Chapter 7 Correction of Nutrient Problems in Established Berry Plantings - *Dr. Eric Hanson, Michigan State University*

Let's review

Previous chapters have covered soil characteristics, soil testing and interpretation, pre-plant soil treatments, plant tissue analyses and interpretation. This chapter will cover what to do if a nutrient need is known in an established planting. Macro-nutrients include N, P, K, Ca, Mg, and S. Micronutrients include B, Cu, Fe, Mn, Mo, and Zn.

Nitrogen management

Nearly all berry crops require nitrogen on an annual basis. The big question is what you can do to use nitrogen efficiently. Answers to this question include choosing the right fertilizer, fertilizer rate, application timing, and product placement.

Nitrogen fertilizers

There are a lot of nitrogen fertilizers to choose from. Products with the highest nitrogen content tend to be the cheapest per pound of nitrogen and are generally the most preferred N sources. Nitrogen products also vary in their reaction in the soil (Table 21).

Table 21: *Nitrogen fertilizers and their lime equivalents*

Source	%N	Reaction	Lime equivalent (lb lime/lb N)*
Ammonium nitrate	32	acidic	-1.8
Ammonium sulfate	21	acidic	-5.3
Calcium nitrate	16	basic	1.3
Potassium nitrate	12	basic	1.9
Urea	46	acidic	-1.8
Diammonium phosphate (DAP)	17	acidic	-4.1
Monoammonium phosphate (MAP)	11	acidic	-3.5
Blends	variable	variable	variable

**Lb lime equivalent to alkalinity from 1 lb N (positive values) or required to neutralize the acidity from 1 lb N (negative values)*

All those that supply nitrogen in the ammonium (or ammonium plus nitrate) form tend to have an acidifying reaction in soil. Those fertilizers that supply nitrogen only as nitrate have a basic reaction in soil. The measurement of this effect is called the lime equivalent. Essentially the lime equivalent is the lbs of lime that would be equivalent in reaction to 1 lb of nitrogen supplied as a nitrogen fertilizer. For example, if you were to apply 1 lb of N as calcium nitrate it has a positive number indicating for every lb of nitrogen applied as that source it would have the equivalent reaction in soil as 1.3 lb of lime. This is not a large amount of lime but over time could accumulate and affect soil pH. Those with negative numbers would indicate you need to add lime to neutralize the acidity supplied by those sources. Ammonium sulfate is known to be a good N fertilizer for blueberries. The reason for that is that it is so acidifying. For every pound N applied ammonium sulfate as you would need to apply 5 lb of lime to neutralize the acidity.

Choosing nitrogen sources

The choice of nitrogen source should be based first on cost per pound of nitrogen, and then second on the need for other nutrients, particularly phosphate. That would be a reason to choose ammoniated phosphates. Thirdly, one should take into consideration soil pH needs to be changed and in which direction, and then finally, volatilization losses.

For blueberries, preferred nitrogen sources are urea and ammonium sulfate. If your pH is below 5.0 the material of choice would be urea (less acidifying); you might opt for Monoammonium phosphate (MAP) or Diammonium phosphate (DAP) if your P is also low (slightly acidifying). Ammonium sulfate is the product of choice if your soil pH is above 5.0 to further reduce pH. Again you might consider using MAP or DAP if your P is low in this case.

For brambles and strawberries, usually the cheapest forms of nitrogen fertilizer are again best so urea and/or ammonium nitrate are good choices. A number of growers use calcium nitrate; there may be some reasons for that particularly in the middle of the summer when there is concern about volatilization losses.

Volatilization losses of nitrogen

When we talk about this volatilization aspect we are primarily concerned with urea. When you apply urea prills to the soil surface the first thing that happens is hydrolysis (Figure 23a). As it takes up water that small organic molecule hydrolyzes and produces ammonium and bicarbonate. The important aspect to this is that it has the immediate effect of increasing the pH around that prill or in that immediate vicinity. If ammonium is present near the soil surface under high pH conditions it can be converted to ammonia gas and lost to the atmosphere (Figure 23b).

Figure 23a: *The urea volatilization process*

Urea + Water $\longrightarrow$ Ammonium + Bicarbonate

Urea Hydrolisis: $CO(NH_2)_2 + H^+ + 2H_2O \longrightarrow 2NH_4^+ + HCO_3^-$ **(pH increase)**

Figure 23b: *The urea volatilization process (continued)*

Ammonia Volatilization: $NH_4^+ \longrightarrow NH_3^- + H^+$

This is not to say that ammonium that is applied as ammonium sulfate can't volatilize, it can also. But in most cases the pH of the soil is low enough to where volatilization losses are not a big deal.

What increases the potential for volatilization losses of ammonia gas are promoted by 1) Urea particles remaining on the soil surface (not irrigated in immediately, no rainfall), 2) High temperatures (above 80 ^oF) and 3) high soil pH. In the case of blueberries where pH is naturally low there is less likelihood for loosing nitrogen as ammonia gas. It is something to consider however in the case of strawberries when you might be fertilizing in the middle of the summer when temperatures a very hot. The potential then for volatilization is very high. One would need to make accommodations to reduce that potential by irrigating the fertilizer into the soil to protect it.

General nitrogen rates for berry crops

Applying the proper nitrogen rate is important in terms of maximizing the efficiency of nitrogen use by any crop. If one applies more than the crop needs, use efficiency decreases and other problems may ensue from the excess.

Recommended rates vary from state to state and region to region, and certainly with various soil types. Tables 22 a, b, and c give a general range for blueberries, raspberries and blackberries, and strawberries.

Tables 22a, b, c. *General nitrogen rates (lb actual nitrogen/acre) for berry crops (rates may vary by region)*

Table 22a. Blueberries (higher rates on sandier soils low in organic matter)			
Yrs. 1-2	**3-4**	**5-6**	**7 and older**
15-20	20-40	30-60	40-70

Rates for blueberries start out relatively low at 15 – 20 pound actual N per acre for plants 1 to 2 years old and increase over time. As the planting reaches maturity (7 years and older) the rate would be between 40 and 70 lb actual N/A. The sandier the soil, the lower the organic content, the higher the rate of N you might need.

Table 22b. Raspberries and blackberries (higher rates on sandy soils and fall bearing types)		
Yrs. 1	**Yrs. 2**	**Yrs. 3 and older**
20-40	30-60	50-100

For brambles the progression is similar starting with a lower rate of 20 to 40 lb actual N the first year, and up to 30 to 60 lb actual N/A the second year. The third year (and older) the rate would be 50 to 100 lb/A. Again the higher rates would be applied on sandier soils. There is also some indication that fall-bearing raspberries would require higher rates than summer-bearing raspberries. This makes sense as they are cut entirely to the ground each spring and then generate a whole new stand of canes and a producing a fruit crop all in one season. Growers particularly on sandier ground will find that rates even as high as 100 lb actual N/A may be optimizing yield for fall-bearing raspberries.

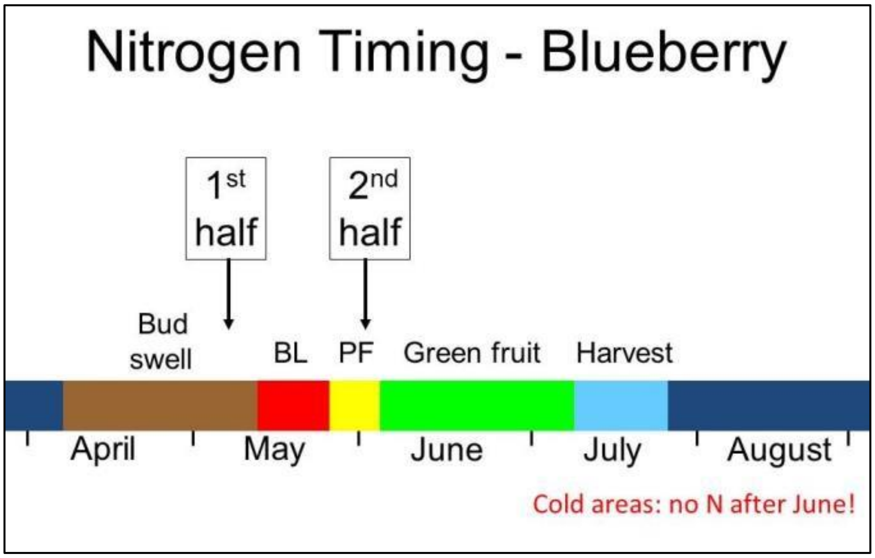
Table 22c. Strawberries (higher rates on sandier soils)	
Yrs. 1	**Yrs. 2 and older**
40-60	50-100

For strawberries the rates vary somewhat from region to region but for the planting year rates of 40 to 60 lb actual N per acre are suggested and then for production years 50 to 100 lb with rates higher on sandier soils.

Nitrogen application timing

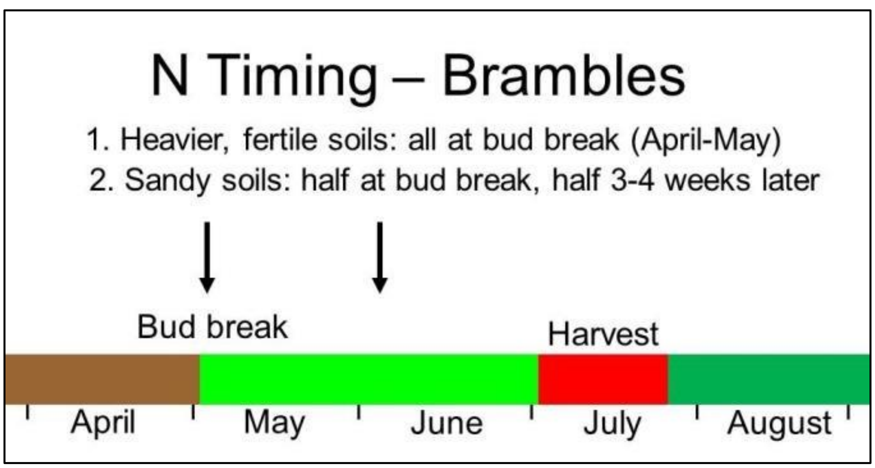
Timing is a critical factor in terms of optimizing nitrogen use (Figures 23a, b, c). A good system for blueberries is to apply N fertilizer in a split application with half of it going on a bud swell time before bloom, and the second half going on during petal fall perhaps 3 weeks later (Figure 24a). This provides nitrogen to the plant early during the rapid growth flush through bloom, petal fall and green fruit. The second application maintains adequate levels through the harvest period. If growing on heavier soils or with higher organic content you may not observe a significant benefit with a split application; one application at bud swell may suffice. The split application system is likelier to be of benefit particularly on sandier sites. If growing blueberries in colder locations where winter injury is a concern then applying nitrogen later than June 30th should be avoided. N applications made later than June in colder growing areas tends to reduce hardiness of the bushes going into winter. If growing hardy blueberries in a less stressful winter location nitrogen may be applied a little bit later in the season. If you are growing blueberries in locations that are stressed by the winter year after year care should be taken in applying nitrogen or maintaining high levels of nitrogen later in the season.

Figure 23a. *Timing of nitrogen applications for blueberries.*



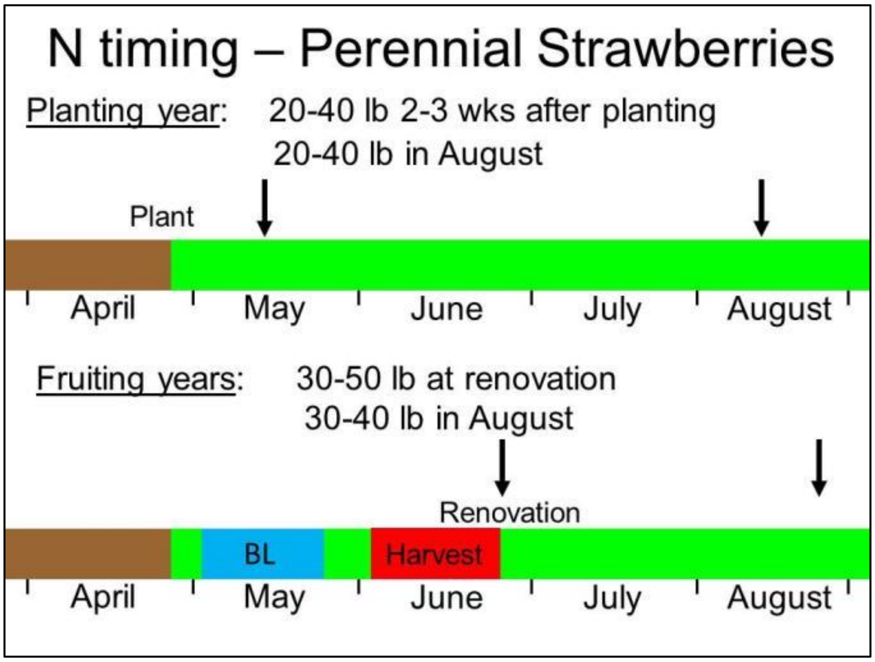
For brambles, the decision on when to apply nitrogen again is somewhat dependent on soil type (Figure 23b). On heavier, fertile soils it is best to apply all of the nitrogen at bud break time in April or May. If growing brambles on sandier soil with low organic matter a split application is recommended with half of the N fertilizer being applied at bud break and the remaining half being applied 3-4 weeks later. This maintains levels of nitrogen available to the plants later into the growing season; this is particularly important for fall-fruiting types to support production into September and October.

Figure 23b. *Timing of nitrogen applications for brambles.*



Recommendations for N application timing vary from planting year to fruiting years for perennial strawberries (Figure 24c). The planting year recommendation is for 20-40 lbs N to be applied 2-3 weeks after planting. This application should be delayed until rain or irrigation has settled the soil around the plants. A second application should be made in August. During the fruiting year the recommendation changes somewhat; 30 to 50 lb nitrogen should be applied at renovation time after harvest, followed by about the same amount again in late August to early September. Some growers producing strawberries on sandy ground feel they need a small amount of nitrogen (10 lb/A or so) in early spring,. This type of application is somewhat risky as it may generate too much vegetation.

Figure 23c. *Timing of nitrogen applications for perennial strawberries.*



Nitrogen placement

The issues in nitrogen placement are a balance between the need to put the fertilizer where it's readily available to the plant vs. not concentrating the fertilizer so much you create salt issue with resulting plant injury. With young plants in the 1st and 2nd years, apply fertilizer by hand in a 2 to 3-ft wide circle around the plant or in a 3 to 4-ft wide band down the row. Broadcasting fertilizer over the entire surface at this point is very inefficient. As the bushes mature, the root systems of these old bushes intertwine in between the rows; any advantage then with banding fertilizer in the row is likely lost and broadcasting fertilizer makes more sense.

Nitrogen placement in brambles again would be similar to that of blueberries. During the planting year it would be applied in a circle around each plant or in a band down each row. In an established planting the situation might also to be to broadcast the fertilizer in a band down the row as most growers are trying to establish a sod row middle along with fertilizing the raspberries.

In perennial strawberries the planting year strategy would be to broadcast the fertilizer in larger because of the close row spacing; it may make some sense to band apply the fertilizer in a smaller planting. Broadcast application would be most suitable for fertilizing established plantings.

Nitrogen release rates from organic nitrogen sources

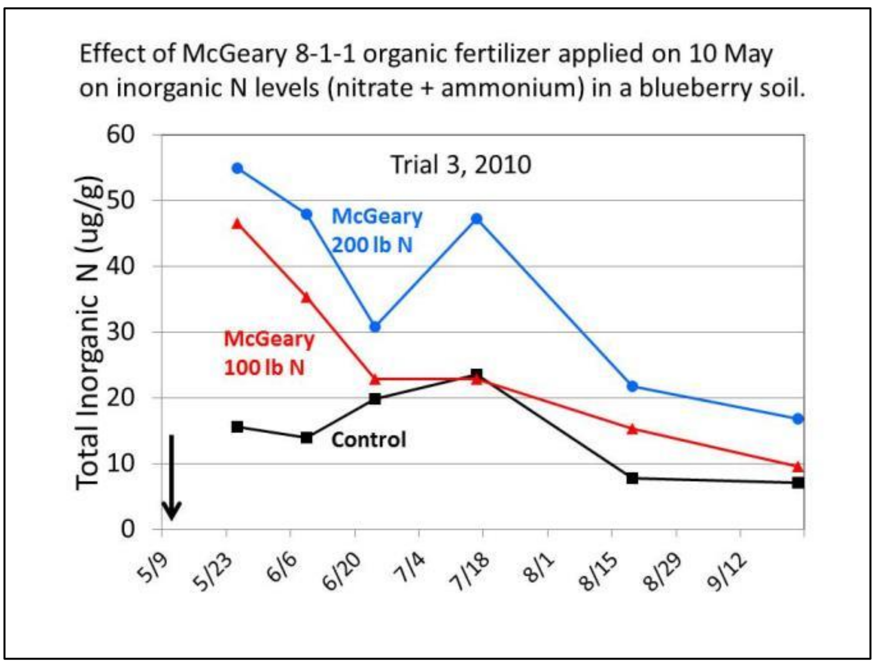
There are a number of organic materials to choose from, of both of plants and animal origin (Table 23). They are relatively high in nitrogen and release a larger percentage of their nitrogen the first year. Composts and aged manures tend to be more stable and release lower percentages of nitrogen during the first year.

Table 23. *Nitrogen content and release rates of some organic sources.*

Material	% N	% available in year 1
Soy meal	7	60-90
Cotton seed meal	6	60-90
Dried blood	12	70-100
Fish meal	14	70-100
Nitrate of soda	16	100
Manure – fresh	0.5 – 2.5	40-80
Manure – dried	2.0 – 5.0	40-80
Compost	0.6 – 2.5	10-40

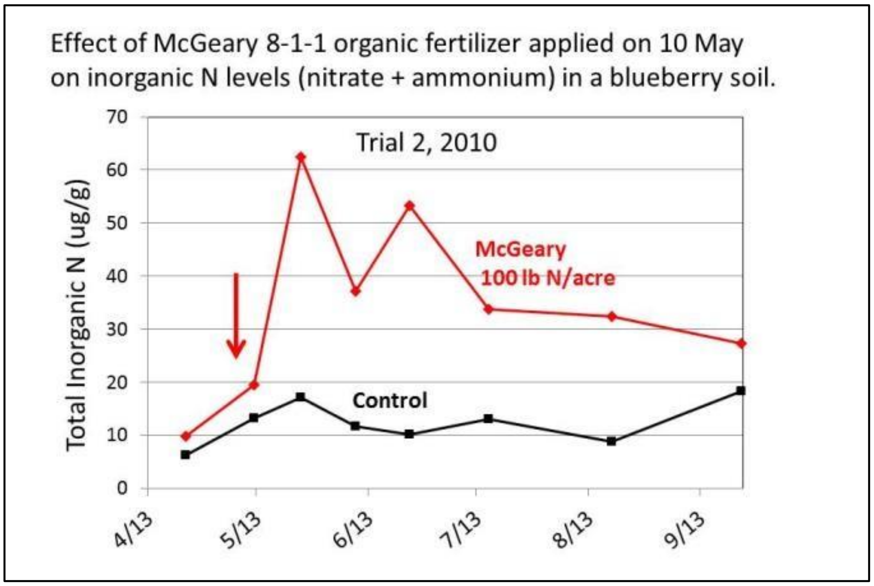
Figure 24 illustrates work done in Michigan with release rates of N from a soy-based organic fertilizer McGeary's 8-1-1 at 2 different rates. The fertilizer was applied on May 10th and total inorganic N (ammonium and nitrate in the soil profile) was monitored. There was an immediate release of available N after application then the release rate tended to decline as the season progressed. Particularly with the higher rate there was still an elevated rate of available N being released into the middle to end of September in this study. This seasonal release on a gradual basis tends to mimic the nitrogen demand needed by the blueberries.

Figure 24. *Release rates of N from a soy-based organic fertilizer, field 1.*



In a study in another field with the same fertilizer (Figure 25); only the lower rate was in this instance. In both of these trials a similar trend was observed with an immediate increase of available nitrogen which declined gradually over the season. And again there was still an elevated rate of available N being released into September. These trials highlight a concern as to how organic blueberries may be fertilized without elevating levels of available nitrogen late in the season when plants should be slowing down and getting ready for winter. A corresponding increase in the levels of bud damage during the winter and winter injury was observed in both trials.

Figure 25. *Release rates of N from a soy-based organic fertilizer, field 2.*



Potassium

Most berry crops have a fairly high demand for potassium; and K needs to be applied perhaps not an annually but often on a somewhat regular basis. Selection of K sources should be made based on whether the production system is conventional or organic, the cost per unit K_2O, the need for other nutrients, and the potential hazard from chloride.

The cost per unit K is cheapest for potassium chloride, potassium sulfate is somewhat higher. The cost for potassium magnesium sulfate. Sul-Po-Mag is even higher per unit K (Table 24). The potential problems with potassium chloride are myriad. It contains chloride which when present in high concentrations are damaging to berry crops. There are organic sources of K including potassium sulfate and Sul-Po-Mag (less processed than conventional sources), and wood ash. Wood ash is very alkaline and not recommended for use in blueberries.

Table 24. *Conventional and organic potassium sources.*

Conventional fertilizers	% K_2O	Comments
Potassium chloride	60-62	Chloride hazard
Potassium sulfate	50-54	Moderate expense
Potassium-magnesium sulfate (Sul-Po-Mag)	22 (11% Mg)	Expensive if Mg is not needed
Organic fertilizers	**% K_2O**	**Comments**
Potassium-magnesium sulfate (Sul-Po-Mag)	18 (11% Mg)	Expensive if Mg is not needed
Potassium sulfate	40-48	Moderate expense
Wood ash	4	Very alkaline

Rates of potassium for existing plantings are those based on soil tests, but generally 100-200 lb K_2O per acre is used to correct most shortages followed by 50-100 lb K_2O per acre for maintenance.

Unlike nitrogen, the timing for potassium is not so critical; it may be applied anytime. That said, fall application is preferred for potassium chloride (muriate of potash) to allow time for chlorine$^-$ to leach out of the root zone before plants begin growing the following spring. This is especially important of you are applying high rates of K. It is important to note excessive K use can cause Mg shortages.

Phosphorus

There are a number of different P materials to choose from; conventional sources are all very highly soluble and highly available to berry crops (Table 25). If you have a need for P then ammoniated phosphates are good choices but if you need only P they are rather expensive. For organic producers bone meal and fish meal are good sources. Rock phosphate isn't used too often as a P source but in the case of blueberries where very acidic soils are present rock phosphate might be a reasonable source as the solubility is quite a bit higher.

Table 25. *Conventional and organic phosphorus sources.*

Conventional fertilizers	% P_2O_5	Availability of P
Superphosphate	21	Very high
Concentrated superphosphate	45	Very high
Di-ammonium phosphate	46	Very high
Mono-ammonium phosphate	52	Very high
Organic sources	**% K_2O**	**Comments**
Bone meal	20-30	moderate
Fish meal	4	moderate
Rock phosphate	3	Very low

Magnesium and Calcium

Sources vary from Epsom salts to various limes (Table 26). Typically, if soils are low in magnesium or calcium it almost always indicates pH is too low. If pH is low, use of dolomitic or calcitic lime is recommended; select one or the other based on soil test results; often dolomitic lime is the material of choice when Mg is low. If pH is appropriate, use gypsum for Ca, or Epsom salts or potassium-magnesium-sulfate for Mg. Apply Ca and/or Mg whenever need is determined.

Table 26. *Calcium and magnesium sources.*

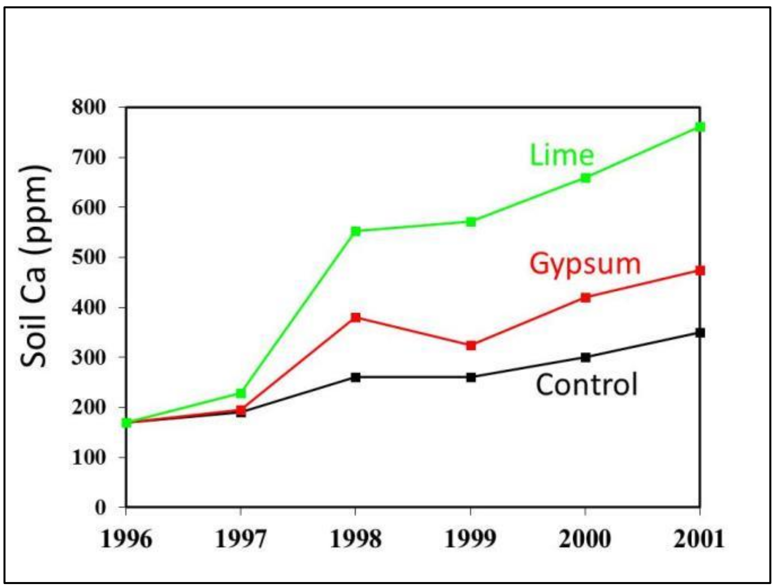
Ca and Mg Sources	% Mg	% Ca	% K
Magnesium sulfate (Epsom salts)	10	--	--
Calcium sulfate (gypsum)	--	22	--
Potassium-magnesium sulfate	11	--	22
Calcitic lime	<5	>30	--
Dolomitic lime	>5	<30	--

Calcium and fruit quality

Elevated levels of calcium in tissue are often associated with improved fruit quality. Research has shown there is a reduced incidence of some physiological disorders in fruit with elevated calcium levels. For example, bitter pit is a localized deficiency of Ca in apple fruit. There is also an increased firmness that accompanies an increase in fruit calcium concentration. Ca inhibits enzymes associated with degradation of cell walls and tissue senescence. There is also a reduction of rot caused several fungal pathogens. This may also be related to Ca inhibiting fungal enzymes that break down tissues.

Calcium also affects berry quality. Increasing levels of Ca in berries can improve the quality of berry fruit. For example, post-harvest Ca fruit dips increased firmness and/or reduced rot in blueberries and strawberries but the commercial utility of this practice is limited due to quality issues in itself. These dips did demonstrate however if there are ways to increase Ca levels in fruit there is some benefit. The most likely approach would be spraying fruit with Ca sprays prior to harvest. Preharvest calcium sprays have been demonstrated in studies to sometimes increase firmness, prolong shelf-life, and/or reduced Botrytis rot…but not always consistently. If Ca sprays are to be used, consider leaving an untreated area in the filed so comparisons may be made to verify effects (or lack thereof…).

Figure 26. *Effect of annual application of lime (1,000 lb) and gypsum (500 lb) on calcium levels in an acidic blueberry soil.*

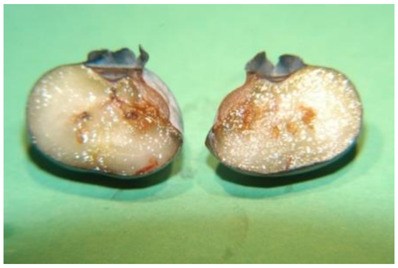


Another way to supply calcium to berry plants is through the roots (Figure 26). For blueberries modest rates of lime and gypsum raised soil pH and Ca, but had inconsistent effects on leaf Ca levels and no effect on fruit Ca. Treatments did not affect fruit yield, shelf life, or firmness.

Boron

Boron is an interesting micronutrient and it can become deficient in berry crops. If there is a boron deficiency it generally causes poor shoot growth and dieback, reduced fruit set or sometimes fruit deformities (Figures 27 a, b, c). Berries are sensitive to excess boron; it is not wise to apply boron unless soil tests indicate a deficiency. Apply proper rates if soil or leaf analyses show a need. Application options include: 1) a foliar spray of 2 lb Solubor (20% B) per acre in June, 2) a soil spray of 3 lb Solubor in spring, or 3) a soil application of 5 lb borax (11% B) in spring.

Figure 27a, b, c. *Blueberry showing Ca deficiency (left); inside view, note corky area (center); and strawberries showing B deficiency, (right).*



Iron

Iron deficiencies only occur in berries periodically but almost always occur where soil pH is too high. The best treatment for this usually is to reduce pH. Foliar sprays of Iron chelate may alleviate some leaf symptoms (Figures 28a, b) but usually do not improve overall plant vigor.

Figure 28a, b. *Blueberry showing iron deficiency symptoms on leaves (left); strawberry leaf symptoms of the same (right).* Photos courtesy E. Hanson and M. Pritts.

Manganese

Manganese deficiencies occur occasionally in berries in the Midwest, and appear to be even less common in the Northeast. The cause is usually a pH that is too high. Blueberries are seldom if ever are deficient in Mn as they are grown on low pH soil where Mn is readily available. To alleviate Mn deficiencies follow these steps. First, check and reduce pH if it is too high. Second, use foliar sprays of manganese sulfate or Mn-chelates to correct shortages if pH is appropriate. And third, Maneb, Dithane, and Manzate fungicides contain about 16% Mn, and can be good sources of manganese for labeled crops such as brambles when used in disease management programs.

Zinc

Zn deficiencies occur occasionally in berries in the Midwest and also the Northeast. Shortages typically occur where soils are sandy and too alkaline (high in pH). Strategies for alleviation of Zn deficiencies are similar to those for manganese: 1) Check and reduce pH if it is too high, 2) Apply foliar sprays of Zn sulfate or Zn chelate products if pH is appropriate and, 3). Ziram fungicide contains about 16% Zn and can be a good source for blueberries and some brambles.

Copper and Molybdenum

Soils in the Midwest and Northeast appear to supply adequate levels of Cu and Mo for berries, as deficiencies in these have not been documented. Copper shortages have occurred in Georgia rabbiteye blueberries. Symptoms include abnormally small leaves and shoot dieback during winter. Fixed copper fungicides (e.g. Kocide, Champ) used in disease management programs are suitable sources of Cu for labeled crops. Note copper salts can potentially injure tissues so use with caution; test the product on a few plants before using widely.

Fertigation

Fertigation is the injection of fertilizers through trickle irrigation systems; this can be a convenient and efficient application method. For berries in the ground, fertigation is most useful for delivering nitrogen and sometimes potassium and phosphorus. The advantages are greater control over nutrient placement and timing and as a result, improved efficiency in terms of reducing the amount of product required, with some caveats. Disadvantages may include cost of investment in equipment and the need for regular maintenance and management (Table 27).

Table 27. *Advantages and disadvantages of fertigation.*

Advantages	Disadvantages
Greater control over nutrient placement and timing	Capital costs: injector, tanks, backflow valve
Improved efficiency; less fertilizer required (if not over-irrigating)	Maintenance (tanks, line plugging) and calibration

Many of these typical fertilizers are very soluble, for example, ammonium nitrate, ammonium sulfate, calcium nitrate. Potassium materials are somewhat lower in solubility than nitrogen materials. Table 28 gives some common products and their solubility in pounds per gallon; note they are extremely high in some cases like ammonium nitrate at 16 lb per gallon. Note values listed in the table are their solubilities at 70 ^{o}F; all product solubilities are lower in cold water.

Table 28. *Solubility of some common fertilizers.*

Fertilizer	Solubility (lb/gal)*
Ammonium nitrate (33-0-0)	16.0
Ammonium sulfate (21-0-0)	6.2
Calcium nitrate (15-0-0)	11.2
Di-ammonium phosphate (21-54-0)	5.7
Mono-ammonium phosphate (11-48-0)	3.1
Urea (45-0-0)	8.8
Potassium chloride (0-0-60)	2.1
Potassium sulfate (0-0-48)	0.9

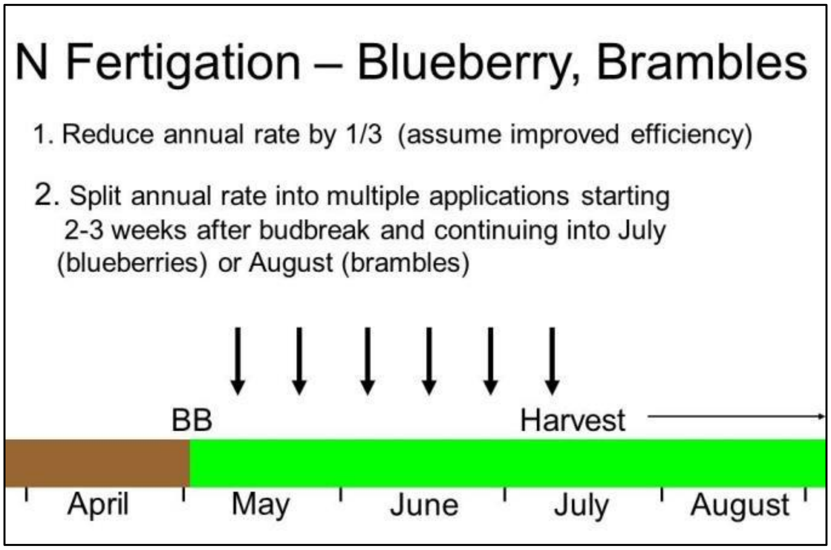
* At 70 ^{o}F. Solubility of all materials is lower in colder water.

Most mixtures may reduce the solubility of some salts. For this reason do not mix calcium with sulfates or phosphates as they may form precipitates causing plugging. Use a “jar test” to test for precipitates.

Nitrogen fertigation for blueberries and brambles

If you are new to fertigation, assume this system will provide improved efficiency and reduce the needed annual nitrogen amount by 1/3rd. Then split the resulting annual rate into multiple applications beginning 2 to 3 weeks after bud break and continuing into July for blueberries and into August for brambles (Figure 29). Fertigation may be done weekly, bi-weekly or every time you irrigate. There may not be much of an improvement seen if one fertigates every time you irrigate versus 3 to 4 times at intervals during the season.

Figure 29. *Nitrogen fertigation for blueberries and brambles.*



Fertigation can be very efficient if the irrigation system has high uniformity, nutrients are applied when demand is high, and plants are not over-irrigated. Over irrigation leaches nutrients below roots making them unavailable. It is very easy to push nitrogen through the profile and down out of reach when pulsing fertilizer through the system and then irrigating heavily afterwards. Figure 30 shows a ditch dug alongside a row of raspberries in a high tunnel with drip irrigation; note water movement into soil.

Figure 30. *Soil profile under raspberry row in high tunnel showing movement of water from fertigation system. (Photo courtesy E. Hanson)*