Phosphorus (P)	Medium	Normal
Potassium (K)	High	High
Calcium (Ca)	Medium	Normal
Magnesium (Mg)	Medium	Normal
Manganese (Mn)		High
Iron (Fe)		Normal
Copper (Cu)		Normal
Boron (B)	2.0	Normal
Zinc (Zn)		High
pH	4.1	-----
Organic Matter	3.4%	-----

Your checklist:

- ✓ **pH**:_____
- ✓ **Organic Matter**:_____
- ✓ *Soil Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Leaf Macronutrients* (P, K, Ca, Mg):_____
- ✓ *Soil Micronutrients*: (Mn, Fe, Cu, B, Zn)_____
- ✓ *Leaf Micronutrients***:** (Mn, Fe, Cu, B, Zn)_____

Your Recommendation(s):_____

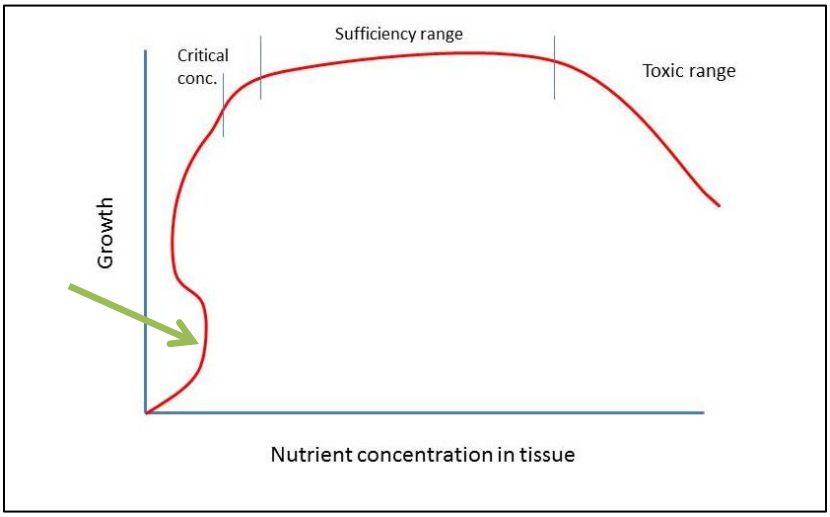
_____

Checklist: pH, organic matter, Boron are all good; other soil nutrient levels good; leaf nutrient levels also good. Why poor growth, what's going on? **Recommendation:** There's a possibility of a toxic level of a non-essential element. Check soil test or redo it, asking for all elements to be reported. Look for electrical conductivity/soluble salts. Specifically look at sodium (mid-west, more than east) and aluminum levels. Aluminum is high in many soils and is released at low pH.

The Steenbjerg effect - When adding a fertilizer actually decreases the level of nutrients in a leaf.

This happens when nutrient levels are very low. Think about a situation where the plant has adequate levels of nutrients with the exception of a single nutrient that is very low. Let's select Mg for example. The low level of Mg is limiting growth. Mg is added to the soil and the plant starts to grow rapidly. The concentration of nutrients in the plant may become diluted for a time. This occurs because the plant is now growing faster than it can take up Mg from the soil (Figure 22). After things come to an equilibrium , more normal patterns are expressed. This is why, occasionally, after a recommendation to fertilize, foliar levels decrease the next year, instead of rise.

Figure 22. The Steenbjerg effect



Summary

Soil test results do not always correlate with foliar test results for a variety of reasons. Foliar tests are not meaningful for fertility guidelines unless the soil pH is within the correct range. Foliar tests are useful for diagnosis, but not for detailed guidance unless growth and yield are good. Applying nutrients may result in a decrease in foliar concentrations under certain circumstances, as seen with the Steenbjerg effect. Correcting deficiencies or imbalances in established plantings is more difficult than amending soils prior to planting.

Additional Resources

1. Marschner, H. 1995. Mineral nutrition in higher plants. Academic Press, New York.
2. Plant, cell and environment. 17:1053 – 1060.
3. Wikstrom, F. 1994. A theoretical explanation of the Piper-Steenbjerg effect.