Managing the Nutrition of Big bush Blueberries

Blueberries evolved under acidic soil conditions where levels of many nutrients are naturally low. Generally, this crop is sensitive to too much nutrient, therefore many fertilizer practices common to bush and tree fruit production are not appropriate for blueberries. Proper management of nutrition is particularly important in blueberry culture because most blueberries are grown on sandy soils that are prone to leaching. Efficient use of fertilizers will reduce production costs and minimize adverse effects on water quality.

This bulletin describes the diagnosis of nutrition related problems, traditional commonly used fertilizers and new techniques for correcting nutritional problems.

Symptoms of Nutritional Problems

Nutrient deficiency and toxicity symptoms are useful in diagnosing specific problems, though accurate diagnoses can be difficult because similar symptoms may be caused by a variety of stresses (e.g., water, herbicides, nutrition, etc). Basing nutritional practices on symptoms and bush appearance alone is not advised because symptoms indicate acute nutrient shortages that may have already reduced yield or bush health.

Nitrogen (N). Inadequate N limits bush growth. New shoot growth is reduced and often only one flush of growth occurs. Few new canes are initiated. Leaves are pale green (chlorotic) rather than the lush, dark green of adequately fed plants. The chlorosis is uniform across the leaf, with no mottling or pattern. The older, lower leaves usually develop the pale color before younger leaves at the tops of shoots. Leaves of deficient plants often develop fall colors and drop off early. Yield is usually reduced.

Excessive N causes abundant vigorous shoots and large, dark green leaves. Bushes may produce several growth flushes, the last of which may be too late to harden off properly before winter. Tips of these shoots are often winterkilled. Bushes receiving too much N often produce lower yields of small, late-ripening berries also recent growth flushes can be scorched leading to necrosis of growing tips

Phosphorus (P). Symptoms of P deficiency are not commonly seen on field plants. In addition, field plants seldom respond to P applications. Deficient plants may be stunted and have small leaves. Leaves may be tinted dark green to purple, particularly on the tips and margins. Leaves may lie unusually flat against the stems. Twigs are narrow on deficient plants and may also exhibit a red, purple color. Symptoms of excessive P have not been reported, but very high P levels may cause iron (Fe) deficiencies by inhibiting uptake. This is generally associated with high soil pH as, at optimum pH, phosphorus availability is reduced

Potassium (K). Potassium deficiency causes a dieback of the tips of shoots. Leaves may develop several symptoms, including scorching along the margins, cupping and curling, and necrotic spots. Younger leaves toward the tips of shoots may develop interveinal chlorosis similar to that caused by iron deficiency.

Magnesium (Mg). Symptoms of Mg deficiency are seen periodically in commercial plantings. A distinctive pattern of chlorosis develops between the main veins of leaves. These regions may turn yellow to bright red while tissues adjacent to the main veins remain green. Leaves at the bases of canes and shoots show symptoms first. Young leaves at the tips of shoots are seldom affected.

Boron (B). Deficiencies of Boron are not common, however, reported symptoms include a dieback of shoot tips. Leaves close to aborted shoot tips develop a mottled chlorosis and cupping. Flower and vegetative buds may fail to open on severely affected plants.

Iron (Fe). Symptoms of iron deficiency are common in blueberries. Deficiency causes the tissue between veins to turn a light yellow to bronze-gold chlorosis.

Symptoms differ from those associated with Mg deficiency in that the main veins and many minor veins remain green in Fe-deficient leaves. Symptoms normally appear first on the youngest leaves toward shoot tips. Shoot growth and leaf size are reduced.

Calcium (Ca), Sulphur (S), Copper (Cu), Manganese (Mn) and Zinc (Zn). Deficiencies of these nutrients have not been reported on field grown blueberries, but symptoms have been induced by removing nutrients from plants experimentally. Ca deficiency causes an interveinal chlorosis on young leaves and scorching of the margins of older leaves. Young bushes deprived of S develop leaf symptoms similar to those caused by N deficiency, including a uniform chlorosis (no pattern or mottling). Symptoms of Cu and Mn deficiency are similar and include interveinal chlorosis and shoot dieback in severe cases. With Mn deficiency, regions near the leaf margin may die, as well as isolated spots throughout the leaf. Zn deficiency causes a uniform yellowing of young leaves (no interveinal pattern) that develops early in the season.

Testing Soils and Interpreting Results

Soil testing is a valuable part of blueberry nutrition programs. Soil pH needs to be monitored periodically because pH influences the availability of many nutrients to plants. Blueberries require relatively small amounts of most nutrients, and most soils can supply adequate quantities if the pH is maintained in the proper range.

Soil tests also provide estimates of the quantities of P, K, and Mg that are available to plants. Soil tests, however, provide are only an estimation of nutrient availability to plants.

Pre plant sampling. Collect soil samples 1 or 2 years before planting to provide adequate time to adjust pH, if necessary. Collect an adequate number of soil samples to best represent the soil on the proposed site. Soil pH or nutrient levels can vary greatly over short distances. As a general rule, collect 20 samples per site with little visible variation in soil characteristics. If soil organic matter, texture or previous crop history varies, sample each distinctly different area separately. Four to six separate samples may be needed to adequately characterize a variable site. Each soil sample submitted for analysis should be a composite of the 20 to 40 sub samples taken from throughout the area.

Blueberries may root to depths of 12 to 16 inches, so sample soil to these depths if practical. Shallow sampling may give misleading information if pH or nutrient levels vary with depth.

Sampling established plantings. Sample soil from existing plantings every 2-3 years. All plantings may be sampled the same year or portions may be sampled more frequently on a rotating basis. Collect soil from within the row to a depth of 8 to 10 inches. Sample at any convenient time of year. Soil sampling is particularly important where the soils have been acidified. If the acidifying agent was applied to the soil surface and not incorporated, pH will likely increase with depth. Collecting separate topsoil (0 to 8 inches) and subsoil (8 to 16 inches) samples will provide a better understanding of whether the soil has been acidified adequately. Acidified soils often increase in pH over time so these plantings need to be monitored more frequently than sites on naturally acidic soils.

Interpretation. The pH of blueberry soils should be adjusted if needed. Blueberries may perform well when soil pH is between 4.0 to 5.5, but 4.5 to 5.0 appears to be best. Apply lime at rates recommended on the soil test report if the pH is below 4.0. If the soil Mg level is also low, use dolomitic lime. If lime rates are not given and pH is below 4.0, apply 1000Kg lime/ha on sandy soils, 2000Kg on loam soils or 4,000 Kg on soils with high organic content.

If soil pH is greater than 5.5, apply adequate elemental sulphur to decrease pH to 4.5 (see Table 1). The amount of sulfur required is very dependent on soil texture. Relatively little sulphur is needed on sands, whereas soils high in clay or organic matter require much more. It is important to apply and incorporate Sulphur a year before planting to allow the Sulphur time to react. Sulphur cannot be incorporated to change pH quickly after plants are present. If large changes in pH are needed, check soil pH again just before planting and apply additional Sulphur if needed. Do not apply more than 400 Kg of Sulphur per acre to established plantings at one time. When large amounts are needed, spread the application out over several years. Ferrous Sulphate and aluminum sulphate have also been also decrease soil pH, but they are more costly to use than Sulphur and can be detrimental in high quantity. A better method is to gradually reduce pH by acidifying using fertigation of acidic feeds or the use of phosphoric acid.

P and K recommendations based on soil test results are given in Table 2. Sufficient soil test levels are greater than 50 ppm K (all soils) and 40 ppm P (mineral soils) or 30 ppm P (organic soils). These soil P and K levels are general guides -- lower levels may supply adequate amounts to bushes. Soil levels do not predict plant responses with certainty.

Mg may be needed if soil Mg is low in absolute amounts or relative to levels of Ca and K. Mg applications are recommended if soil Mg levels are less than 40 ppm Mg on mineral soils and 75 ppm on organic soils. High Ca and/or K reduce Mg absorption and may also indicate a need for Mg. The relative proportions of Ca, Mg and K are expressed on the MSU Soil Test Report as the percent of bases. If Mg represents less than 4 percent of the bases, or if K exceeds Mg as a percent of bases, Mg applications are recommended.

Tissue Analysis

Leaf analysis is a valuable tool in blueberry nutrition programs. It provides a means of accurately identifying nutritional problems that are difficult to diagnose by soil testing or by observing bush appearance. More importantly, growers can identify and correct potential nutrient shortages before growth or yield is affected.

Procedures. As with soil samples, one tissue sample should not represent more than an acre of crop. If possible, sample different varieties and blocks on differing soil types separately. For routine monitoring, sample bushes before and during and after fertigation period. Each sample should consist of approximately 200g of leaves collected from different bushes throughout the sampling area. Collect leaves from the middle of current-season shoots between mid-June to mid-August. Some consultants suggest washing leaves by swirling them in a dilute detergent solution for several seconds, then rinsing briefly in tap water. However, let leaves air dry before sending them to the lab - wet or moist leaves will rot during shipping.

If the purpose of leaf sampling is to diagnose a suspected nutrient problem, it is often helpful to submit two samples - one from bushes beginning to develop the problem, and a second from nearby healthy bushes.

Although laboratories may use different procedures for analysing tissue samples for mineral nutrients, results from reputable labs should be identical. Labs may offer analysis of single nutrients, such as N, but the cost of complete analyses is usually not that much more.

Interpretation. Tissue analysis results are interpreted relative to a critical or deficient level for each nutrient. When leaf concentrations are deficient, bushes are likely to respond to nutrient applications (Table 3). Sufficient levels are the normal range seen in healthy, productive bushes that are not expected to respond to readily to further nutrient additions. Usually there is a difference between the deficiency level and the lowest concentration that is considered sufficient. Bushes containing leaf levels between the deficient and sufficient ranges would not be expected to respond to nutrient applications but should be monitored closely. Deficient and sufficient levels for some nutrients have been researched extensively and are well understood. The requirements of other nutrients -- such as B, Cu, Mn, S and Zn -- are not as well understood. Deficient and sufficient levels of these nutrients may change slightly as more information is available. Concentrations of several nutrients in leaves change during development. If samples are collected earlier or later than normal, consider seasonal changes when interpreting results.

Nitrogen. Maintain leaf N levels between 1.7 and 2.1 percent (dry weight basis) for optimum yields and fruit quality. Leaf N concentrations are often highest during heavy crop years -- berries compete with and reduce vegetative growth so that leaf N is more concentrated. Plants growing poorly because of water problems or other stresses may contain high leaf N levels. Drought conditions usually increase leaf N concentrations. Leaf N levels decrease throughout the year, so samples collected earlier in the season will contain higher levels of N than leaves sampled later.

Phosphorus. Although most blueberry soils supply adequate P, application may be justified when leaf P levels fall below 0.08 percent. Leaf P concentrations are highest very early in the season and lowest at harvest time. Levels are not greatly affected by yearly variations in crop load or moisture supply.

Potassium. Leaf K levels below 0.35 percent indicate a need for K fertilizer. There is some evidence that blueberry bushes containing up to 0.5 percent K may benefit from K additions, but this is not always true. This confusion is likely the result of the strong influence that crop load has on leaf K levels. Fruit accumulate relatively large amounts of K, so leaf levels are always lower when bushes are bearing heavily and higher when a light crop is present. Leaf K levels between 0.35 and 0.4 percent are adequate if bushes are carrying a full crop of fruit. The same levels observed during a light crop year might be too low. Avoid over feeding blueberries with Potassium - excessive Potassium inhibits Magnesium uptake. Leaf levels above 0.9 percent are excessive.

Calcium. Although blueberries are seldom if ever deficient in Ca, leaf Ca levels can provide an insight into soil pH. Leaf Ca levels generally increase with soil pH. Leaf Ca levels can be strongly influenced by crop load (high Ca concentrations when crop load is heavy) and N fertilizer application (low leaf Ca in vigorous, heavily fed plants), so they may vary from year to year.

Magnesium. The deficiency level of 0.1 percent Mg is given for blueberry leaves (Table 2). However, there have been reports of Mg deficiency symptoms on bushes containing as high as 0.2 percent Mg. It is likely that bushes have higher optimum leaf Mg levels when leaf K levels are also high. Excessive leaf Mg levels (above 0.4 percent) usually indicate soil pH is too high.

Iron. Although Fe deficiency (chlorosis) is common in blueberries, leaf Fe levels have limited value in diagnosing this problem. Symptoms usually develop when leaf Fe approaches 60 ppm but may also appear on plants containing considerably higher leaf Fe. In other cases, plants containing less than 60 ppm Fe may exhibit no symptoms of deficiency. It is wiser to regularly apply low level iron feeds knowing that plants are prone to this deficiency

Other nutrients. The general sufficient ranges and deficient levels for B, Cu, Mn, S and Zn (Table 3) were compiled from reported values in healthy plants and controlled studies on potted young plants. These ranges are tentative.

Fertilizers and Rates

Nitrogen fertilizers that supply N in the ammonium or ureic form are preferred over those supplying nitrate-N, because nitrate may injure blueberries. Most mature plantings need 80 to 120 kg of nitrogen per Ha annually, but rates must be adjusted for soil type and site. Plantings on sandy soils low in organic matter will need higher rates; those on heavier soils high in organic matter require lower rates. Plantings mulched with sawdust or wood chips may need increased application rates recommended because most mulch materials tie up N, making it unavailable to the plants. Apply N between bud break and petal fall in the spring. Earlier applications may be wasteful because bushes cannot absorb soil N readily until leaves begin to grow. Blueberries are reasonably shallow-rooted and can absorb N quickly. Multiple applications will increase the efficiency of N use, particularly on sandy soils where N can easily leach out of the root zone before bushes can use it. Do not apply nitrogen later than July - it may stimulate a late flush of growth that will be prone to winter injury.

Phosphorus can be applied if needed at any time, but apply P sources containing N only in the spring. Use rates recommended on soil test or leaf analysis reports, usually 75 to 100Kg P_2O_5 per hectare

If soil don't provide significant amounts of K, apply this nutrient at rates of 130 to 150Kg K_2O per hectare to ensure a good production. Applications of potassium may be anytime of the year and should be increased during fruiting period.

If soil and water tests indicate Ca and/or Mg are needed, apply rates of 20-40 kg per hectare of each element. Alternatively, to solve Ca deficiencies apply limestone or dolomitic limestone at recommended rates (usually 1-2 tonnes/Ha). Occasionally Ca levels may be low when pH is in the proper range. Gypsum is a good Ca source in this situation because it does not change pH.

Ideal ratios for NPK fertilizations programs are 2-1-2 during vegetative growth and 2-1-3 since fruit formation until end of harvest. For each scenario ICL Specialty Fertilizers offers a complete solution, with water soluble fertilizer formulas that will fulfill the nutrition requirements. Each product line contains a complete array of nutrient balances, allowing to customize the fertilization program according to each location and plant growth stage:

- Agrolution Special will supply the three main nutrients (NPK) and contains additionally Ca and Mg, making this the complete solution for regions where water does not supply enough nutrients. Additionally it provides as well a full package of micronutrients, with concentrations above the market standards.

- For regions where irrigation water is hard and rich in Ca and Mg, ICL Specialty Fertilizers created Agrolution pH Low. This product supplies the perfect balance of NPK while offering the added value of its acidifying effect. Thanks to its inner "Pekacid technology", it will prevent the formation of precipitates in the drippers, ensuring like this an homogeneous irrigation and distribution of nutrients. Just like Agrolution Special, this product contains a full package of micronutrients.

- Nova WSF: this line of straight water soluble fertilizers is characterized for its unrivaled quality and are high solubility. They can be mixed with other straight fertilizer products or compound water-soluble fertilizers such as Agrolution pHLow or Agrolution Special. The combination of different straight fertilizers will offer the maximum flexibility for users which prefer to have highly customized fertilization programs.

Additionally, ICL Specialty Fertilizers offers a complete line of Foliar fertilizers called Agroleaf Power and Agroleaf Special, which will prevent and solve any nutrient deficiency problems plants may present during the growing cycle. This products not only contains nutrients, but also additives and bio-stimulants, which maximize the response obtained by the plants

Organic nutrient sources. Livestock manure and manure/bedding mixtures can be useful sources of nutrients for blueberries. The nutrient content of manure needs to be known to calculate appropriate application rates. Nutrient concentrations in manures vary enormously, depending on the animal species and feed, presence of bedding or other additions, and handling procedures. As a result, specific materials need to be analyzed to determine nutrient content and application rates. Manures contain organic N and ammonium N. Generally, all of the ammonium N and 25 to 50 percent of the organic N will be available to bushes the year of application. Adjust manure rates so that the available N does not exceed recommended N rates. The nutrient content of plant residues such as straw, bark and sawdust is minimal. Usually nitrogen rates need to be increased by 50 to 100 percent where these materials are used because the microbes that decompose these plant residues may have relatively high N demands.

Record keeping. Detailed record keeping is highly recommended. Records allow growers to learn from experiences and gain understanding of crop nutrient needs. Records will also be useful if a grower's management practices are challenged. Keep annual records on individual fields, including soil test and tissue analysis reports, growth and yield observations, and the dates, quantities and analyses of fertilizers applied.

Table 1. Elemental Sulphur needed to lower pH to 4.5 (Kg/Ha)			
Soil type			
Current pH	***Sand***	***Loam***	***Clay***
5.0	175	530	800
5.5	350	1030	1600
6.0	530	1540	2300
6.5	660	2020	3030
7.0	840	2560	3830
5.5	350	1030	1600
6.0	530	1540	2300

Table 2. Potash and phosphate recommendations			
K2O or P2O5	***All soils***	***Mineral soils***	***Organic soils***
	Recommended rate (lb/acre) (ppm)*		
0-10	90	150	100
10-20	75	125	75
20-30	60	100	50
30-40	30	50	0
40-50	20	0	0
>50	0	0	0
**To convert ppm soil test to kg per ha (to 6.7-inch depth), multiply by 2.*			

Table 3. Deficient, sufficient and excessive nutrient concentrations in blueberry leaves.			
Deficient		***Excessive***	
Nutrient	***below***	***Sufficient***	***above***
N (%)	1.7	1.7 2.1	2.3
P (%)	0.08	0.08-0.4	0.6
K (%)	0.35	0.4 0.65	0.9
Ca (%)	0.13	0.3 0.8	1.0
Mg (%)	0.1	0.15 0.3	na
S (%)	na	0.12 0.2	na
B (ppm)	18	25 70	200
Cu (ppm)	5	5 20	na
Fe (ppm)	60	60 200	400
Mn (ppm)	25	50 350	450
Mo (ppm)	na	na	na
Zn (ppm)	8	8 30	80

na: information not available.

Table 4. Agrolution portfolio			
Agrolution Special		**Agrolution pHLow**	
Formulation	**Name**	**Formulation**	**Name**
7-14-35+3.5MgO+TE	125	20-20-20+TE	222
14-8-22+5CaO+2MgO+TE	324	15-30-15+TE	242
12-6-29+7CaO+TE	214	10-50-10+TE	151
13-5-28+2CaO+2.5MgO+TE	316	10-10-40+TE	114
23-10-23+TE	212	15-13-25+TE	335
14-7-14+14CaO+TE	313	25-15-5+TE	531

Table 5. Nova fertilizers line			
Item Number	Brand Name	Product name	Analysis (%)
2487	Nova Calcium	Calcium Nitrate	15.5-0-0+26.5CaO
2850	Nova MagPhos	Soluble PK plus Mg fertilizer	0-55-18+7MgO
2851	Nova PeaK	Mono Potassium Phosphate	0-52-34
2852	Nova MAP	Mono Ammonium Phosphate	12-61-0
2853	Nova Ferti-K	Muriate of Potash	0-0-61
2854	Nova Quick-Mg	Soluble Potassium and Magnesium	0-0-15+13MgO
2856	Nova PeKacid	Soluble acidic PK fertilizer	0-60-20
2857	Nova Mag-S	Magnesium Sulphate	0-0-0+16MgO+32SO_3
2858	Nova N-K	Potassium Nitrate	13.5-0-46
2859	Nova Potassium	Soluble fertilizer for fertigation	5-0-49+21SO_3
2860	Nova SOP	Potassium Sulphate	0-0-50+46SO_3

By Scott Garnett
Senior Agronomist
ICL Specialty Fertilizers