Soil pH is More Important Than Fertilizer for Blueberries

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Most farmers know that blueberries perform well in acidic soils. What may be news is that keeping soil pH low is even more important than fertilizer applications when it comes to getting good yields on most soils.

We initiated a Blueberry Nutrition Survey in the summer of 2007 because blueberry farmers in the South Central NY area use different fertilizer programs that vary widely from the standard (as recommended in the Blueberry Production Manual, see Figure 1 for growers' fertilizer rates), and most of those farmers weren't sure how well their individual programs were working. Fifty percent of the farms involved did not take regular leaf or soil samples to measure bush nutritional status.

> "In south central NY state blueberry yields are not correlated to nutrient levels in the soil or with leaf nutrient levels. We suspect that in general, nutrient levels in our region are in the optimal range and are not limiting to blueberry yield. However, yields were highly correlated to soil pH with the lower pH soils having the best yield. For high yields growers should ensure that soil pH is below 4.5."

The results of the survey were used to correlate the widely varying fertilizer regimes with bush health and yield. We used soil and leaf mineral analysis to take a "snapshot" of the nutritional status of blueberries on 10 farms to determine how past fertilization practices were affecting the health and yield of the bushes. This was not a controlled study where we could conclude cause and effect relationships between fertilizer and yield, since many management and site factors were different between farms. What we were able to do was to draw correlations between nutrient status and management inputs and from there make recommendations for management adjustments.

Soil and leaf samples were taken on 10 area blueberry farms in July, 2007, just before and during harvest. Seven of the 10 farms were on relatively heavy clay-silt loam soils such as Volusia that are typical of the upland soils in South Central NY. Two were on gravelly soils, while the remaining farm was on fertile, well drained river flats soil. Samples were analyzed for mineral nutrient content by the Cornell Nutrient Analysis lab. A yield estimate was taken at the same time as the nutrient samples. Bluecrop was sampled wherever possible, but Blueray was sampled in a couple of instances where Bluecrop wasn't present. Growers were surveyed about their fertilizer program, weed, insect, and disease control, irrigation, mulching and pruning over the last three years. Comparing yields on heavy versus lighter soil types showed no significant difference in our small sample size.

Farm	leaf N (%)	#N/A/yr	#K/A/yr	#P/A/yr	SOM%
1	1.8	65	0	0	2.3
2		7	0	0	3.0
3	1.74	52	0	0	4.1
4	1.67	20	0	0	5.3
5	1.58	25	0	0	4.7
6	1.92	88	0	0	5.6
7	2.06	13	11	42	4.8
8	2.2	165	22	35	3.7
9	1.73	87	0	17	3.8
10	1.52	64	92	0	8.7

Figure 1. Fertilizer rates used on 10 blueberry farms in the Southern Tier of NY. Growers' nitrogen applications (averaged over 3 years) ranged from 7 lbs/A actual N to 165lbs/A actual N. (Actual N per acre means that if you put 100 lbs of urea on an acre of blueberries you've really only applied 46 lbs of actual nitrogen, because urea is 46% nitrogen by weight). Some growers used ammonium sulfate, others used urea; 15-15-15 and MAP were applied on one occasion each. Six growers calculated the actual nitrogen/A they wanted, while the other four did not apply their fertilizer with a target N rate in mind.

Lessons Learned from the Survey

1. Soil nutrient levels and leaf nutrient levels are not well correlated. The Blueberry Production Manual recommends using a soil test to determine soil pH, and then to use a *leaf analysis* to determine if the bush is actually getting enough of the other nutrients to grow optimally. This implies that the soil nutrient levels determined by a soil test can't be used alone to develop good fertilizer recommendations.

Sure enough, in our study we found no correlation between levels of nutrients in the soil and the levels measured in the blueberry leaves, except for Zn (Figure 2). No correlation means, for example, that low magnesium in the soil was not associated with low magnesium in the leaves. Despite the low soil test magnesium

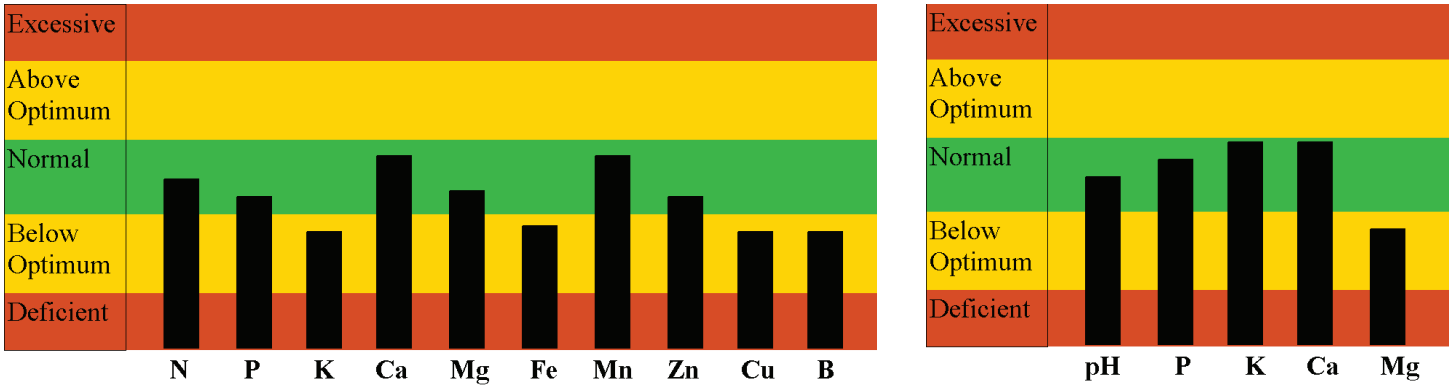

Figure 2. A representative leaf analysis result (left) and soil sample result right).

level, the leaf level magnesium level showed that the bush actually had enough magnesium for optimum growth. The soil levels didn't match the leaf levels for P, K, Ca, Mg, Fe, or Mn. Cu and Boron were not measured in the soil. Nitrogen level from the soil test is known to not be a good predictor of N available to the plant in any crop, since the regular soil test only shows a snapshot of the N available at the time the sample was taken, and does not predict the N release from the soil for the rest of the season.

The idea that the soil nutrient levels determined from a soil test do not explain blueberry plant nutrient levels has been a difficult concept for many farmers to accept. An allegory can be used to explain. Nutrients in the soil can be looked at like the food in a child's home. A number of factors influence whether that child eats the food and is nourished by it. Simply having food in the cupboard is not enough to assure that the child is getting proper nutrition. A doctor would look at the child's growth and appearance to determine if that child is adequately fed. If the child isn't growing right even a blood sample (likened to the leaf analysis) would be occasionally taken to try to pinpoint a cause. Similarly many factors affect how many nutrients a blueberry plant actually takes up including soil pH, root health (wetness, drought, disease), weed pressure, etc. Blueberry plants actually take up many nutrients via their symbiotic root fungi, called mycorrhizae, so factors that affect the symbiont also affect the blueberry.

How can a nutrient level be in the "adequate range" in the soil but "low" in the leaves? If the soil pH is too high, many nutrients aren't in the chemical forms that the blueberry plant can pick up, so there can be adequate amounts in the soil but not enough in the leaves. Also, if the blueberry plant happens to be growing rapidly, either because of a N application or because of the time of year, nutrient levels in the leaves can be diluted in the expanding leaves and appear to be low in the leaf sample while levels in the soil are quite adequate. It is for this reason that leaf samples should be taken just before or during harvest, when the spring flush of growth is over and the leaf expansion factor is minimized.

Conversely, how can a nutrient level be "low" in the soil while the leaf test shows that the blueberry plant has enough of this nutrient? This can happen when the bush is growing slowly for some reason, be it a deficiency in another nutrient, improper pruning, winter damage or poor root growth. In this case the plant isn't growing very fast so even the low amount of nutrient in the soil can keep up with the demand by the plant.

The mismatch between soil test results and leaf test results mean that although the soil test is important to determine pH, the soil test alone can't be used to determine if the bush has enough of any one nutrient.

2. Lower soil pH was correlated with higher yield. It turns out that the only soil factor we measured with a strong correlation with yield was soil pH (see Figure 3). Farms with lower soil pH tended to have higher yields. That itself is reason enough to keep close tabs on the soil pH in blueberry plantings and justifies a soil pH test. In fact, Gary Pavlis, the blueberry specialist at Rutgers Extension, even recommends that the New Jersey growers check their soil pH every spring and fall.

3. More nitrogen fertilizer did not correlate with a higher yield. The standard recommendation from the Highbush Blueberry Production Guide (NRAES) is to apply 65 lb/A of actual N to mature bushes in the form of ammonium sulfate or urea, and to adjust the applications of other nutrients based on leaf analysis results.

We found no correlation between leaf N levels and the amount of N applied. Neither were there correlations between leaf N and yield nor applied N and yield. This means that applying more nitrogen didn't lead to more nitrogen in the leaves or to higher yield, in our survey (see Figure 4). With our group of growers, a lack of nitrogen didn't appear to be limiting blueberry growth or yield, and farms applying higher rates of nitrogen didn't have higher yields.

4. None of the nutrients tested in leaves seemed to be limiting yield in our survey. In general, higher yielding farms did not have higher nutrient levels in the leaves (there was no correlation between leaf nutrient levels and yield). Phosphorus was the one exception, showing a weak correlation between measured leaf levels and yield, even though most growers' leaf analysis showed P to be in the optimal range. This might indicate that the low end of "optimal" Cornell P range is actually still a little low, but our result may not be significant and we cannot draw conclusions from only one season of surveying.

Blueberry Nutrition Questions and Answers

1. Q. If leaf nutrient analysis is supposed to be a more accurate look at bush nutritional status than soil analysis, then why didn't leaf nutrient levels correlate with yield?
   A: Plant growth generally follows a yield response curve (Figure 5). Many times a lack of correlation between yield and fertilizer (or yield and leaf levels) can be explained with the plant growth/nutrient response curve. When the nutrient in question is anywhere in the optimal region, increasing

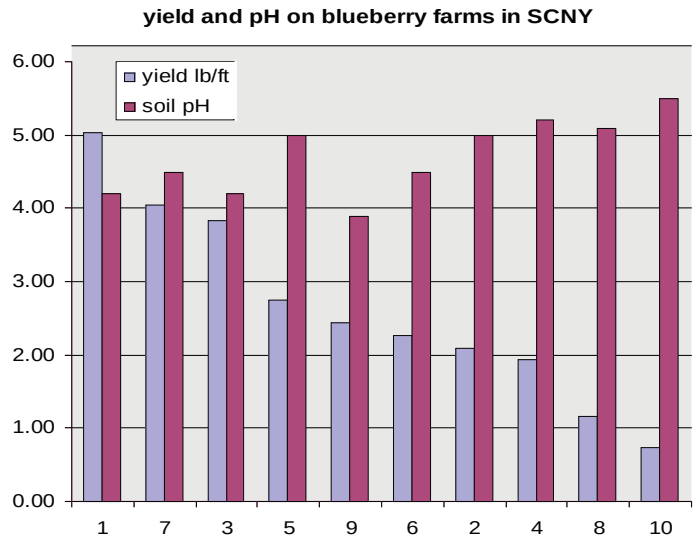

Figure 3. Soil pH and yield of 10 blueberry farms in South Central NY state) (correlation of soil pH and yield = -0.687, p-value = 0.028).

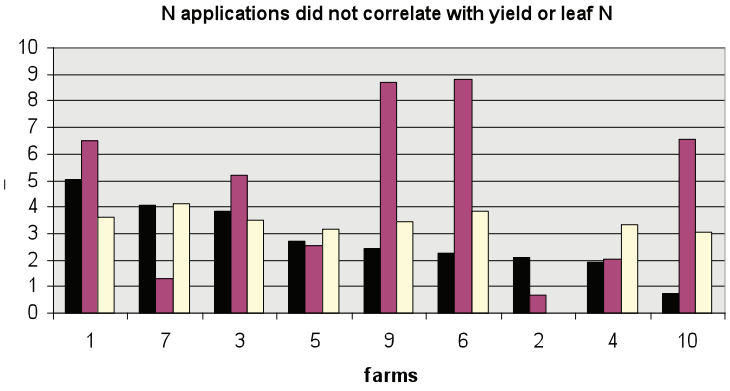

Figure 4. Yield, nitrogen fertilization and leaf nitrogen level of 10 farms in South Central NY state. Higher nitrogen applications did not correlate with higher yield or higher leaf N. Farm #8 is omitted from this chart as an outlier. It's 165lb/A N application rate was too high to fit on the graph.

amounts of that nutrient don't increase yield, thus correlation with leaf levels and yield or with fertilizer applications and yield are not apparent. We suspect that in general, nutrient levels in our region are in the optimal range and are not limiting to blueberry yield.

2. Q: If soil pH and yield are significantly correlated (yield goes up as pH gets lower), then why don't we see higher nutrient levels in blueberry leaves grown on a lower pH?
   A: Growth rates are variable between the farms. If low pH stimulates greater growth, then nutrient levels in leaves of the rapidly growing plants could be diluted rather than enhanced.
3. Q: How can the soil nutrient analysis indicate a low level of a nutrient (Mg, for instance), and the leaf nutrient analysis indicate Mg is adequate?
   A: This can happen when the plant isn't growing very fast, so Mg uptake keeps up with demand—even though soil levels are low.
4. Q: If leaf nutrient analysis indicates a nutrient level is "satisfactory", wouldn't higher than just "satisfactory" be better?
   A: The "satisfactory" level is a place where additional applications of that nutrient are unlikely to make a measurable difference in growth or yield. So, yes, the ideal may be a little higher than the lowest value of the satisfactory range, but one is unlikely to see a measurable response by applying more.

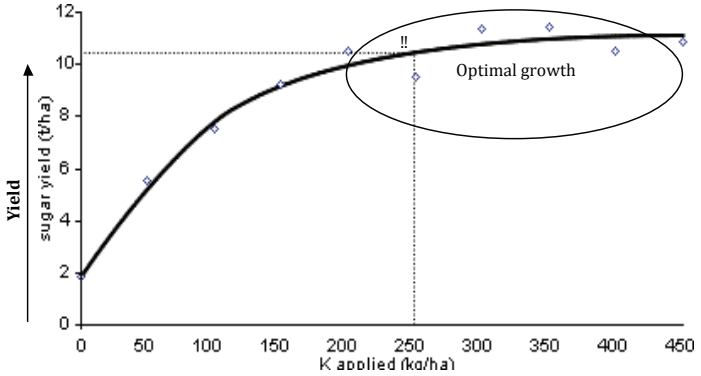

Figure 5. A sample yield/response curve shows that at in the optimal range, increasing the nutrient level available to the plant does not significantly increase plant yield. Therefore, in the optimal range, yield and nutrient application rate no longer correlate.

5. Q: If a soil nutrient analysis shows high K, but K is low in the leaf nutrient analysis, what is the explanation?
   A: This is common in blueberries where either the soil is clayey and root growth is limited (blueberries have a hard time with root proliferation in clay soils), or where boron is low. Boron is used for auxin synthesis during root growth. Less root growth means less nutrient uptake. Higher than ideal pH can also contribute to this problem.
6. Q: If leaf Mg level is a little low, and soil pH is fine (4.5 or even lower), how can a grower increase Mg levels in the plant?
   A: Epsom salts (magnesium sulfate) add magnesium without changing the pH. Sulpomag is also a good source of magnesium, while also adding some potassium. Price them out (dollars per pound actual Mg) and use the least expensive.
7. Q: If a grower increases N fertilizer applications, can't he expect better yield?
   A: Not as indicated by our study. If nitrogen isn't limiting as shown by the leaf test, then it's not going to help to add more.
8. Q: If yields are on the low end, but the soil nutrient analysis shows that pH is fine, and the leaf nutrient analysis shows adequate levels of all nutrients, what is the explanation?
   A: Plants that aren't growing very fast will often have high levels of nutrients since the nutrients accumulate and have no place to go. This doesn't mean that yields will also be high. Plants that are growing rapidly and producing lots of yield will often have low leaf values because the nutrients don't accumulate in leaves and used in other parts of the plant. Length of growing season, soil constraints on root growth, and winter injury can also contribute to low yield.
9. Q: If leaf N levels were low and the plants were fertilized with N resulting in other nutrients now appearing low, what is going on?
   A: The plants likely weren't growing well because of low N. The N fertilizer stimulated the plant began to grow more which diluted the levels of nutrients in the leaves, even N. Suddenly many nutrients appear to be "deficient" but in reality, it is because the plant is growing rapidly and the existing nutrients are diluted—irrespective of soil values.

10. Q: If iron is low in the leaf nutrient analysis, but soil pH is 4.5, what should be done?
    A: Cornell uses 70 ppm iron as the low end of the normal range, while the Blueberry Production Guide uses 60 ppm as the low end of the normal range. If your value shows up above 60 ppm and your pH is low enough, that's probably not a problem. If it's lower than 60 and your pH is 4.5 or lower, be aware that Al, which is more readily available at lower pH's, competes with Fe for uptake, and could be contributing to the deficiency.

Recommendations Based on Our Work

1. Test the soil, adjust pH to 4.5 or lower. In our sample of 10 South-Central NY blueberry growers, some of the highest yielding farms had pH's below 4.5.
2. Use shoot growth as a measure of Nitrogen status. The bottom line is how well the plant grows and produces shoots for next year's crop. If new shoot growth is less than 1 ft long and you are already applying the recommended 65lb/A of actual nitrogen, use a leaf test to determine if any other nutrients are limiting.
3. And remember, as Gary Pavlis (Rutgers Extension Blueberry Specialist) says, "If you aren't doing a good job pruning, fertilizing is just icing on a bad cake."

Acknowledgements

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