Chapter 4 Correction of Preplant Soil Problems for Berries - *Dr. Eric Hanson, Michigan State University*

This chapter will discuss means of correcting soil nutritional problems for berries, emphasizing preplant considerations. There are a number of things beyond nutrition to be concerned about prior to planting any berry crop. Things to think about that may or may not relate to nutrition:

- Have a good appreciation of how soil texture varies across the site. The site may contain one or more soil types. Have an idea where breaks in soil types occur - it may influence how you manage nutrition in coming years.
- Consider the past history of management on the site – was it used for farming for a long time prior to berry crops - would it benefit from cover cops, manure, compost or other organic amendment additions to build OM in soil prior to planting?
- Are there wet spots? This does relate to nutrition to some degree as it interacts with fertility. Are there poorly drained areas? Consider tile draining and/or surface ditching help to get rid of excessive water.
- Have you done an adequate job of soil testing for pH and nutrient levels prior to establishing your plants?

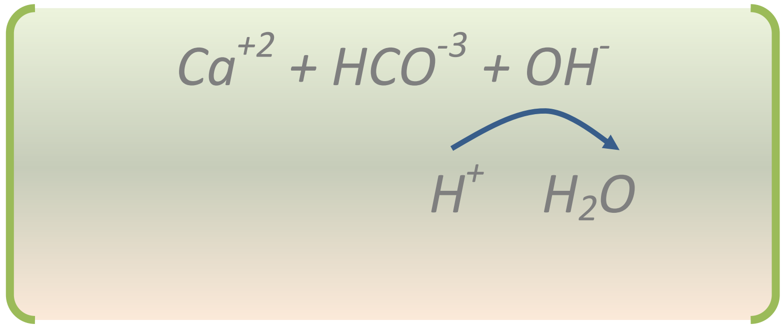
Let's review

Soil analysis laboratories - There are many private and university labs to choose from. Only use the interpretation recommendations from that lab not a different one as methods vary from lab to lab. Make it simple on yourself: pick one lab and stick with it.

Optimum pH range for berries – There are two basic groups of berry crops: *1)* Brambles and strawberries like slightly acidic soils ranging from 6.0 to 6.5 and 2) Blueberries and cranberries which are very acid-loving so way down on pH scale (4.2 to 4.5). The first order of business is getting pH in the range you'd like for these plants.

Continued below.

Preplant pH adjustment



Liming

If pH too low, liming is in order. Lime is calcium carbonate ($CaCO_3$); it dissolves slowly in soil solutions and releases calcium and carbonate anions. There a lot of different liming materials and a number of considerations for choosing the best type.

General benefits of liming

Liming reduces possibility of toxic levels of aluminum and manganese. As pH increases the solubility of these elements declines. Liming supplies calcium and depending on lime source possibly magnesium. It also Increases availability of phosphorus if you are outside of the desired range for crops. Liming increases microbial activity associated with nitrogen fixation (legumes perform better at higher pH) and nitrification (oxidation of ammonium to produce nitrate); microbes for this prefer higher pH. In addition, organic matter decomposition and nitrogen mineralization tend to be promoted by more neutral pH ranges.

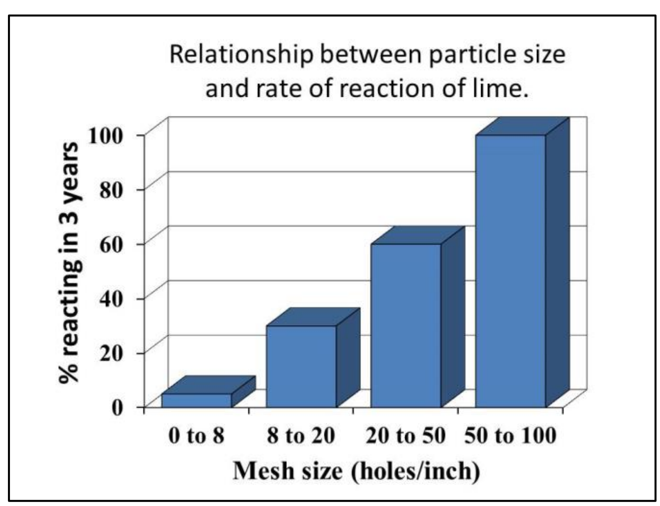
How to choose a lime source

Ask yourself the following questions when selecting a lime source to use to lower pH. First, what is the neutralizing value (calcium carbonate, $CaCO_3$ equivalent) of the product you are considering and how effective it is in increasing pH? (*Table 4*).

Table 4. *Neutralizing value of liming materials (as compared to pure $CaCO_3$)*

Material	Neutralizing value
Calcium carbonate (CaCO3)	100
Dolomitic lime	95-108
Calcitic lime (High-Cal lime)	95-100
Hydrated lime	120-135
Marl	50-90
Gypsum (CaSO4)	0

Second, what is the reaction rate (dictated by particle (mesh) size of the product; in other words, how fast does it react in soil? Is there a need for supplemental magnesium also that may be supplied as part of the lime product selected? What's the product cost, ease of application, and availability in your location?



An additional consideration is the speed of reaction of the various materials which is dictated by particle size as a function of available surface area (*right*). Smaller mesh size equals larger particles. A mesh size of greater than 20 reacts fairly well within year or 2 in soils. Eight to twenty mesh size particles react very slowly, less than half has reacted in 3 years; zero to eight mesh size particles are almost inert. When you think of value of lime material product contains high percentage of these size particle sizes pretty much worthless in terms of fast reaction.

Marl is a kind of lime mud, mined in different locations; it tends to vary greatly in liming capacity. Gypsum contains calcium but is not a liming material; it has no effect on soil pH.

Another type of lime used in fruit production in various areas is pelleted lime, "Pell-Lime", a finely ground (smaller than 100 mesh) Calcitic or Dolomitic lime formed into 4-20 mesh size pellets using binders. Pell-lime generally reacts about as quickly and neutralizes the same amount of acidity as an ag-lime with similar neutralizing values. Pell lime is easier to apply and handle and wind-blown losses may be less. That being said, it is much more expensive than most ag-lime; you are paying more for all that convenience…

Lowering soil pH

Lowering soil pH is not usually desired except on blueberry sites where pH is above 5.0. In some instances, however, lowering soil pH may be desirable with other berry crops (strawberries and raspberries) where pH is 6.5 or above. This may be the case on sites with naturally occurring alkaline soils and/or a history or lime applications associated with agronomic crop production.

Acidifying agents

There are a number of materials for lowering soil pH but sulfur is the material of choice to use. Elemental sulfur, depending on the brand, comes as prills, chips, or powders; ranging from 90-95% sulfur. So if the recommendation is 500 lb/acre sulfur then you would want to increase the application by 5-10% to compensate. Prills easiest to use, being low in dust and easy to spread with fertilizer spreader. Chips are intermediate in ease of use, come in lots of different sizes and tend to be dusty during application. Powdered sulfur is difficult to use altogether, being extremely dusty, except perhaps in a back yard situation where a small quantity is needed.

Iron sulfate is a salt that also reduces pH and reacts quickly in soils, but is more expensive than sulfur because 6 times as much is required for same pH reduction. Its use may also result in salt stress.

Aluminum sulfate is pretty much the same as iron sulfate reacting quickly in the soil but also requires high rates and may result in aluminum toxicity.

Sometimes people think about using acidifying N fertilizers to reduce pH. Ammonium sulfate is a very acidic N fertilizer; it helps to maintain pH low but should not be used to reduce pH initially as it will result in excessive N. For example 1 lb sulfur provides same acidity as 2.8 lb ammonium sulfate $(NH_4)_2SO_4$ so if the recommendation is for 500 lb/A sulfur the equivalent $(NH_4)_2SO_4$ would provide 294 lb/A N! This would be neither efficient in terms of nutrient use nor cost effective.

A little bit about sulfur…

Sulfur is oxidized by a specific group in bacteria in soil thus its pH lowering function is a biological process. As such, nothing much happens during off season when soils too cold for the bacteria to work. Sulfur lowering of soil pH occurs best in moist, warm, aerated soils; bacteria oxidize sulfur to sulfuric acid. The reaction requires the better part of an entire growing season (year) to occur. Apply sulfur the year before planting; it's important is to incorporate it well for the quickest reaction.

Sulfur may be broadcast over a site (recommended) or banded in planting rows. For heavier, highly buffered soils, it is most economical to do this where bushes will grow as one only needs apply perhaps half the sulfur amount needed as compared to broadcast application.

Soil types are instrumental to the amount of sulfur needed to drop pH; 2-3 times as much needed to drop it on a loam vs. sand; 4-5 times as much for a clay soil as opposed to a sand (*Table 1*). It may not be economical to produce blueberries on a soil with high pH that is also a highly buffered soil as it would take so much sulfur to get to proper pH.

Cautions

If applying more than 500 lb/acre sulfur, split the application. Apply half in the season prior to planting and the remaining half in spring prior to planting so its reacting in soil at 2 different times. It is important to note sulfur produces hydrogen sulfide on poorly drained soils and is toxic to plant roots. Toxic levels could develop in those areas due to anaerobic conditions in the root zone.

Preplant phosphorus use

Incorporate phosphorus (P) prior to planting at rates indicated by soil test results. Choose materials based on coast per unit of P_2O_5 and the percent availability of P from the materials (*Table 6*). Standard materials such as superphosphate and concentrated superphosphate are readily available (100% soluble); the choice between these is based on pricing per unit P.

Table 6. *Sources of phosphorus*

Fertilizer	Total P_2O_5%	% P available
Superphosphate	21	96-100
Concentrated superphosphate	45	96-99
Rock phosphate	34	3-8

Rock phosphate the (mineral other P fertilizers are manufactured from) is fairly high in P but very low in soluble P. It may have some utility in organic settings but also in blueberry settings where you want a slow release of P over time. In high pH soils, rock phosphate would be non-effective as its solubility goes down as pH goes up; in acidic soils this might be a nice material to supply a gradual release of P over time as long as pH remains low.

Diammonium and/or mono-ammonium phosphate doesn't make much sense preplant as you typically don't want to be putting a large amount of N in soil preplant; they are also very, very expensive sources of P unless you need the N also.

Preplant potassium

Incorporate potassium (K) prior to planting at rates indicated by soil test results. Choose potassium materials based on cost per unit of K_2O, the need for other nutrients, and the potential hazard from chloride if considering the use of muriate of potash (most cost effective) as your K amendment source (*Table 7*). The potential hazard from chlorine (muriate) if applying low levels (<200 lb/A) is minor and probably safe on most of these crops. If muriate is the material of choice (lower price) on a sandy soil, and there is a concern about chlorine toxicity, apply it in fall so most of chlorine anions leach out of root zone during the winter to reduce potential risk.

Table 7. *Sources of potassium*

Fertilizer	% K_2O	Cost per unit K_2O
Potassium chloride (muriate of potash)	60-62	$
Potassium sulfate (SOP)	50-54	$$
Potassium-magnesium sulfate (Sul-Po-Mag)	22 (11% Mg)	$$$

Preplant magnesium and calcium

Again, incorporate magnesium (Mg) and calcium (Ca) prior to planting at rates indicated by soil test results. Choose Mg and Ca materials based on cost per unit of Mg or Ca, the need for pH adjustment up or down, and then the need for other nutrients (Table 8). The cheapest sources for Mg and Ca are the limestones (calcitic lime, dolomitic lime); these are good choices for increasing pH. Ratios of Ca and Mg in these limes vary with the source of the materials.

If there is a need to add Mg but not increase pH then magnesium sulfate would be the material of choice. If calcium is needed without increasing pH then calcium sulfate (gypsum) is a good option Magnesium low also? Consider Sul-Po-Mag; it has a higher K_2O cost per unit but may still be a good choice economically as it contains both K and Mg.

Table 8. *Sources of magnesium and calcium*

Fertilizer	% Mg	% Ca	% K
Magnesium sulfate	10		
Calcium sulfate (Gypsum)		22	
Potassium-magnesium sulfate	11		22
Calcitic lime	< 5	> 30	
Dolomitic lime	>5	<30	

Gypsum

Gypsum supplies calcium but does not alter pH. This product is known to be very beneficial on soils high in salts (sodic soils) where it improves flocculation (adhesion) of clay particles and thus improves water infiltration/drainage. Sodic soils are not typically found in eastern US as this region tends to be a humid environment with ample precipitation most of the time.

However, another interesting fact about gypsum is that it has also been shown to reduce raspberry root rots caused by Phytophthora species in NY (*Maloney et al., 2005*) and to some extent in Washington trials (*Pinkerton et al., 2009*).

Gypsum was also demonstrated to reduce Phytophthora diseases of avocado (*Messenger et al*., 2000), soybean (*Sugimoto et al*., 2010) and ginseng (*Maloney et al.,* 2005).

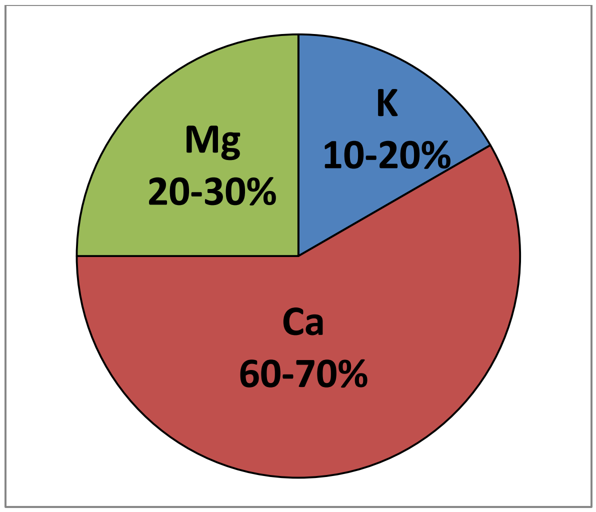
These are different fungal species and the gypsum seems to benefit the plants in each regard. This is not an effect of calcium on soil drainage or physical properties but is apparently due to the inhibitory effect of high calcium concentrations on fungal growth and infection of plant tissues, along with reproductive rate of the fungi.

The recommendation from the NY work with raspberries is to incorporate 3-6 tons of gypsum prior to planting raspberries on sites with a history of Phytophthora root rot.

Potentially then, enhancing free calcium levels in soil with gypsum would reduce incidence of other Phytophthora diseases; for example, red stele disease of strawberries.

A related question would be whether you get the same response if you are working with soil that is naturally high in calcium. That is unknown at this point. In Michigan we think about a balance of Ca, Mg and K in soils. This is expressed as a balance of total bases on the cation exchange complex in soil (*Figure 7*).

Figure 7. *Desired ranges for % of bases*



Salt stress

Salt in water reduces its water potential, making it less available to plants, causing them to be water stressed. High soil salt levels tend to be a problem in western arid regions, and are much less common in humid areas where precipitation tends to leach salts out of the top soil horizons (i.e. eastern US states). However, growers can create salt problems in soils by using fertilizers inappropriately (excessive use, application of inappropriate types of fertilizers at the wrong time) or by using a high-salt irrigation water source. Salty water conducts electricity; this makes measurement of soil salinity possible using electrical conductivity or EC.

Berry crops are among the least tolerant of elevated salt levels in soil. Table 9 below gives EC readings for various fruit crops. Tree fruits tend to be more tolerant than blackberries, raspberries or strawberries. Blueberries were not included in this listing but would likely fall at or below the same levels as raspberries and strawberries or perhaps be even more sensitive to high salts.

Table 9. *Soil salt levels based on saturated paste extract potentially causing yield reductions in fruit crops.**

Crop	Soil EC** (dS/m)***
Olives	2.7
Grapefruit	1.8
Apple/pear/peach	1.7
Apricots	1.6
Grapes	1.5
Blackberries	1.5
Raspberries/strawberries	1.0
Blueberries	<1.0

*Western Fertilizer Handbook (1990).

**EC Electrical conductivity

***1 dS/m = 1mmho/cm

The effect of fertilizers on salt content of soil has been well-documented; it's expressed as salt index. Table 10 lists some of the more common N fertilizer sources and their salt indices. Quite often published values for salt indices of fertilizers are essentially expressed per unit fertilizer not per unit nutrient. So although ammonium nitrate has a very high salt index of 105, it contains a higher concentration of N than some other nutrient sources. So if one extrapolates that salt index on a per unit nitrogen basis (lb N), the potential for salt injury would be less than with calcium nitrate. The assumption being if you desired to apply desired a certain amount of N you would contribute less salt per the amount of N using ammonium nitrate than you would with calcium nitrate - even though calcium nitrate is often touted as being more safe fertilizer from a salt standpoint.

Table 10. *Salt index values for some common nitrogen fertilizers*

Fertilizer	% N	Salt Index*	Salt Index per Unit N
Ammonium nitrate	33	105	300
Ammonium sulfate	21	69	328
Calcium nitrate	12	53	442
Di-ammonium phosphate	18	29	161
Mono-ammonium phosphate	11	27	245
Natural organic	13	3.5	70
UAN 28%	28	71	222
Urea	46	75	162

*Salt index is the increase in osmotic pressure resulting addition of fertilizer to a solution, relative to effect of the same amount of $NaNO_3$ (SI = 100).

Table 11 provides salt indices for some common P and K fertilizers. For the most part phosphorous fertilizers are relatively low in salt indices except for ammoniated phosphates. With potassium fertilizers chloride has a higher risk of salt injury.

Table 11. *Salt index values for some P and K fertilizers*

Fertilizer	% Nutrient	Salt Index*	Salt Index per Unit Nutrient
P2O5			
Superphosphate	20	8	39
Concentrated superphosphate	45	10	22
Mono-ammonium phosphate	11	27	245
Di-ammonium phosphate	18	29	161
K2O			
Potassium chloride	63	114	181
Potassium sulfate	54	46	85

*Salt index is the increase in osmotic pressure resulting addition of fertilizer to a solution, relative to effect of the same amount of NaNO3 (SI = 100).

Organic nitrogen sources

There are a lot of different sources of organic nitrogen (*Table 12*). Some of the higher N content sources include dried blood, fish meal, and nitrate of soda. Be sure to check with you certifier for which types of these they accept. Good phosphorous sources would be bone meal or fish meal; kelp and wood ash are potassium sources.

Table 12. *Nutrient content of some common organic nutrient sources**

Material	N	P2O5	K2O
Bone meal (steamed)	1-2	18-34	--
Compost	1-3.5	0.5-1.0	1-2
Cotton seed meal	6	2.5	1.7
Dried blood	12	1.5	0.6
Fish emulsion	5	2	2
Fish meal	14	4	1
Kelp	1	0.5	4-13
Marl		2	4.5
Nitrate of soda	16	--	--
Rock phosphate	--	3	--
Soybean meal	7	2	2
Wood ash	--	1-2	3-7

Preplant manure and compost addition

This has a lot of significance now with given the increasing prices of nitrogen fertilizer which have doubled in the last decade. Prices for two common phosphates and potassium chloride have more than doubled (*Figures 8a and 8b*).

Figure 8a. *Average nitrogen fertilizer price trends in the US*

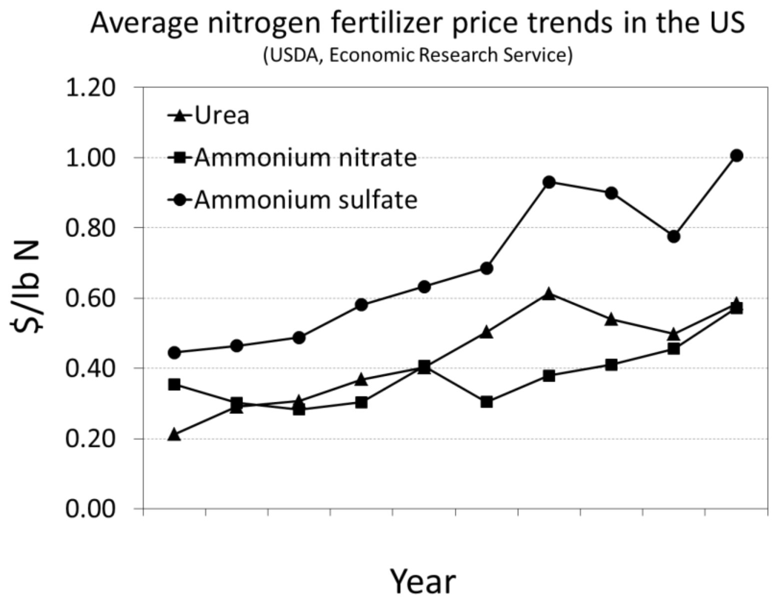
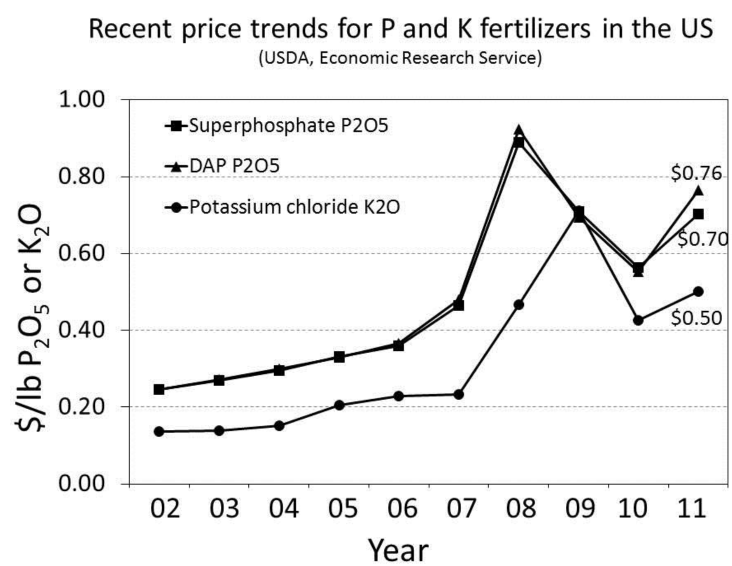


Figure 8b. *Recent price trends for P and K fertilizers in the US*



Manure and/or compost additions are beneficial, particularly on sandier soils or heavily farmed sites to provide nutrients, increase soil organic matter and improve soil structure. Apply and incorporate raw manure in the fall before spring planting. Table 13 provides a short list of different manures types and their nutrient content in pounds per ton.

Any material to be applied should be analyzed prior to application to avoid excessive total salts, excessive P, N tie-up or excess, and/or specific element toxicities (heavy metals such as boron, sodium or chloride). Avoid manure or compost with salt levels > 10 dS/m. Apply materials with moderate salt levels in the fall to allow salts to leach.

Table 13: *Manure nutrient content (lb/ton)**

Material	NH_4-N	Total N	P_2O_5	K_2O
Swine, no bedding	6	10	9	8
Beef, no bedding	7	21	14	23
Dairy, no bedding	4	9	4	10
Dairy compost	<1	12	12	26
Poultry, w litter	36	56	45	34
Poultry compost	1	17	39	23
Turkey w litter	13	20	16	13

**From: Rosen and Bierman. Univ. Minn. Ext. Bul. M1192.*

Summary

There are a number of things beyond nutrition to be concerned about prior to planting any berry crop. Things to think about that may or may not relate to nutrition include:

- Have a good appreciation of how soil texture varies across the site. The site may contain one or more soil types. Have an idea where breaks in soil types occur - it may influence how you manage nutrition in coming years.
- Consider the past history of management on the site – was it used for farming for a long time prior to berry crops - would it benefit from cover cops, manure, compost or other organic amendment additions to build OM in soil prior to planting?
- Are there wet spots? This does relate to nutrition to some degree as it interacts with fertility. Are there poorly drained areas? Consider tile draining and/or surface ditching help to get rid of excessive water.
- Have you done an adequate job of soil testing for pH and nutrient levels prior to establishing your plants; if so, have you made the recommended amendments?

Additional resources

1. Pritts, M. 2012. Site and Soil Requirements for Berry Crops http://www.fruit.cornell.edu/berry/production/pdfs/sitesoireqsmfru.rev.pdf
2. Pritts, M., and Hancock, J. (eds.) 1992. “Nutrient Management” Chapter 11 in: Highbush Blueberry Production, Plant and Life Science Publishing, Ithaca, NY. 200 pp. Fair use copy available in pdf format: http://host31.spidergraphics.com/nra/doc/Fair%20Use%20Web%20PDFs/NRAES-55_Web.pdf
3. Bushway, L., Pritts, M. and Handley, D. (eds.) 2008. “Soil and Nutrient Management”, Chapter 7 in: Raspberry and Blackberry production Guide for the Northeast, Mid-West and Eastern Canada. Plant and Life Science Publishing, Ithaca, NY. 157 pp. Fair use copy available in pdf format: http://host31.spidergraphics.com/nra/doc/Fair%20Use%20Web%20PDFs/NRAES-35_Web.pdf
4. Pritts, M., and Handley, D. 1998. Soil and Nutrient Management”, Chapter 7 in: Strawberry production Guide for the Northeast, Mid-West and Eastern Canada. Plant and Life Science Publishing, Ithaca, NY. 162 pp.
5. Hanson, E. and Hancock, J. 1996. Managing Nutrition of Highbush Blueberries. Michigan State University Extension Bulletin E-2011, 8 pp.