NUTRIENT REQUIREMENTS OF HASKAP IN NOVA SCOTIA

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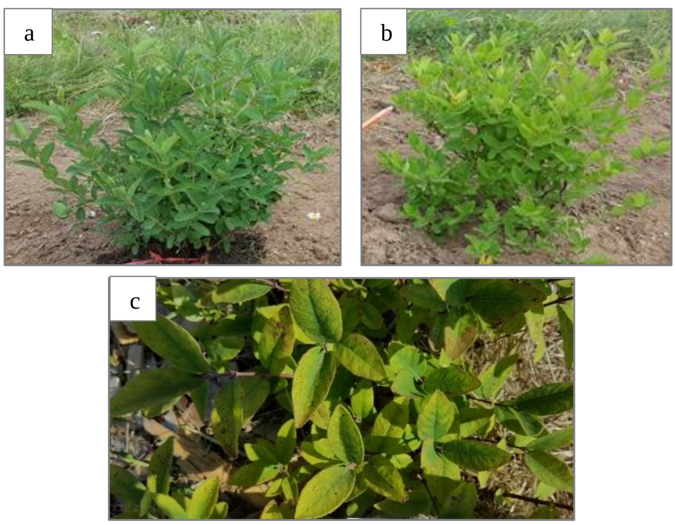
Background

Haskap (*Lonicera caerulea* L.) is a relatively new fruit crop of rapidly growing interest due to its early fruiting, good flavour, and excellent health benefits. The growth habit of commercial haskap varieties is comparable to that of other small bush fruits such as black currants and high bush blueberry. New haskap orchards in Nova Scotia (NS) have been established in a wide range of soils including newly cleared forest land, old hay land, and recently productive crop land. Slow haskap growth and signs of nutrient deficiency have been seen in a number of orchards. Slow vegetative growth during the establishment years and related low yields delay the time frame to commercially viable harvesting and return on investment. While haskap is known to be adapted to a wide range of soil conditions, the nutrient requirements under commercial production are not well known.



Healthy (a) and nutrient deficient (b, c) haskap plants.

This research aimed to identify optimal levels of soil fertility and leaf tissue nutrients by determining:

i) if haskap varieties differ in their nutrient uptake,
ii) the relationship between soil fertility status and leaf tissue nutrient contents, and
iii) studying the relationship between soil and leaf tissue nutrient status and plant health indicators using Indigo Gem as a model variety.

To achieve these objectives, we collected and analyzed 148 paired soil + leaf samples from 19 farms, primarily in NS, as summarized in the methods on the last page.

Nutrients:
N-nitrogen, P or P_2O_5-phosphorus, K or K_2O-potassium, Ca-calcium, Mg-magnesium

Soil and Tissue Sampling Procedure

Plan your sampling protocol so that samples will provide the appropriate information. In our case, we always collected soil and leaf samples to represent a single row of one variety.

Soil samples should be collected to a depth of 15 cm between plants within a row in **May**. A 5-10 samples should be collected and mixed to represent a specific area of interest. For leaf tissue analysis, ~15 leaves should be collected at 3 - 4 nodes down from the tip of the branch from 10 - 20 plants when 50% of the berries had turned color, typically in **late June** but may vary depending on location. Keep samples (especially soil) cool until submitted to the laboratory.

Soil (a) and leaf tissue sampling (b)

Is there a difference in leaf nutrients among varieties?

Leaf nutrient content varied widely across sample locations (**Table 1**) and among varieties when compared with Indigo Gem (**Figure 1**). The greatest variation was in P and Mg, with P and Mg content higher in Aurora, Berry Blue and Borealis than Larisa, Tundra and Indigo Gem. Indigo Gem tended to have lower K uptake and higher Ca uptake than most other varieties. Overall, there were few differences among Tundra and Indigo Gem. The difference in P uptake among varieties suggests that some varieties are better at taking up P. Indigo Gem may not be as responsive to P fertility in the soil as Aurora, Berry Blue and Borealis.

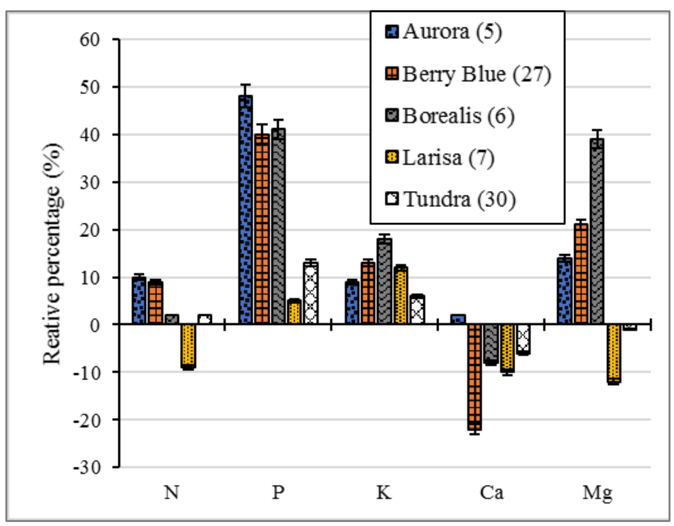


Figure 1. Relative comparison of leaf tissue nutrient content of other haskap varieties to Indigo Gem (100%). Variety (# of samples).

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Table 1. Leaf tissue nutrient content (mean and range) from 148 samples of multiple varieties aged 2-5 years across 19 farms and nutrient sufficiency ranges based on **Indigo Gem** growth rate.

Nutrients	Average	Range	Sufficiency ranges (optimum)[1]
		Macronutrients (%)	
N	2.11	1.20 - 3.19	2.2 -3.0
P	0.25	0.09 - 0.52	0.22 - 0.28
K	0.83	0.23 - 1.69	0.8 - 1.3
Ca	1.76	1.03 - 3.19	1.6 - 2.1
Mg	0.43	0.15 - 0.94	0.14 - 0.50
		Nutrient Ratios	
N:P	9.28	4.08 - 16.08	8.8 - 12.6 (10.8)
N:K	2.99	1.09 - 9.43	2.3 - 3.5 (2.9)
N:Mg	5.85	1.90 - 19.93	(8.0)
Ca:Mg	4.67	1.96 - 13.28	4.9 - 7.9 (6.4)
K:Ca	0.52	0.09 - 1.68	0.42 - 0.72 (0.57)
K:Mg	2.43	0.24 - 12.00	2.1 - 3.7 (2.9)
Ca:P	7.88	3.26 - 16.38	(7.4)

n.d. - not determined.

[1]***NOTE:*** *Nutrient sufficiency ranges were derived from leaf tissue nutrient content and growth rate of* ***Indigo Gem****.*

How did soil fertility affect leaf nutrient status?

The optimum soil fertility range for haskap was determined based on the relationship with leaf tissue nutrient content since yield data was not available.

A number of expected relationships between soil and plant nutrient levels were seen (and will not be discussed here) and among nutrients within the leaf. Possibly of greatest importance was the observation that the content of Mg in the leaf tissue had a negative relationship with leaf K and Ca. This is a well-known interaction, where high levels of one of these nutrients may displace the uptake of others, resulting in deficiency of the displaced nutrient.

The nutrient sufficiency ranges in the soil are shown **Table 2** in comparison with the observed ranges on the sampled sites and the NS Department of Agriculture general recommendations for small fruits. The sufficiency ranges did not always correspond with general small fruit recommendations, particularly for K. Based on this analysis and recommendations from our research, we found that just over 50% of soil samples were deficient in K, 8% were deficient in P_2O_5, 19% were deficient in Ca and 46% were deficient in Mg.

How did nutrient status affect plant growth?

The relationship among soil and leaf tissue nutrient status and plant health indicators of Indigo Gem is shown in **Figure 2**. Plant health in terms of growth and leaf size were most strongly related to soil and leaf K. This suggests that K may be a key factor limiting plant growth and supports the K deficiency symptoms commonly seen in field observations.

Table 2. Soil fertility status[1] of 148 sample locations in haskap orchards and suggested ranges of sufficient soil nutrient status based on leaf tissue nutrient content (i.e. not growth or yield).

	Observed Average	Observed range	**Suggested sufficiency range for haskap**	*NSDA recommend-ation for small fruits[1]*
pH	5.95	5.1 - 7.0	**n.d.**	*5.8 - 6.5*
P_2O_5	709	39 - 3989	**232 - 360***	*232 - 360*
K_2O	290	65 - 753	**270 - 580**	*122 - 236*
Ca	2499	784 - 9291	**2700 - 4000***	*1188 - 3083*
Mg	306	91 - 933	**245 - 380***	*81 - 329*

n.d. - not determined no data

***** updated from initial draft

[1] **IMPORTANT**: Unit of measurement for nutrients is kg ha^{-1} Methods of soil analysis and resulting recommendations varies across geographic regions depending on soil type and environment. The results from Mehlich III soil analysis in NS may not be applicable to other regions.

[2] NS Department of Agriculture Analytical Lab's Soil Test Interpretation Ratings recommendations for small fruits, representing the Medium range (sufficient for crop requirements) have been provided for comparison and reference. http://novascotia.ca/agri/documents/lab-services/analytical-lab-soil-interpretation.pdf)

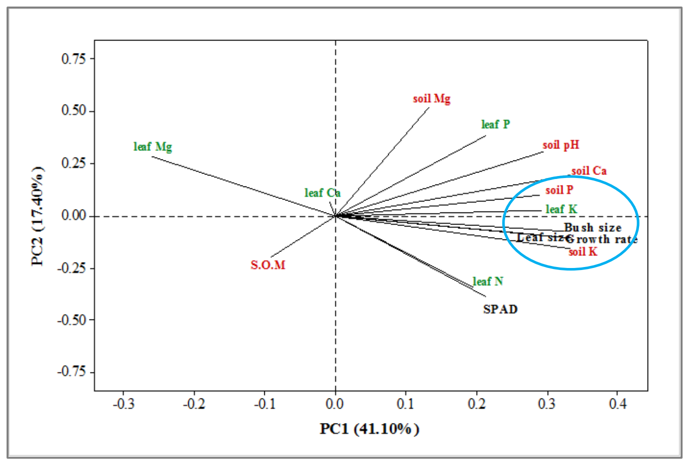
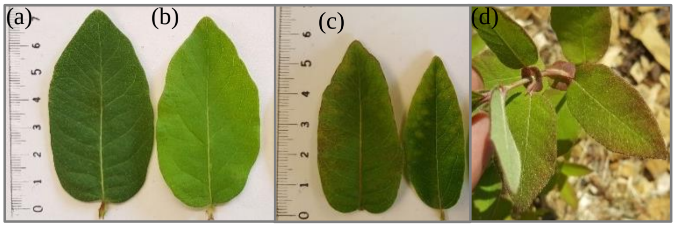


Figure 2. Relationship among soil and leaf nutrient status and plant health indicators of Indigo Gem. The closer the line endpoints are together, the stronger the relationship between two variables. Here we see a strong relationship between plant growth indicators and both leaf and soil K.

Soil P and Ca levels were also important, as was N nutrition which was closely related to chlorophyll content (SPAD). A strong negative relationship between leaf Mg and leaf K as well as bush growth and leaf size were observed. Further analysis showed that Mg is still an important nutrient for haskap growth, however, higher levels of Mg in leaf tissue may compete with K uptake and may result in a K deficiency which is affecting plant growth. A proper balance of these nutrients is needed in the soil and plant tissue. This suggests that K may be a key nutrient for improving haskap bush growth in NS.



Visual nutrient deficiency symptoms observed on haskap. a) healthy dark green leaf, b) nitrogen deficiency indicated by pale green colour of whole leaf, c) K-deficient leaves showing chlorosis (yellowing) from leaf edges moving inward and where tissue along veins and leaf base remain green; d) P-deficient leaves showing purple colouration of leaf tips which progresses until the entire leaf is purple; this plant also shows N deficiency by its pale colour.

Nutrient sufficient levels and ratios of leaf nutrients was determined in relation to plant growth rate (**Table 1**). Considering the leaf tissue nutrient levels observed in the studied locations and the nutrient sufficiency ranges, it can be concluded over 50% of the sample locations were deficient in N, P and/or K (**Figure 3**). It was also clear that many sample locations had an imbalance of nutrient ratios in the leaf tissue. Considering that leaf K has been identified as a key nutrient affecting growth rate, the N:K and K:Mg ratios require particular attention. Excess N, for example, may exaggerate a K deficiency.

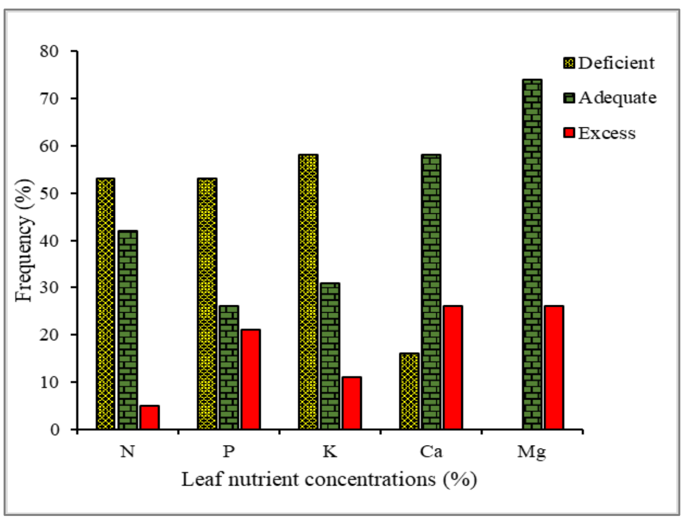


Figure 3. Frequency of occurrence of Indigo Gem nutritional status from 19 locations based on sufficiency levels determined from leaf tissue nutrient content and plant growth rate.

Response to fertilizer application

In preliminary experiments, two rates of an N-P-K blend fertilizer (EZ-GRO's Nature's Nectar N, P, and K solutions, organically permitted) was applied in a split application to different varieties of haskap in May/June of their second or third growing season. The unfertilized Control treatment was compared with a Low rate of 15g N, 30g P_2O_5, and15g K_2O per plant, and a High rate that was double the Low rate. In short, a significant response (**Table 3**) was seen in leaf tissue nutrient content (particularly N and K) and in plant growth (data not shown) for both the Low and High rates compared with the Control, but the High rate was not different from the Low.

Table 3. Haskap leaf tissue nutrient response to supplemental fertility application.

Treatment	N	Ca	K	Mg	P
			Berry Blue		
Control	2.73b	1.86a	0.46b	0.68a	0.24a
Low rate	3.11a	1.60b	0.60a	0.56b	0.20b
High rate	3.06a	1.37c	0.67a	0.47b	0.19b
			Indigo Gem		
Control	2.31c	1.97a	0.94b	0.34a	0.21a
Low rate	3.20a	1.76b	1.17a	0.28b	0.13b
High rate	2.89b	1.63b	1.09ab	0.30b	0.15b
			Larisa		
Control	1.85b	1.86a	0.69c	0.49a	0.28a
Low rate	2.76a	1.44b	0.94a	0.37b	0.19b
High rate	2.81a	1.23c	0.84ab	0.33b	0.16b

Note: For an individual variety and nutrient, numbers followed by the same letter are not statistically different.

In one experiment the plots were split to compare the residual fertilizer effect in the next season with repeating the application in the second year on the same plots. No residual effect on leaf N or P content was observed for either rate but the High treatment did maintain leaf tissue K in the sufficient range for a second year while the Low treatment did not (**Figure 4**).

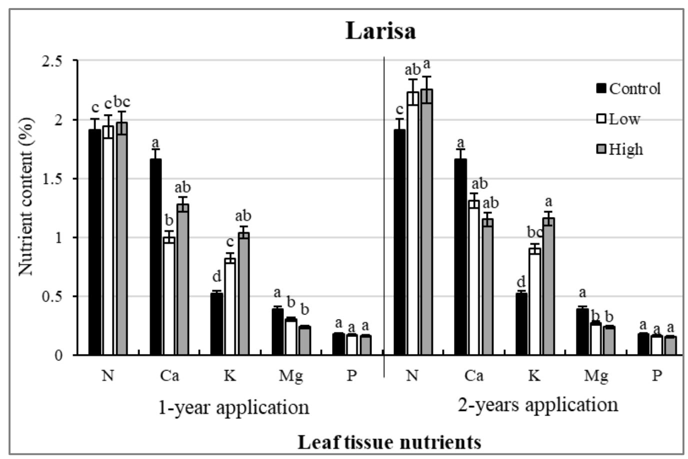


Figure 4. Effect of 1- and 2-years application of an N-P-K blend on Larisa leaf tissue nutrient concentration. *Note: for a single nutrient across both application years, columns with the same letter on top are not statistically different.*

At one site with wood mulch applied 2 years earlier at planting, the liquid fertilizer blend was poured directly at the base of the plant. The High rate treatment stressed the plants, in some cases severely. With closer observation, it was noted that the plant had established roots in and just below the mulch and direct contact of the fertilizer caused stress on the plant.

In all experiments, it was noted that leaf tissue P, Ca and Mg declined with increasing rate of the N-P-K fertilizer (**Table 3 and Figure 4**). At this point it is hypothesized that while the highly available N and K stimulated uptake of those nutrients and plant growth, the concentrations of less available nutrients were diluted with plant growth, even in the case of P fertilizer application. This observation reinforces the need to balance nutrient ratios in the fertility management plan.

No significant effect was observed between one- and two-year fertilizer applications on Larisa (**Figure 5**). Overall, the Low rate had greater berry yield compared to the High rate. However, differences between the Low and High rates were not statistically significant but both yielded significantly better than the Control (no fertilizer) (**Figure 5**). It can be concluded that fertilizer applications had impact on haskap yield especially by increasing berry number and but also weight.

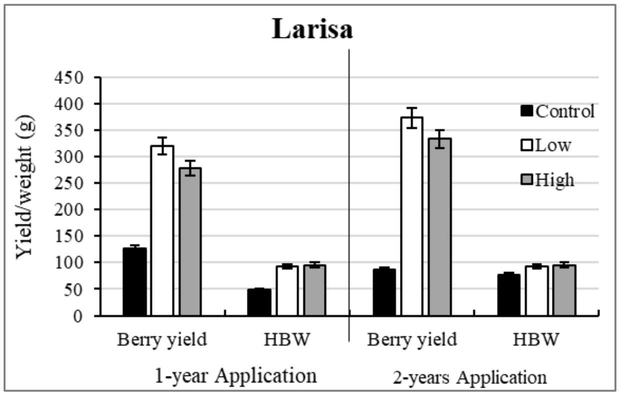


Figure 5. Effect of one and two-years nutrient application on haskap (cv. Larisa) berry yield/bush and 100-berry weight (HBW).

Discussion

From this research it is clear that nutrient deficiencies and imbalances are holding back growth in NS haskap orchards and delaying the return on often significant orchard investment. Background soil fertility levels should be carefully surveyed prior to planting to allow correction of major deficiencies and development of an appropriate nutrient management plan that is compatible with other orchard management practices such as weed control. This is particularly important for the establishment of organic orchards, where the cost of fertility amendments can be high and may require incorporation. Ensuring that nutrient applications are designed to provide an appropriate balance of all essential nutrients is important as excess application of one nutrient may result in a plant deficiency in another.

Use of wood mulch or other high carbon materials for weed control can be effective but may exaggerate nutrient deficiency issues as soil micro-organisms will temporarily reduce the availability of soil nutrients in order to help them decompose the organic matter. These mulches also make it more difficult to apply and incorporate granular amendments.

Conclusions and Recommendations

1. Leaf tissue nutrient sampling is more reliable for assessing plant health, but soil sampling is important for correcting soil fertility issues. Collect both soil and leaf tissue samples to inform your nutrient management plan. Mehlich III soil test results and related recommendations may not apply to other regions with different soil tests.

2. Leaf tissue nutrient sufficiency ranges are provided for Indigo Gem (**Table 1**). Leaf sampling should be done strategically due to differences among varieties; either collect only from Indigo Gem and adjust results for other varieties or collect from all varieties evenly.

3. Deficiencies of K were common among orchards, and may be related to soil deficiency, competition with Mg, or an imbalance of N:K nutrition. Application of N should be balanced with K, and choice of liming agent should consider soil Mg status. **Caution**: the salt effect of K fertilizer may stress plants if high levels are concentrated near roots.

4. Deficiencies of P may be a common problem but may also depend on the variety. Supplement P prior to planting and maintain P applications each year as needed.

5. During early establishment years, excessive application of N-P-K fertilizer may not benefit the plant and may create an imbalance with other nutrients. Moderate application to young plants is sufficient.

Acknowledgements

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For further reading, visit:
https://dalspace.library.dal.ca/bitstream/handle/10222/73917/Iheshiulo-Ekene-MSc-AGR-April-2018.pdf