

Plant Sap Journal 2020

Results Discussion with Nathan Harman of AEA

Two varieties: Sweet Sixteen (north block) and Bonkers (south block)

ROUND ONE

Leaves collected on June 2

Pre-bloom nutrients already engaged; full bloom underway, shoot extension at 3-4"

Telephone conversation on June 11:

We (AEA) are on the outer loop of apple fertility land compared to other crops.

What the grower is doing versus what the plant wants.

K and Mg will generally be at "plant desirable level" as both are soluble elements.

Forcing this dynamic with foliar feeding shows up when older leaf level much higher than new leaf level. Other macronutrients are semi-soluble; not as easy a read.

Ca, Mg, Fe appear low but are proportionally so, which may be all right. Samples running on the low side are not necessarily problematic if balanced across the board. Can indicate a more controlled vigor, less vegetative push. May be seen on larger trees with more space to fill. Does any of that add up?

Ideally want high Ca, Mn, and B to go with decent levels of the NPK growth nutrients.

Spend more on foliar nutrients, all numbers will slide upward.

If leaf color is good, leaf size is good, and shoot extension is good . . . that's telling you

Mg is happy from tree perspective and reserves are available in older leaves.

Potassium appears slightly deficient. Suggest a couple quarts after fruit set period.

Phosphorous is happy; biology handles this.

Nitrogen going to new leaves, as seen by shoot extension. Could become deficient but we can assume fish has this covered going forward.

Try upping Manganese to 2 quarts. Slowly mobile so tree doesn't pull Mn from old leaves during fast growth period. Flowering used a lot of Mn, as does early stages of seed development.

Cell division in apple runs 2 to 3 weeks [NOTE: I'm familiar with "up to 28 days" for Malus] so especially important to double up Mn during first two weeks after petal fall.

K is not limiting Ca uptake but this is looking at leaves not fruit. Need to direct Ca to fruit. Spray formulations vary.

Xylem is more mobile than phloem. Nutrients go up the xylem (bulk flow with water) from roots to aerial parts of the plant. Foliar apps move through phloem by diffusion from leaf surface to shoots and fruits. Foliar is like a *cherry on top* but really want good Ca in soil to make things happen. Results dependent on soil moisture as well.

Most effective time for ground application of gypsum is 30 to 45 days before flowering.

Calcium released 30 to 60 days after that by soil biology. This coincides with blossom phase, fruit set, and buds initiating on pome fruits for next year's crop.

Suggest catching up with Boron. Perhaps a quart the next app and then a pint the next two apps beyond that. Late for fruit set impact but still relevant to cell division phase.

Will help improve Ca levels as tree redirects Ca from new leaves to developing fruit.

Molybdenum keeps nitrates low.

K is running only 10 to 15% higher in older leaves thus reserve of potassium is low.

Indicator will be new leaves showing browning on edges. Adding pint foliar K in comp apps will shift this. [NOTE: will test earlier application in south block in 2020]

Can be more liberal with Fe. Say quart 2X at pink and petal fall then drop to maintenance rate of pint or even half-pint through cell division phase.

Do nothing and will see silica climb in summer months, Mg hold steady, but K will drop.

Nutrient formulations are generally acidic. Okay if spray solution has pH 3 or 4 or 5 when adding nutrients. If pH tends toward alkaline, add vinegar.

ROUND TWO

Leaves collected on **June 22**

Cell division nutrients already engaged; fruitlets 18-24 mm, shoot extension up to 9"

Query email:

I sent along leaf samples this past Monday and came in from spraying Comp2 on Friday to find sap analysis results waiting in my inbox. That's some impressive turnaround!

I know we will talk but thought I'd jot down some comments/questions to start this off.

These Round Two results have seen whatever influence from spray choices three times since the first round of sap testing in early June. Primarily, I added Mg and B to the routine of Ca, Mn, and Fe. Fermented plant extracts are also in play now with what I call Comp(rehensive) sprays for the cell division phase. My north block looks great but drought is exacerbating the yellow leaf factor in the south block. Young trees in the east block generally look good though those darn Akane on MM.111 rootstock are still not growing despite an earlier nitrogen boost. (This could well be a non-thriving cultivar planted one zone too far north.) I've upped the rate of liquid fish to 3 gallons per hundred per acre throughout since that first test.

Seeing silica go through the roof seemed exciting, as just one treatment of horsetail extract had been applied by this point . . . but coupled with high aluminum . . . I realize this is the influence of Surround kaolin clay despite trying to dry wipe any visible white residues off sampled leaves. That one clay spray made on June 9 was especially relevant on older leaf portion.

There are more potassium reserves this time around particularly on the 'Bonkers' where I added one pint K to the tank mix for the south block in the Comp1 application.

Weaving in different approaches (like when to start K) helps me distinguish recommendations. But even 'Sweet 16' improved without additional K being provided in north block.

Calcium remains a struggle. I can see myself driving to Pennsylvania to load up on gypsum at \$6 a bag for next spring (versus the \$19.36 that North Country Organics charges for a 50# bag up this way). I've used up my supply of BioMin Ca and am now relying on nettle/comfrey extract for Ca. I want to try HoloCal next season in the spring applications of foliar calcium. Also appreciate the boron connection here . . . which has improved considerably. Next year B will be applied earlier as is

traditionally recommended. I am reconsidering Solubor for the pink and petal fall apps as that seems the more economical choice.

Iron remains confounding. This is what you told me last year and I'm wondering if we need to rethink this for 2021:

Iron will contribute to an overall darker and more vibrant cast of green, and more efficient photosynthesis. It is shocking how often Iron is a limiting factor for photosynthesis even on high Fe soils. It is one of the elements that seems to need a little kick in most crops every year. I would not bother adding it to the soil. It's already abundant there, in an oxidized state. And most of anything you add will have a similar fate. Rebound Iron (3% Fe) rates of 1 quart down to .5 pint per acre, foliar, are enough to correct. I like to start with 1 quart at any point in the season that we see need from a sap test. Then the next spray at 1 pint. Thereafter half a pint on occasion is usually sufficient. The plant can mostly use the same iron all season long, once it has accessed it. I am not aware of a seasonal timing issue other than making sure Fe is present when leaves are. So, if it is a perennial issue, I would include very small rates three to five times in the growing season. Adding the volume we are talking about through foliar, will of course, never have meaningful bearing on the volume of iron in the soil.

I've made four applications of Fe so far this year, starting at tight cluster with a pint, then a quart at pink, then pint amounts since with magnesium as well.

Nova Crop is no longer analyzing ammonium and nitrate aspects? Last year my results included NO₃ but not NH₄ but this year neither are provided. Another grower friend in Wisconsin gets NH₄ results but not NO₃. What's this about?

I have no idea why the excessive levels of sodium. Is that a concern?

Finally, I think we've nailed manganese. Apps have been quart, quart, 2 quarts, 2 quarts, quart respectively each time calcium was applied. Should I continue to add Mn?

Reply email from Nathan:

I am so glad you mentioned the aluminum thing with Surround spray. An orchardist in Michigan and I just hit upon that likely connection a couple weeks ago. Or maybe I'd heard it before and it's a known thing? But yes, it's a high aluminum material and seems to show up when used.

And kaolin is as much silica as aluminum, so in addition to your horsetail-nettle, and the general upward trend of Si through the season in healthy plants, I believe Surround plays a role there too.

NH₄ and NO₃ are both always analyzed, it's just that when there is less than 5 or 20 ppm detected, then it shows up as a non-detect. And that's very good news, usually. We want to see no nitrate, no ammonium and high total N. So here, while you may still want more N (keeping in mind balanced vigor), it is all being used. But no worry at all to see nitrogen ions making their way quickly to total (protein) N.

Telephone conversation on June 30:

Does silica get within leaf from a Surround application? Or is the increase shown more of a residue factor? Si is a bit of a mystery, tied to fungal activity, otherwise varies widely.

Results with foliar potassium are noticeable. Grower applies → K increase results.

Calcium is an all-season kind-of-nutrient. There's a Michigan orchard that scores upper range of Ca for apples on plant sap analysis (3000 ppm in old leaf). Grower applies 2 quarts of Holo-Cal each spray. New leaf always a lower number as plant accumulates Ca as leaf sizes up.

I'm not opposed to higher rates of iron to kick things into gear, as much as 3 quarts, followed by maintenance rates once we see noticeable Fe response. Generally, once Fe is up, it stays up, as revealed by deep green leaf color. Some varieties like Golden Delicious may require additional charge of Fe as its leaves tend to be lightest in color. Iron does track visually and as far as I know there's no hindrance to uptake other than maybe aluminum.

I would expect calcium to track harder (improve) now that we got boron levels up.

Manganese is right so time now to step that back. Skip in next week's application and then do summer maintenance rate of pint maximum every two weeks

Adequate K, adequate Mn, and an established calcium baseline established early for continued calcium to build upon is not an either/or thing. The one AEA webinar with Stephen Belink (sp), a fruit grower in Washington, was eye-opening. He did not accept the idea that Ca only into developing embryo before and during cell division is what mattered, that season long application does good. Many disease issues with low Ca, from bitter pit to blossom end rot. Keeping K:Ca in a 3:1 ratio is the sweet spot, noting this is likely to run 2:1 at the start of the growing season. There's no actual point in the plan where you switch from calcium applications to potassium applications. K will slowly climb as the season progresses. As little as a pint gets the ball rolling at end . if not during . cell division phase, based on what sap analysis reveals [probably Round One and definitely Round Two] and then supplement every two weeks for maintenance.

High sodium can generally be said to result during high heat periods as plants respire more, thus accumulating salts, particularly in younger leaf. Sodium acts as a cooling agent but then stays behind as water goes through respiration. Also should find out if binder or filler in Surround introduces a residue factor? Might plant extracts as well?

Nitrogen is on low end. Sweet Sixteen stacks at 374/ 151 ppm (young leaf to old leaf) which is barely sufficient for north block. Bonkers comes in at 255/ 98 ppm and requires attention. Indeed, poorest looking trees are found in south block, both with respect to dwindling Mac-family cultivars and the yellowing issue. Liquid fish as foliar offers a slow gain. Bit of rain will help as low nitrogen is accentuated when very dry. Rain loosens the soil, makes biology happy and thus more active. Protein forms of N in fish and compost; mineral N in high-test fertilizer.

Ride through this next month is all about photosynthesis to size and color fruit.

Magnesium, iron, and more nitrogen (fish) will improve photosynthesis. Do this next 2 or 3 times, along with low rate K and some form of calcium. Actually, probably drop manganese in the summer sprays.

Wisconsin orchardist got over enthused about cobalt idea to hinder scab. Applied half-pint Co, kept raining, kept reapplying. Sap test numbers got up to 20 ppm but only a couple of varieties showed stress as a result of excess cobalt. New client in Michigan read the same comments by John Kempf about cobalt and scab. He applied one pint of Co just one time. Tree color darkened by five shades, with leaves

standing straighter where before had appeared folded over. You could see an absolute line between old growth (like before) and new growth. Ideal cobalt levels are above 0.1 ppm and below 1.0 ppm to abet scab resistance.

Further mp research:

As for mineral content of Surround: The product is made from "95% kaolin clay" but I can't find anything about the other 5% listed as "proprietary ingredients". Kaolinite ($\text{Al}_2\text{O}_3(\text{SiO}_2)_2(\text{H}_2\text{O})_2$) itself is a hydrous aluminosilicate derived from feldspar, and ranges in purity from 74% to 95%. Mineral elements that carry through could include potassium, sodium, or calcium, depending on the associated feldspar deposit. I would suggest organic orchardists using Surround wipe residues off leaf samples with a slightly damp cloth in the month following application. Each new set of samples will eventually outgrow the clay coverage if people stick to shoot tips for new leaves (2nd leaf back) and an older leaf halfway along the shoot, as recommended by NovaCrop. That will be the case when I send a next sample in early August. Any significant drops in high trace minerals (zinc, copper, molybdenum) may be traceable then to the Surround factor. And aluminum, most obviously.

ROUND THREE

Leaves collected on **August 3**

Terminal bud set nutrients already engaged; fruit coloring, shoot extension up to 16"

Query email:

Round Three of plant sap analysis came back within the same week. I'll look forward to seeing the tests for each of the two trees sampled this season laid out side-by-side but in the meanwhile here's what stands out to my eye for discussion.

Four nutrient applications (along with the holistic mix) were made between Round Two and Round Three sap analysis tests. This amounted to a six-week period.

Potassium is apparently the easiest nutrient to *spike* (think volleyball) and thus get in the right place. Bonkers received a pint of BioLink-K in the last two Comp sprays followed by a quart of AgriDynamics' Foliage-K in the two summer apps; Sweet 16 received a pint of Foliage-K plus a quart of apple cider vinegar in the two summer apps. My conclusion is I can wait to start K till July, and I'm seriously wondering if cider vinegar alone will suffice.

We gained slightly with respect to calcium. One aspect of this was getting boron in the zone on the Round Two test (no subsequent B was added since then). The other was consistent application of fermented plant extracts: All trees got 4 gallons of calcium tea in remaining two Comp apps. Bonkers in turn got 2 gallons of calcium tea in the two summer apps in July whereas Sweet 16 received 2 quarts of AgriDynamics' Cal-Sentials instead. Home-grown nutrient brews show a slight edge over purchased product. Certainly product rates could be increased to a gallon each time for a potentially fairer comparison but this at ever-increasing cost. I'd be curious to know what rates you'd have recommended for HoloCal in this situation.

Let's jump to silica next as the trial aspect here also involves fermented plant extracts.

All trees got 4 gallons of silica tea in remaining two Comp apps. Bonkers in turn got

2 gallons of silica tea in the two summer apps in July whereas Sweet 16 received no additional silica in summer apps. Continued use of home-grown nutrient brews show the slightest edge in that Bonkers outscored Sweet 16. It's worth noting how the "kaolin factor" was dealt with this time: Shoot growth on Sweet 16 allowed for older leaves to be selected without clay residues; shoot growth on Bonkers was less (located on dry ridge) and so those leaf samples were wiped clean of clay residues and allowed to air dry before refrigerating.

Nitrogen continues to be low as a result of the soil being parched. We are too dry for robust biological activity and thus release of N from microbe eating microbe. I continued to include liquid fish in the two July apps accordingly. Leaf coloration and turgor looks good overall.

Magnesium settled well for the season. A final app (of three) was included this round in the final Comp app on July 3. Here I ponder if magnesium sulfate (Epsom salts at 5# to 15# per hundred per acre) would serve the holistic grower "straight up" given the humic acid, seaweed, and amino acids from fish in the core holistic recipe. Speaking now of chelating agents directly in the spray tank with certain mineral additions.

Iron remains the bugaboo. Levels dropped from what was seen on Round Two.

Rebound-Fe was applied starting at tight cluster in these amounts: pint, quart, pint, pint, and a final quart in the Comp3 application. Obviously trees here are calling for a doubling if not a trebling of these rates. Your statement a year ago that *the plant can mostly use the same iron all season long, once it has accessed it* makes me think early timing is important here. This ground has now thoroughly demonstrated its "iron capacity" to be a limiting factor that needs to be addressed every year from here on in. I wonder if you've been able to tag other farm soils/ bioregions in a similar ongoing respect for specific nutrients.

Correspondingly, we got "manganese capacity" up where it needed to be by the Round Two test. Levels of Mn tailored off slightly since then but were still functioning well.

On that note, I will report that *Honeycrisp yellows* are still apparent but not awful.

That business of this apple variety being a potassium-hyperaccumulator, and how Mn helps balance cation uptake between Ca and K is spot on . . . but I'm still dealing with less than optimal Ca in this orchard. Gypsum will be applied early next season for sure!

I'm going to spray one more time this coming week. I've traditionally included MicroPak in the terminal bud set application but that will be it for purchased products. I'll include cider vinegar again throughout the orchards but no more fish. There's probably enough calcium tea and silica tea to include at tonic rate as well (being a gallon plus of each per hundred per acre).

Telephone conversation on August 13:

Referring now to results for Bonkers in the South Block. Sap pH has been consistent through the season, which we like to see. Total sugars have increased greatly, indicating photosynthesis has kicked into a higher gear (with respect to photosynthesis efficiency) in the summer months. Energy improves accordingly.

About the AEA composite of results from all three rounds of testing for each tree. Older leaf (in dark green) shows on same line as younger leaf (in lighter green) to better highlight what's going on with mobile nutrients and those that accumulate with time.

Newest sap sample is on the top of each bar to show how each nutrient level changes through the season; each set of three lines (bar) shows sequential results at bloom/ cell division/ terminal bud set for a given nutrient.

The optimum target level is a combination of opinion: Nova Crop recommendations and AEA tweaking based on ever more data samples. Quite likely 50% from each in the current nutrient profile provided for apple. Each winter AEA consultants get together to assess what should be fine-tuned. So, yes, you see differences for some nutrients in what the lab suggests and what AEA thinks we should shoot for.

Each side of the target line shows a range of acceptable levels. Darker blue is perfectly acceptable; lighter blue we can tolerate. Lower than that calls for attention, indicated in pink. Excesses are revealed as well, indicated in purple. Referring now to actual results in ppm for each nutrient, where the first column is for the younger leaf and the second column is for the older leaf.

Wiping leaves of kaolin residues took care of the purported silica and aluminum excess that appeared in Round Two. Might it also be possible that Surround has a manganese component? Levels for Mn in the older leaf dropped back to the target range in Round Three. The residue factor is a thing we need to think more about. Such is expected in a tissue test (based on mineralized ash) but not necessarily the case with sap.

Overshooting K shows leaf will readily uptake potassium. Your thoughts on vinegar as a foliar K source are reasonable. Late season potassium draw to fruit which subsequently gets pressed and fermented means water-soluble K biologically accumulated in the juice (cider/ vinegar).

Cobalt is right on without any supplementation. [NOTE: MicroPak is included at critical points of influence, and this includes a tonic amount of Co.] Older leaf values in Round Three showed 0.43 and 0.56 ppm for the two cultivars tested.

Tend to be conservative with rate recommendations. Now see need for more iron than what was done this year. Seen other instances where as much as a gallon of Fe has been needed to initially kick iron into range. Interesting how deposit in young leaf versus older leaf has flip-flopped this season. Iron plays a critical chlorophyll role. Consider adding iron even at this point in the season to improve absorption of light energy through the harvest period.

Fermented plant extracts have contributed to a major improvement in calcium. Four-fold jump in new leaf levels is significant! Need to get calcium on earlier and more, say 4 quarts to start. AEA's Holocal has other things going for it than calcium products from competitors. Yes on gypsum, heeding that 80-20 split between soil and foliar for this important nutrient.

Toured several orchards in Michigan last week. The more vegetative trees, in terms of shoot extension, show higher levels of P in new leaf. The older leaf only edges ahead at terminal bud set. New leaves after terminal bud set can look P-deficient as having a physically harder time, as expressed through purple veining and diminutive size. Lost Nation results are the opposite from the start; yours are the only orchard samples that we're working with this year showing this trait. Talked about advantages of fungal emphasis and keeping bearing trees calm as a possible explanation. Excessive vigor probably drives jump in terminal P (new leaf) that we see in other orchards.

You see a difference in the target line for P on the AEA composite and the bar graph sent directly from NovaCrop. The lab states optimum P at the 550 midpoint, within a target range of 330-770 ppm. We shoot for 620 on the AEA composite, having seen better plant physiology as a result. This is a work-in-progress as we get more data to better distinguish human opinion from what the plants are actually telling us.

Silica continues to bioaccumulate through the season. Still looking for a product that can kick this aspect into place earlier. Silica products seem to be remarkably expensive. One Texas grower used Sil-*something* (not Sil-Matrix) and got good sap results but no visual improvement in crop health.

Chelating certain minerals in the spray tank probably works well with magnesium sulfate, aka Epsom salts. This might be true for any amendment that works quickly in the soil: magnesium sulfate, potassium sulfate, various sources of boron, zinc sulfate. Other nutrients are more complex as regards formulation. We utilize vortexes, magnetism, filtration, and order of chemistries in making AEA products. These standard practices are critically important for some nutrients whereas buffering capacity and humates in spray tank will help with more mobile nutrients. Epsom salts dissolved in water could even be chelated ahead the day before application and then added along with other AEA foliar.

Chloride consistently climbs through the season. This is universal in apples. IPM growers applying potassium chloride cut off apps and only then see levels drop. Chlorinated water source also unnecessarily ups chloride levels. Generally speaking, chloride levels get higher, especially in hotter weather, as leaves transpire and internal salts accumulate.

Zinc can be added to root zone annually, where needed. Will see quick boost with foliar Zn application. This element is of concern if you actually see zinc-deficiency symptoms such as mouse-ear sized leaves and severe leaf asymmetry (vein off-center). Levels have to be quite low for this. Zinc helps size seed so if your crop is corn and beans think more about Zn. Could check seed cavity in mature apple fruit for good fill as a way to gauge orchard needs but this won't be a good indicator if fruit harvested too early. Keep levels sufficient to prevent deficiency symptoms and no need to worry about Zn.